MINISTRY OF HEALTH

STANDARDS ON DIAGNOSTIC IMAGING AND THERAPEUTIC RADIOLOGY FOR UGANDA

2012
STANDARDS ON DIAGNOSTIC IMAGING AND THERAPEUTIC RADIOLOGY FOR UGANDA

2012
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FORWARD

The Ministry of Health in collaboration with technical and teaching institutions has developed this National Standards on Diagnostic Imaging and therapeutic Radiology. The Standards address a wide range of relevant diagnostic and therapeutic requirements that have so far been missing in the field of Radiology.

The key components in this standard includes Human Resource requirements and qualifications for diagnostic imaging and therapeutic radiology, premises design, specifications for equipment, accessories and consumables, Imaging standards, and Interventional radiology. documentation and report writing, quality control and quality improvement particularly with regard to Ionizing radiation, Magnetic Resonance Imaging (MRI), Ultrasound, Infection Control and safety, patient education, monitoring and evaluation, Training, Research and Continuing Professional development.

Given the low imaging resources, rationalizing resource-utilization requires targeted imaging. The imaging needs (burdens) at national, regional, hospital and individual patient levels have to be studied as and when necessary, taking into consideration the context of available imaging resources. This will ensure delivery of equitable, affordable but appropriate and quality services. A budget for maintenance and repair of the equipments is a pre-requisite.

Since this is the first set of Radiology and Imaging standards ever developed, produced, and disseminated in Uganda, I urge all the users to critically read and use them and recommend ways and means of improvement where gaps and missing information are identified.

Iam glad that the Guidelines will address critical conditions with high burden and where there has been variation in practices and techniques. The guidelines will also be able to reduce changing health outcomes and improve ethical practice of the radiology and imaging professionals.

In conclusion, may I thank all the Imaging and Radiology Professionals and Ministry of Health Departments that participated in the
development of this important document that will greatly benefit healthcare in the country.

Thank you, FOR GOD AND MY COUNTRY.

Dr. Asuman Lukwago
PERMANENT SECRETARY
ACKNOWLEDGEMENTS

I wish to thank the Senior Consultants, Consultants and Specialist Radiologists and Physicians, Medical Physicists, Radiographers, Medical Imaging Technologists, Sonographers, Biomedical Engineers, Biomedical maintenance Technicians, Radiation Oncologists, Oncology Nurses, Radiation Protection and Safety Officers and all those who contributed in one way or the other for their efforts that made it possible to produce this remarkable book.

Special thanks goes to the Department of Quality Assurance for dedicating financial resources and time to ensure that this standard which is the first of its kind is developed for the benefit of target users and for the improvement of the quality of patient care nationwide.

The protracted process of development of this book would not have been possible without the exceptional interest, input and contributions by several key professionals listed at the back of this document as Annex 1.

Furthermore, I wish to thank the Uganda Atomic Energy Council for allowing their staff to be part of this process. In addition may I take this opportunity to thank Professor C. Bal and Mr. Michael Kiza of IAEA for their invaluable contributions.

Thank you,

Dr. Jane Ruth Aceng
DIRECTOR GENERAL OF HEALTH SERVICES
Note

Every effort has been made to ensure that the information in this booklet is accurate, complete and conforms to the current therapeutic practice. However, the publisher, editor and contributors cannot be held responsible for any errors, omissions, individual patient responses to recommended therapies or other consequences which may arise from its use.
# ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>AEC</td>
<td>Atomic Energy Council</td>
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<tr>
<td>ALARA</td>
<td>As Low As Reasonably Achievable</td>
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<tr>
<td>AP</td>
<td>Antero-posterior</td>
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<td>BP</td>
<td>Blood Pressure</td>
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<td>BSS</td>
<td>International Basic Safety Standards</td>
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<tr>
<td>CME</td>
<td>Committee on Medical Equipment</td>
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<td>CP</td>
<td>Circular Polarized</td>
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<td>CPD</td>
<td>Continuous Professional Development</td>
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<td>CR</td>
<td>Computed Radiography</td>
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<td>CRSO</td>
<td>Chief Radiation Safety Officer</td>
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<tr>
<td>CT</td>
<td>Computed Tomography</td>
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<tr>
<td>DICOM</td>
<td>Digital Imaging and Communications in Medicine</td>
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<tr>
<td>DM</td>
<td>Digital Mammography</td>
</tr>
<tr>
<td>DR</td>
<td>Digital Radiography</td>
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<tr>
<td>DSI</td>
<td>Digital Subtraction Imaging</td>
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<tr>
<td>EBR</td>
<td>Evidence Based Recommendation</td>
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<tr>
<td>FIGO</td>
<td>International Federation of Gynaecology and Obstetrics</td>
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<tr>
<td>HIV/AIDS</td>
<td>Human Immunodeficiency virus/Acquired immune deficiency syndrome</td>
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<tr>
<td>HVL</td>
<td>Half-Value Layer</td>
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<tr>
<td>IAEA</td>
<td>International Atomic Energy Agency</td>
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<td>ICD-9</td>
<td>International Classification of Diseases nine</td>
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<td>ICRP</td>
<td>International Commission on Radiological Protection</td>
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<td>ICRU</td>
<td>International Commission on Radiological Units and Measurements</td>
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<tr>
<td>IMRT</td>
<td>Intensity Modulated Radiation Therapy</td>
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<tr>
<td>MLC</td>
<td>Multi-leaf Collimator</td>
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<tr>
<td>MRI</td>
<td>Magnetic Resonance Imaging</td>
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<td>NACME</td>
<td>National Advisory Committee on Medical Equipment</td>
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<tr>
<td>NIRMED</td>
<td>Non-ionising Radiation and Electromedical Devices</td>
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<tr>
<td>OAF</td>
<td>Off Axis Factor</td>
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<tr>
<td>ODI</td>
<td>Optical Distance Indicator</td>
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<tr>
<td>PET</td>
<td>Positron Emission Tomography</td>
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<tr>
<td>QA</td>
<td>Quality Assurance</td>
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<td>QC</td>
<td>Quality Control</td>
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<td>RPO</td>
<td>Radiation Protection Officer</td>
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<td>RPS</td>
<td>Radiation Protection and Safety</td>
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<tr>
<td>RSO</td>
<td>Radiation Safety Officer</td>
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<td>RTT</td>
<td>Radiotherapy Technologist</td>
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<td>SAD</td>
<td>Source Axis Distance</td>
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<td>SPECT</td>
<td>Single Photon Emission Computed Tomography</td>
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<tr>
<td>Acronym</td>
<td>Definition</td>
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<td>SSD</td>
<td>Source to Surface Distance</td>
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<td>TDS</td>
<td>Time Distance Shielding</td>
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<tr>
<td>MDR</td>
<td>Medium Dose Rate</td>
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<tr>
<td>LDR</td>
<td>Low Dose Rate</td>
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<tr>
<td>TLD</td>
<td>Thermolumiscent Dosimeter</td>
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<tr>
<td>HDR</td>
<td>High Dose Rate</td>
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<tr>
<td>TPS</td>
<td>Treatment Planning System</td>
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<tr>
<td>US</td>
<td>Ultrasound</td>
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<td>WHO</td>
<td>World Health Organization</td>
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CHAPTER ONE

1.0 INTRODUCTION:

1.1 Background

The National Standards for diagnostic imaging and therapeutic radiology contains guidelines for all imaging techniques that are usually performed in this country. These standards and guidelines will be reviewed regularly at least every two years to ensure that the latest information is captured and included in the revised document. This shall be done through consensus of expert panels using the best available research evidences and opinion of the experts.

To ensure optimum and equity as well as appropriate and safe imaging, in light of limited resources, this guideline which has been developed, tested and approved by the Ministry of Health (MOH) will be referred to and followed for all imaging investigations.

The Guideline covers General radiography, all types of ultrasound, vascular imaging, contrast imaging studies, MRI, Breast imaging, CT, interventional radiology, nuclear medicine, radiotherapy among others.

The guidelines in this document are meant to assist in clinical decision-making and to improve effectiveness and reduce costs of health care. Their development has to be based on the best available evidence. The Guidelines state the recommendation and defines the procedure. They spell out the indications and contra indications, options, outcomes, perspectives and evidence benefits. They also spell out the equipment, the qualification of the personnel and specification and performance of the procedure. They also outline issues of quality control, safety, infections control and patient education concerns.

The Guidelines takes care of priority medical and surgical conditions which are prevalent and carry significant cost and risks. The guideline formulation process involved the following steps.

1. Generation of evidence based recommendation (EBR)
2. Ratification of the EBR
3. Formulation of practice guidelines
4. Independent review of the guidelines
5. Ownership of the policy by Ministry of Health, Hospitals, Practitioners through their input and participation.

After the launch of the standards the following will be carried out;

1. Adoption of the guidelines
2. Dissemination of the guidelines
3. Implementation of the guidelines
4. Maintenance of guidelines and encouragement of use
5. Evaluation of impact of guidelines.
6. Periodic review of the guidelines
1.2 Principles in developing National Imaging and Therapeutic Standards (key elements):

- **Setting clearly defined goals and strategies** by every hospital and departments towards effectiveness, efficiency and safety.

- **Departmental design** responsive to the functions and resources of that particular hospital but also compliant with national and international (IAEA) safety standards.

- **Specification and maintenance of equipment.** These specifications should be in line with the qualitative and quantitative needs of the hospital and reflect trends in technology. They should also be user and maintenance friendly.

1.3 Human Resource

The rapid and continually evolving imaging technology requires a flexible and responsive staffing structure. As newer fields and specialties develop, their relevance to our imaging needs has to be assessed before they are adopted, but thereafter, the staffing and nomenclature of cadres including the numbers thereof should reflect job description and function.

There must be local personnel who are competent in repair and maintenance of the particular equipment. Software and hardware updates should be done regularly. Training of users to carefully and optimally utilize all functions of the equipment helps to promote longevity. Equipment should be decommissioned before they become a liability.

Appropriate Human Resource shall be competently trained by recognized and registered institutions. They shall be certified and registered by relevant councils. Performance of complex imaging procedure requires special certification and registration in addition to registration based on one’s basic health training.

Registration shall be renewable after a set period, and upon provision of baseline score of Continuing Professional...
Standards on diagnostic imaging and therapeutic radiology for Uganda

Development (CPD) to the relevant councils.

Whereas the qualifications and certification have to be responsive to technology trends, they should meet the requirements set out by the relevant councils. The Certification must be from a college or institution recognized and registered by the relevant council and the Ministry of Education. If that Institutions is not one of those registered by the Council or the Ministry of Education, the academic transcript or other relevant documents should be availed to the Council by the applying staff for vetting and verification.

Should a Council decide to set up National board Examinations so as to maintain uniform standards, the applicant must be certified to have passed these. Regardless of the imaging specialty, all imaging training should include sufficient content in basic sciences namely anatomy, physiology, biochemistry, pathology, microbiology, medical physics as well as public health. There should also be proof of adequate knowledge, attitude and skills training in the relevant imaging subjects.

All personnel should register by the relevant Councils for the basic training in addition to the specialized training. Highly specialized imaging like cardiac imaging will require additional post basic certification and registration.

All registration has to be renewed at intervals specified by the various Councils. Renewal of registration depends on fulfillment of CPD requirements by that Council.

1.4 Premises design
Imaging services are envisaged at all levels of health service delivery from health centre IV to tertiary hospitals.

The design will reflect the diagnostic imaging needs (burdens), the equipment to be installed in the department, the intended functions of the department, and accessibility by clientele. It will
also reflect the level of training and number of imaging personnel in the department. It will comply with radiation safety and infection control standards and harmonize with the recommendations by the National Advisory Committee on Medical Equipment (NACME), Atomic Energy Council (AEC) and the IAEA radiation safety regulations. For highly specialized equipment, manufacturer’s recommendations on departmental design are necessary.

1.5 **Equipment, Accessories and consumable specifications**

The equipment specifications are the responsibility of the technical user. The specifications must however reflect the quantitative and qualitative imaging and treatment needs of the hospital or department. Specifications will take into consideration not only recent trends in technology but will also be user and maintenance friendly. The specifications will also comply with radiation safety and infection control standards. Equipment, Accessories and consumables should be of quality, affordable and durable.

1.6 **Documentation and report writing**

Guidelines for documentation of images and writing reports shall be developed. These shall be followed to ensure quality and uniformity as well as comprehension of reports. Only certified and registered imaging personnel shall write patients’ reports. A report of findings is a requirement for all imaging procedures.

Clear hardcopy and where possible soft (electronic copies) of all findings have to be documented. The report should be written by a person, qualified to perform the procedure, and to write the report. This has to be the very same person who carried out or supervised the study. The report is to be written in proper grammatical English. Detail of the patient including at least two names, age, date of birth and registration number are mandatory. The date when the examination was performed should be recorded. It is prudent to start the report with a brief statement of the indications for the procedure.
A detailed description and a logical conclusion should follow. The report has to be signed and the names of the writer printed clearly. Urgent or emergency reports should reach the referring clinician expeditiously so as not to endanger the patient and delay subsequent management. Important but unexpected findings should also be relayed expeditiously to the referring doctor. It is desirable that the technique also be described in appropriate details including modifications from the standard technique.

1.7 Quality Assurance

1.7.1 Ionizing radiation
Each imaging and therapeutic facility should have documented policies, guidelines and standard operating procedures for monitoring and evaluating the effective management, safety and operation of imaging and therapeutic equipment. The quality control program should be designed to minimize patient, personnel and public radiation risks and maximize quality of diagnostic information.

At least annually, equipment performance should be monitored, and a qualified medical physicist should conduct a quantitative dose determination. All equipments shall have a documented quality program, which spells out routine and annual quality and safety checks by technologists, physicists and service engineers. Rectification of faulty, non-functioning equipment or decommissioning shall be done when and as necessary. The Medical Physicists shall perform quality and safety checks after equipment repair or modification to ensure conformity to the standard performance. Soft and hardware updates to ensure quality performance and safety are mandatory.

1.7.2 Non-ionizing radiation
Magnetic Resonance Imaging (MRI)
A documented quality program shall be maintained at the MR site. Daily quality control testing should be conducted by the technologist and or service engineer with review on at least an
annually basis by supervising physician and or qualified Medical Physicist.

**Ultrasound**

Each Facility should have documented policies and procedures for monitoring and evaluating the effective management, safety, and proper performance of imaging equipment. The quality control program shall be designed to maximize the quality of the diagnostic information. Equipment performance should be monitored.

1.7.3 **Infection Control.**

Each facility shall have policies and procedures in place, to control the spread of infection among patients and personnel.

These shall include adherence to universal precautions and the use of clean or aseptic techniques as warranted by the procedure or intervention being performed.

1.7.4 **Safety**

Each facility shall have in place policies and procedures to provide for the safety of patients and personnel. These shall include attention to the physical environment, the proper use, storage, and disposal of medications and hazardous materials and their attendant equipment, and methods for addressing medical and other emergencies.

1.7.5 **Patient Education.**

Each facility should have in place policies and procedures for educating and informing patients about procedures and/or intervention to be performed and facility processes for the same. This shall include appropriate instructions for patient preparation and aftercare, if any. This information shall be provided in an appropriate form to the patient and /or next of kin.

1.7.6 **Monitoring and Evaluation.**

Examinations, interventions and therapies shall be systematically reviewed and evaluated as part of the overall quality
improvement programme at the facility. Monitoring shall include evaluation of the accuracy of interpretation and effectiveness of therapies and interventions as well as their appropriateness. Complications and adverse events or activities that may have the potential for side effects shall be monitored, analyzed and reported as required, and periodically reviewed in order to identify opportunities to improve patient care.

Each examination or group of examinations shall be reviewed and evaluated as a part of overall quality improvement program at the facility and nationally. The accuracy of performing as well as interpreting the examination and its appropriateness shall be documented and analyzed.

The data shall be collected in a manner compliant to ethics and national scientific requirements. Corrections and improvements on the National and hospital guidelines and procedures, which are based on evidence, shall then be carried out.

1.7.7 Training, Research and Continuous Professional Development (CPD)

To ensure needs responsive and technology responsive imaging and therapies to enable evidence based guidelines and policy development. It is imperative that research in all relevant aspects of imaging and therapeutics
be carried out at all levels of health service delivery.

In view of this, systematic and organized documentation and archiving of patient data is mandatory. Institutions will undertake research depending on their priority issues. Ethical clearance is to be obtained from relevant ethical authorities and research findings shall be disseminated to relevant stakeholders for action. Such findings will be referred to when making or modifying guidelines and policies.

CPD is a way of maintaining quality, with respect to knowledge, attitudes and skills of Health providers. It facilitates exchange of ideas and experience as well as problem solving among the personnel both at National and International levels.

CPD is a requirement by the relevant Councils before renewal of practicing license. Baseline CPD scores from the Councils will be referred to before renewing registration. Institutions are therefore advised to facilitate their personnel to attend and actively participate in CME sessions relevant to imaging. All imaging personnel are encouraged to arrange their own CME sessions and carry out self-directed learning using books, journals and electronic media.

1.7.8 Imaging/ Therapy Standards

All procedures shall be carried out following the standard practices and treatment guidelines. The equipment, imaging and radiotherapy personnel shall meet the guidelines requirements. Equipment requirements and clinical requirements shall be fulfilled. Patient preparation, monitoring and management of adverse effects shall be compliant. All procedures performed in this country shall be according to standard guidelines. The guidelines shall outline the equipment and facilities to be used, the human resource, their qualifications and experience.

The guidelines shall spell out the ethical and consent issues, patient preparation, counseling, and procedure technique. In addition they will spell out management of anticipated
complications, including physiological monitoring of the patient during and after the procedures as well as resuscitation.

Each facility shall adhere to set policies and procedures of infection control and safety among patients and personnel. These include attention to physical environment, proper use, storage and disposal of medicines and hazardous materials and their attendant equipment and methods for addressing medical and other emergencies. The facility shall adhere to set policies and procedures for educating and informing patients about procedure and interventions to be performed and facilitate processes for the same. Patients shall receive appropriate instructions for patient preparation and after care. Informed patient consent shall be sought.
CHAPTER TWO:

2.0 LEGAL FRAMEWORK

2.1 National Radiation Protection and Safety Policy
While the use of ionizing radiation is justified and has found beneficial application in medical practices, it carries potential and actual risk to man and the environment. Exposure to high doses of radiation can cause damage to human tissue and has a potential for delayed induction of malignancies (Studies of 1945 atomic bomb survivors) The effects of radiation are classified into two categories; stochastic and deterministic.

Stochastic effects occur as a result of the law of chance or probability and are independent of radiation dose. Such effects can lead to cancer induction or have an influence on genetic material affecting future generations. These effects have no threshold dose.

Deterministic effects (non-stochastic) are effects that occur due to radiation exposure and these will always occur, but only when exposure is exceeding a certain threshold. The degree of damage (severity) increases the more the threshold value is exceeded.

Presence of risk, actual or potential, calls for protection against radiation. All types of radiation are natural and permanent features of the environment, thus the risk associated with radiation exposure can only be restricted, not eliminated entirely. For any facility using radiation, it should have a well established and documented Quality Assurance (QA) programme to encompass all the safety culture aspects.

The principle of optimization of protection; keeping radiation doses As Low As Reasonably Achievable (ALARA) is the cornerstone of radiation protection in the workplace. It is important to recall that ALARA relates not only to engineering or physical protection measures but also to aspects such as safety organizational, management, security and training. A safe
workplace must be ensured without compromising diagnostic quality; taking into account economic and social factors.

Exposure of workers who perform diagnostic and therapeutic procedures is an unavoidable part of the risk that accompanies the health benefits obtained. These workers form the largest group of people in Uganda and the world exposed occupationally to ionizing radiation. Under good practice, these exposures have been reduced to a level whereby annual doses to the overwhelming majority of the personnel are lower than the current dose limits.

Necessary steps and procedure must be put in place to offer and achieve protection. This is done through legislation, structural design of premises, safety culture, education and training. Responsibility to implement legislation resides with the national authority - Atomic Energy Council (AEC) as established by the Atomic Energy Act of 2008.

The standards apply to both the commencement and the continuation of practices that involve or could involve radiation exposure. For a practice, the provision for radiation protection and safety can be made before its commencement, and the associated radiation exposures and their likelihood can be restricted from the onset.

The licensees shall develop, implement and document a radiation protection and safety programme commensurate with the nature and extent of the risks associated with the practices under their responsibility and sufficient to ensure compliance with the standards.

The objectives of the national standards on radiation protection and quality assurance are to:

- Provide protection for radiation workers, patients, public and environment against harmful effects of ionizing radiation, without limiting the beneficial practices of such exposures.
• Ensure maximum benefit for the patients when the practice is justified and ensure that exposures are optimized and doses are kept as low as is compatible with the medical purposes without compromising image quality (ALARA principle) (IAEA, BSS, WHO)

• Establish a system for radiation monitoring, identifying deficiencies and enforcing compliance to established standards as specified in authorizations or license of the practice by the AEC.

• Establish Standards to ensure that medical exposures are carried out in compliance with the requirements of the Atomic Energy Act of 2008 and the Atomic Energy Regulations of 2012, International Basic Safety Standards, and other recommendations of the IAEA, WHO, ICRU and ICRP.

2.2 General Policy Statements
The Atomic Energy ACT of 2008 and the Atomic Energy regulations Of 2012 govern the application of atomic energy/ionizing radiation in Uganda.

The purpose of standards on radiation protection and quality assurances is to establish requirements for protection and safety for radiation workers, patients, the public and the environment.

The National Management Structure consists of:

• The Atomic Energy Council which is responsible for Policy formulation.

• The Atomic Energy Secretariat which is responsible for implementation of policy and compliance.

• The Radiation Safety and Quality Assurance Committee at the MOH under Quality Assurance Department (See section 2.6.2 for the composition)

• Every hospital will have a Radiation Safety and Quality Assurance Committees, which will report to MOH Radiation Safety and Quality Assurance Committee.
The Regulatory authority for Radiation Protection shall be the Atomic Energy Council and this will guide through established departments of other ministries where the use of ionizing radiation is applied for medical practices, industrial, nuclear security or research. The personnel to use radiation will be qualified and registered. These shall be Radiologists, Radiation Oncologists, Nuclear Medicine Physicians, Cardiologists, Sonologists, Medical Physicists, Medical Radiation Technologist, Medical Imaging Technologists, Radiographers, Radiopharmacists, Sonographers, Biomedical Engineers and Technicians.

2.3 Protection and Safety of Radiation Workers, Patients, Public and Environment

The provision of quality diagnostic information and therapy is central to delivery of safe, equitable and accessible health care.

- This shall be achieved through setting up an effective and efficient quality assurance Program for diagnostic imaging and therapy services.

- The Radiation Safety and Quality Assurance Committee of the Ministry of Health shall oversee and ensure an operational quality assurance program as well as review and update standards.

- The Radiation Safety and Quality Assurance Committee of the Ministry of Health shall be supported by the professional associations of the relevant health providers, public and private health institutions and other stakeholders in formulation of standards and guidelines.

- Provision of infrastructure, radiation protection gear, and equipment that conform to the IAEA radiation protection and national standards, and are compatible with Digital Imaging and Communications in Medicine (DICOM).

- Regular checks on the premises, protective gear and equipment for compliance to specifications and IAEA standards as well as certification for radiation protection adequacy.
• Develop guidelines and ensure compliance to the principles of justification, optimization and dose limitation and constraints for the various diagnostic, therapy and interventional procedures.
• Develop national dose reference levels (DRR’s) or different imaging modalities and techniques.
• Formation of radiation protection and safety committees at the various levels of health care delivery.
• Develop a monitoring and reporting system for exposure.
• Develop protocols for diagnostic and interventional procedures to ensure quality and safety.
• To ensure appropriate infrastructure provision and human resource deployment for provision of quality radiology and imaging services.
• To ensure standard patient evaluation consistent and reliable reporting/communication of the findings through the use of standard examination protocols and report formats.
• To define scope, success rates, complication rates and thresholds for radiology, intervention, therapy and imaging as well as interventional procedures.
• To ensure continuous professional development and provision of quality radiological and imaging services through support supervision, and in-service training and certification of radiation workers.
• To ensure patient safety through regular reviews of quality assurance reports by the radiation safety and quality assurance committees at the various levels of healthcare delivery.
• To ensure that all radiation workers are licensed by their relevant health professional councils.
• Each facility using ionizing radiation should appoint and employ a radiation Safety Officer (RSO) to work on aspects of radiation protection for the facility and report all issues pertaining safety to the Atomic Energy Council.
2.4 **Standards to Improve the Quality of Diagnostic Imaging and Therapy**

- Diagnostic imaging and Therapy shall be practiced by adequately trained, certified and licensed health professionals, at the various levels of health care delivery to ensure provision quality diagnostic information.

- Appropriate equipment and accessories shall be provided for safe therapy, radiology and imaging services at various healthcare levels.

- Standard requisition, consultation and referral forms shall be developed and used by radiation workers to ensure effective communication.

- Develop and administer standard health education materials to patients receiving radiology and imaging services.

- Standard examination and interventional protocols shall be developed, and regularly updated to ensure safety and quality.

- Standard reporting formats for the various imaging modalities shall be developed regularly, updated by radiation workers.

- Standard consent forms shall be developed and administered to patients who undergo interventional invasive procedures.

- Develop a report format for notification of all complications arising from non-interventional and interventional procedures.

- Create Quality Assurance Committees at all healthcare levels to monitor, evaluate all matters related to quality of imaging and therapeutic procedures make appropriate recommendations of remedial actions.

- Develop reject forms for examinations, which are not appropriately requested.

- Ensure mandatory periodic radiation monitoring of
premises, equipment, personnel and environment.

- Ensure safety and protection of pregnant radiation workers and pregnant patients.
- Ensure safe transport of radioactive materials.
- Ensure proper management and disposal of radioactive waste and waste materials.

2.5 **The Atomic Energy Council (AEC)**
Proper implementation of standards requires that the government regulate and conduct use of any practices involving a source of radiation establish a regulatory authority. The AEC is the regulatory authority in Uganda.

The regulatory authority must be independent of licensees. There shall be separation of responsibilities so that regulators retain their independent judgment and decision as safety authorities. The Atomic Energy Council shall be responsible for:

- Policy formulation and implementation
- Advisory role
- Appointment of RPO’s and Council Committees.

2.5.1 **Functions of the AEC**
The functions of the Council are:

- To define the exposures of ionizing radiation that is excluded from the application of the Atomic Energy Law on the basis of their not being amenable to regulatory control.
- To issue licenses and grant exemptions for the possession and use of radiation sources.
- To define the detailed obligations, including financial conditions, to be imposed on persons who possess radiation sources.
- To conduct inspections to assess radiation safety conditions and compliance with the Atomic Energy Law.
and the regulations and other requirements specified in an authorization.

- To take such action as is necessary to enforce the requirements in the Atomic Energy Law and any regulation or authorization and to protect the health and safety of workers and the public.
- To ensure that corrective action is taken if unsafe or potentially unsafe conditions are detected.
- To ensure proper documentation, storage and retrieval of records relating to the safety of facilities and activities of ionizing radiation.
- To establish and inform licensees of any requirements for systematic safety reassessment or periodic safety review.
- To encourage and promote the effective use of atomic energy and nuclear technology to further the overall interests of Government.
- To co-ordinate its activities and allocate its priorities in a manner that ensures the efficient utilization of atomic energy and nuclear technology for the benefit of the general public.
- To enter into a partnership with any institution within or outside Uganda to carry out research on the development of practical application of atomic energy and nuclear technology for peaceful uses.
- To prescribe and collect fees for authorization, inspections and other related services.
- To assist in emergency responses to radiological incidents and accidents.
- To initiate, recommend, or provide support on intervention, as may be appropriate.
- To advise other government authorities and organizations on matters relating to the peaceful applications of atomic energy.
- To promote or carry out research on radiation safety issues of regulatory concern.
• To maintain contact for information exchange and co-operation with regulatory bodies of other countries and relevant international organizations.

• To establish appropriate mechanisms to inform the public about the regulatory process and the radiation safety aspects of regulated practices.

• To ensure that appropriate measures are made regarding the management of radioactive waste and the transportation of radioactive substances.

• To perform any other function that is incidental or consequential to its functions under this Act, or the Minister in writing may confer as on it.

2.5.2 Committees
The Council may appoint committees of the Council

- To inquire into and advise the Council on any matter concerning the functions of the Council as it may refer to the Committee.
- To exercise such powers or perform such functions of the Council as the Council may delegate or refer to the committee.

A committee appointed under subsection (1) shall consist of a Chairperson and other persons, whether members of the Council or not, as the Council may determine.

The Council shall in writing, specify the terms and conditions of service of the members of committee appointed under this section.

Members of a committee appointed under this section may be paid such allowances as the Council may determine.

The Council may require a committee appointed under this section to act jointly or in co-operation with any other committee.

Subject to any direction given by the Council, a committee appointed under this section may regulate its own procedure.
2.6 Radiation protection and safety (RPS) committees of the Ministry of Health

The Ministry of Health shall establish committees to oversee radiation protection and safety. The Ministry shall be mandated by the AEC regarding medical practices for compliance.

2.6.1 Functions of MOH Committee:

- The Radiation Safety and Quality Assurance Committee of the Ministry of Health shall oversee and ensure an operational quality assurance program as well as review and update standards.

2.6.2 Composition of MOH committee:

The Committee will be appointed by the Top Management of the Ministry of Health. Consist of 9 members from the following:

- Senior Consultant Radiologist/Therapist/ Nuclear Medicine as Chairperson.
- The Head of Department Quality Assurance - MOH as secretary
- Medical Physicist
- Representative of Nuclear Medicine
- Representative of Radiology
- Representative of Radiotherapy
- Representative of Private hospitals
- Representative of Regional Referral hospitals
- Representative of Biomedical Engineering.

2.6.3 National Referral Hospitals RPS committee will comprise of the following:

- Deputy Director as Chairperson
- Chief Radiation Safety Officer (CRSO) as Secretary (This can be a Medical Physicist or a at least a senior radiographer, radiologist, radiation oncologist, Nuclear
• Qualified expert (Should be a medical physicist)
• Representative of radiation workers (this can at least be senior radiographer, radiologist, radiation oncologist, Nuclear medicine physician, Imaging technologist)

2.6.4 Regional Referral Hospitals RPS committee will comprise of the following:
• Clinician / Medical Director as the Chairperson
• Radiation Safety Officer (RSO) as Secretary (This can be a Medical Physicist or (a at least radiographer, radiologist, radiation oncologist, Nuclear medicine physician, Imaging technologist with extra specialized training in radiation protection)
• Representative of radiation workers (this can at least be radiographer, radiologist, radiation oncologist, Nuclear medicine physician, Imaging technologist with extra specialized training in radiation protection)
• Qualified Expert (Medical physicist or at least radiographer, radiologist, radiation oncologist, Nuclear medicine physician, Imaging technologist with extra specialized training in radiation protection)

2.6.5 Hospital RPS Committees Will Comprise Of the Following:
• Medical Superintendent as the Chairperson
• Medical physicist or radiologist with specialized training in radiation protection as the qualified expert.
• Medical physicist or radiographer with specialized training in radiation protection as secretary and is the Radiation Safety Officer
• Nursing Officer with specialized training in radiation protection as the representative of workers.
2.6.6 Health Centre IV
- The in charge of HCIV as the chairperson
- Radiographer as the secretary.
- Nursing officer as the representative of workers.
- Any other person cleared to be on the committee.

2.7 Principal parties
2.7.1 The principal parties having the main responsibilities for the application of the Standards shall be:
- Licensees
- Employers

Licensee shall be primarily responsible for Radiation protection and safety at the workplace and should have a well documented Quality Assurance Programme relating to site selection, machine procurement and installation, acceptance testing and commissioning, machine operationalizing and quality control and plans for emergency response and decommissioning.

2.7.2 Other parties shall have subsidiary responsibilities for the application of the Standards. These parties may include, as appropriate:
- Suppliers;
- Workers;
- Radiation protection officers
- Radiation Safety Officer
- Medical practitioners;
- Health professionals;
- Qualified experts;
- Ethical Review Committees; and
- Any other party to whom a principal party has delegated specific responsibilities.
2.7.3 Responsibilities of Principal Parties

- To determine the measures and resources needed to achieve the protection and safety objectives and to ensure that the resources are provided and the measures properly implemented;
- To keep such measures and resources continually under review, and regularly to verify that the protection and safety objectives are being achieved;
- To facilitate and ensure radiation workers are monitored regularly and to update records of personal doses annually.
- To identify and failures and shortcomings in the protection and safety measures and resources, and to take steps to correct them and prevent their recurrence;
- To establish arrangements, through representatives if appropriate, for facilitating consultation and co-operation between all relevant parties with respect to protection and safety; and
- To keep appropriate records regarding the discharge of their responsibilities.

2.7.4 Licensing and Authorization of Practices

- The appropriate council will license the health practices utilizing radiation for medical purposes.
- Atomic Energy Council will license the ionizing radiation equipment and sources.
- The Atomic Energy Council shall ensure that the requirements of the Standards are consistent with existing national health care regulations.

2.7.5 Monitoring

Monitoring compliance shall be conducted by the Atomic Energy Council to determine whether sources are being used in
accordance with the regulations and any conditions of authorization. Key elements of compliance monitoring include on-site inspections, radiological safety appraisal incident notifications and periodic feedback from users about operational safety parameters. However, each facility using ionizing radiation shall employ a Radiation Safety Officer (RSO) for daily, periodic and continuous monitoring of the safety of the facility. The RSO will take charge of the Atomic Energy Council for their site visits and report on all aspects of radiation safety and security and the facility. He/she shall work closely with the principle parties to ensure compliance with the Atomic Energy Act of 2008 and the Atomic Energy regulations of 2012.

The principal parties shall permit duly authorized representatives of the Atomic Energy Council to inspect their protection and safety records and to carry out appropriate inspections of their authorized activities.

In the event of a breach of any applicable requirement of the Standards, principal parties shall, as appropriate:

- investigate the breach and its causes, circumstances and consequences; take appropriate action to remedy the circumstances that led to the breach and to prevent a recurrence of similar breaches; communicate to the Atomic Energy Council, and to the relevant Sponsoring Organizations when applicable, on the causes of the breach and on the corrective or preventive actions taken or to be taken; and take whatever other actions are necessary as required by the Standards

2.7.6 Reporting Emergency Exposures

- Failure to take corrective or preventive actions within a reasonable time in accordance with national regulations shall be grounds for modifying, suspending or withdrawing any authorization that had been granted by the Atomic Energy Council or, when applicable, by the relevant Sponsoring Organization.

- Non compliance by the principle parties shall be dealt
with by the AEC as per the Atomic Energy regulations of 2012

- Willful breach of, attempted breach of or conspiracy to breach any requirement of the Standards may be grounds for prosecution.

2.8 Responsibilities for Diagnostic and Therapeutic Radiation Exposure to Patients

2.8.1 Licensees shall ensure that:

- No patient shall be administered a diagnostic or therapeutic medical exposure unless the exposure is prescribed by an authorized medical practitioner;
- Authorized radiation workers shall be assigned the primary task and obligation of ensuring the overall patient protection and safety during the process of medical exposure;
- Medical exposures shall be administered only by a certified, registered and licensed Health professional.
- The exposure of individuals incurred knowingly while voluntarily helping (other than in their occupation) in the care, support or comfort of patients undergoing medical diagnosis or treatment be constrained and specified.
- Training relevant to radiation usage be specified or be subjected to approval by the Atomic Energy Council in consultation with relevant professional bodies.
- The medical uses of Radiation and quality assurance requirements of the Standards are fulfilled.

2.8.2 Radiation workers shall promptly inform the licensee of any deficiencies or needs regarding compliance with the Standards with respect to protection and safety of patients and shall take such actions as may be appropriate to ensure the protection and safety of patients.

2.9 Optimization of Protection for Medical Exposures

The requirements in this subsection shall be considered to be in
addition to any relevant requirements for optimization of protection specified in other parts of the standards.

2.9.1 Licensees shall:

- Take into account information provided by suppliers, identify possible equipment failures and human errors that could result in unplanned medical exposures;
- Take all reasonable measures to prevent failures and errors, including the selection of suitably qualified personnel, the establishment of adequate procedures for the calibration, quality assurance and operation of diagnostic and therapeutic equipment, and the provision to personnel of appropriate training and periodic retraining in the procedures, including protection and safety aspects;
- Take all reasonable measures to minimize the consequences of failures and errors that may occur; and
- Develop appropriate contingency plans for responding to events that may occur, display plans prominently and periodically conduct practice drills.

2.9.2 Requirements for radiation generators and equipment using sealed sources for diagnostic imaging and therapy

Licensees, in specific co-operation with suppliers, shall ensure that:

- Radiation generators and their accessories be designed and manufactured so as to facilitate the keeping of medical exposures as low as reasonably achievable consistent with obtaining adequate diagnostic information;
- Operational parameters for radiation generators, such as generating tube potential, filtration, focal spot size, source-image receptor distance, field size indication and either tube current and time or their product be clearly and accurately indicated;
- Radiographic equipment be provided with devices that
automatically terminate the irradiation after a present time, tube current-time product or dose; and

- Fluoroscopic equipment be provided with a device that energizes the X ray tube only when continuously depressed (such as a ‘dead man’s switch’) and equipped with indicators of the elapsed time and/or entrance surface dose monitors.

### 2.9.3 Requirements and Radiation Generators and Irradiation Installations for Radiotherapy

Registrants and licensees, in specific co-operation with suppliers, shall ensure that:

- Radiation generators and irradiation installations include provisions for selection, reliable indication and confirmation (when appropriate and to the extent feasible) of operational parameters such as type of radiation, indication of energy, beam modifiers (such as filters), treatment distance, field size, beam orientation and either treatment time or present dose; irradiation installations using radioactive sources be fail-safe in the sense that the source will be automatically shielded in the event of an interruption of power and will remain shielded until the beam control mechanism is reactivated from the control panel:

- High energy radiotherapy equipment.
  - Have at least two independent ‘fail to safety’ systems for terminating the irradiation.
  - Be provided with safety interlocks or other means designed to prevent the clinical use of the machine in conditions other than those selected at the control panel

- The design must have safety interlocks system

- Radioactive sources for either teletherapy or brachytherapy be manufactured, packaged, labeled and transported according to the both national and international standards.
• Monitoring equipment should be installed or be available to give warning of an unusual situation in the use of radiation generators and radionuclide therapy equipment.

• Licensees shall ensure that:
  o Exposure of normal tissue during radiotherapy be kept as low as reasonable; achievable consistent with delivering the required dose to the planning target volume, and organ shielding be used when feasible and appropriate;
  o Radiotherapeutic procedure or likely to be pregnant be avoided unless there are strong clinical indications;
  o Administration of radionuclide for therapeutic procedures to women who are pregnant or likely to be pregnant or who are nursing be avoided unless there are strong clinical indications;
  o Any therapeutic procedure for pregnant women be planned to deliver the minimum dose to any embryo or foetus; and
  o The patient should be informed of possible risks.

2.9.4 Requirements for radionuclide generators and other unsealed sources in diagnostic and therapeutic nuclear medicine

• Radionuclide generators and other unsealed sources shall be stored in well sealed areas to prevent radiation exposure to health workers and the public.

• Proper shielding of radiopharmaceutical preparations should be done during the compounding dispensing and administration.

• Area and personal radiation monitoring equipment should be provided in the premises.

Licensees shall ensure for nuclear medicine that:
The medical practitioners who prescribe or conduct diagnostic applications of radionuclides:

- Ensure proper selection of diagnostic/therapeutic procedures for individual patients
- Ensure that the exposure of patients be the minimum required to achieve the intended diagnostic objective;
- Take into account relevant information from previous examinations in order to avoid unnecessary additional examinations; and
- Take into account the relevant guidance levels for medical exposure;
- To ensure proper evaluation of patients for diagnostic and therapeutic radiation procedures to avoid unnecessary exposure to radiation to high-risk patients.

2.9.5 Calibration

Licensees shall ensure that:

- The calibration of sources used for medical exposure be traceable to a Standard dosimetry laboratory;
- Radiotherapy equipment be calibrated in terms of radiation quality or energy and either absorbed dose or absorbed dose rate at a predefined distance under specified conditions e.g. following the recommendations given in IAEA Technical Reports Series No 398 and other protocols.
- Sealed sources used for brachytherapy be calibrated in terms of activity, reference air kerma rate in air or absorbed dose rate in a specified medium, at specified distance, for a specified reference date;
- Unsealed sources for nuclear medicine procedures be calibrated in terms of activity of the radiopharmaceutical to be administered, the activity being determined and recorded at the time of administration, using a dose calibrator.
- The calibrations be carried out at the time of commissioning a unit, after an maintenance procedure that
may have an effect on the dosimetry and at intervals approved by the Atomic Energy Control Board.

2.9.6 Dose limitation for comforters and visitors of patients
The dose limits set out in this part shall not apply to comforters of patients, i.e. to individuals knowing exposed while voluntarily helping (other than in their employment or occupation) in the care, support and comfort of patients undergoing medical diagnosis or treatment, or to visitors of such patients.

However, the dose of any such comforter or visitor of patients shall be constrained so that it is unlikely that his or her dose will exceed 5 mSv during the period of a patient’s diagnostic examination or treatment. The dose to children visiting patients who have ingested or administered with radioactive materials should be similarly constrained to less than 1 mSv.
CHAPTER THREE:

3.0 MONITORING STRUCTURE FOR RADIATION PROTECTION AND CLINICAL AREAS IN DIAGNOSTIC IMAGING AND THERAPEUTICS

Radiology and imaging services is an area of specialization that requires clinical and technical skills to offer diagnosis and treatment. This can be achieved through team work and effective supervision.

Shall develop and improve the work environment in radiology departments through effective management structures, team work and supervision.

- Strengthen management and supervision in radiology and imaging
- Improve knowledge and skills of radiological workers.
- Improve the quality of services in radiology and imaging
- Effective communication to build synergy and institutional development.
- Mentoring in order to promote skills through apprenticeship.
- Facilitative supervision to improve performance in radiology and imaging.
- Interdisciplinary diversity for maximum benefit to the patient.
- Time management for efficient and effective intervention in patient care.
- Conflict resolution for good working relationships
- Stress management for maximum output by the radiation workers
- Job satisfaction for performance improvement and commitment
- Performance assessment to identify quality gaps and solutions.
Supervision and Monitoring Structure for Imaging and Therapeutic
3.1 Monitoring division

3.1.1 Functions of monitoring division

The Monitoring division shall be responsible to ensure:

- the safe use of electromagnetic radiation (ionizing, non-ionizing radiation and electro-medical devices) in health facilities for quality diagnostic and therapeutic services
- that the health providers, patients, public and environment are protected from radiation hazards.
- that diagnostic imaging and therapeutic standards are adhered to.
- the health facilities are authorized and appropriately licensed to administer radiation.
- technical support to users and distributors
- in service training of radiation workers where specific needs are identified
- investigation and compilation of reports on radiation incidents and accident.
- maintenance of hazard notification system.
- liaison and collaboration with international institutions, government, non-governmental agencies and regulatory authorities on issues of radiation protection and safety.
- regular reviews of the national standards on diagnostic imaging and therapeutics
- compilation of national safety standards and guidelines and formulate regulations.
- supply of information and advice to manufacturers, distributors, maintenance personnel, users, inspectors, the media and the general public
- safe disposal of radioactive wastes

3.2 Devices and materials to be monitored

3.2.1 Non-ionising Radiation and Electromedical Devices (NIRMED)

The Monitoring Division shall ensure the purchase, deployment and use of appropriate range of listed NIRMED products at the various levels of healthcare which are in two broad categories i.e. those producing non-ionising radiation and those classified as high and medium risk electromedical devices.
Electronic products producing non-ionising radiation in turn are divided into three categories:  
The radiofrequency and microwave region stretches from 0 Hz (static magnetic fields) to 300 GHz. This region includes power frequency (50 Hz) electromagnetic fields, low frequency heat sealers, high frequency surgical and physiotherapy equipment and microwave applications such as cellular phones, microwave ovens and radar equipment.  
The optical radiation region stretches from infrared-C with a wavelength of 1 mm to ultraviolet-C with a wavelength of 180 nm. The optical region from 400 to 700 nm is also included. The acoustical region includes only devices producing ultrasound.  

Electromedical devices are divided into two broad categories:  
High risk electromedical devices consist of 20 generic device types such as intra-aortic balloon pumps, ventilators, cardiac pacemakers and defibrillators, syringe pumps and haemodialysis units. Medium risk electromedical devices consist of a further 18 generic device types such as electrocardiographs, electroencephalographs and physiological monitors  

3.2.2 Ionizing Radiation (Electronic Products)  
Electronic products capable of emitting ionizing radiation have been freely available to the public and could be used by anybody on any premises. These regulations forbid the use of any electronic product generating X-rays or other ionizing beams, electrons, neutrons or other particle radiation, unless such equipment and premises are licensed. In terms of these regulations powers were granted to the Director-General of Health Services to perform inspections at x-ray facilities. The objective of these regulations are to ensure that the patient, the operator and general public are only exposed to ionizing radiation if such procedure is justified, optimized and the individual dose minimized.  

3.2.3 Radionuclides  
Radioactive materials which are used for medical, scientific,
agricultural, commercial and industrial purposes are controlled by strict safety regulations based on national and international guidelines. No person may engage in any activity involving radioactive material without having obtained a written authority from relevant regulatory bodies. This is done for each nuclide, the different applications, laboratories, etc. Regular on-site inspections of the premises of holders of authorities are carried out to ensure compliance with the requirements laid down by the Act and Regulations.

3.3 Team work and supervision
The imaging services shall develop and improve the work environment in radiology departments through effective team work and supervision.

Team work implies some synergy. Which literally means a team is a carefully and meaningfully selected group of individuals or people who are able to work together towards achieving a set of goals. Therefore good leadership is very important in the formation and supervision of an effective team.

3.2.1 Standards to improve the quality of Radiology services
It is important that while standards are to be developed concern must be put on the skills needed to improve the quality of radiology service and this can be achieved by looking at the following:

Communication:
Promote effective, professional and consistent standards of communication across the institution.

All staff are expected to practice and maintain high standards of communication in all aspects of the activities of the institution and adhere to the defined acceptable standards of communication.

Mentoring:
The staff should know what is expected out of them to be productive at work by explaining the job duties and standards.
Under this initiative the Government requires through the ministry to provide mentoring programs for the staff/people disengaged from education, training and awareness programs.

**Effective coaching:**
Policy should be in place to meet the staffs job expectation that focus on meeting the residents needs.

There must be strategies to communicate encouragement and rewards.
Have mechanisms of identifying performance and measure successful outcomes. E.g. support supervision

**Cultural Diversity:**
Plan strategies for accommodating new staffs from different regions who will work as a team.

Ensure exposure of staff to learning opportunities for increased global awareness e.g. knowledge and culture.

**Time Management:**
The policy should entail job expectations of the staff to see if its achievable.

Create with staff a tentative schedule for cares based on facts

**Conflict Resolution**
Conflict resolution is an important feature of both personal, and international relations. Conflict analysis, negotiation, mediation, conciliation, facilitation, arbitration and judicial settlement are aspects of collaboration towards a compromise or consensus decision.

Negotiation can be aided by good working relationships, persuasive value systems and soft power.

Develop policies that support management to uphold it.
Stress Management:
Interventions designed to reduce the impact of stressors in the workplace. Aimed at increasing an individual’s ability to cope with stressors.

Policy should identify stress mgt. strategies in radiology. For example, improving communication may reduce uncertainty.

Job Expectation:
Staff members need to understand what is expected of them or they receive conflicting messages. The problem may be that official policies, standards, and guidelines do not cover Performance appraisal or are outdated

Policy-makers and program managers need to identify desired communication behaviors in national policies and guidelines, develop standards to define their quality, and help providers and their supervisors operationalize these standards

Six factors that most influence health care staff behavior on the job
- Job expectations,
- Performance feedback,
- Knowledge and skills,
- Work environment,
- Incentives and motivation,
- Capacity.

Team work/Positive work environment/Positive Rewards
- Identify characteristics of an effective team
- Describe skills leaders can use to foster commitment and collaboration
- Develop guidelines to treating staff with respect and helping staff learn from each other

Goal Setting/Performance Reviews
- Develop guidelines to set specific goals with staff and
help them plan to meet these goals

- Develop policy that encourages staff to seek education goals through career ladders
- Develop guidelines for effective observation and feedback toward goal achievement (by staff)

**Constructive Criticism/Consequences**

- Establish clear standards of behavior, and that recognizes and reward staff when they meet the standards
- List ways to approach staff whose performance is a concern (with a win-win frame of mind)
- Describe how learning empathetic communication will help front line leaders handle conflict/constructive communication and help plan for solutions
CHAPTER FOUR

4.0 HUMAN RESOURCE QUALIFICATIONS AND RESPONSIBILITIES OF RADIATION WORKERS

4.1 Medical Officer and Medical Specialist

Qualification:
- Medical degree (MBCHB)
- Additional training and certification for specialized areas like Surgery, Medicine, Paediatrics, Obstetrics and Gynaecology.
- Registered and licensed by the Uganda Medical and Dental Practitioners Council
- Shall be a practicing Clinician.

Duties and Responsibilities:
- Request for radiological examination and procedures
- Pattern recognition of images of plain radiographs and ultrasound.

4.2 Radiologist

Qualification:
- Medical degree (MBCHB) and Master of medicine (Radiodiagnosis).
- Additional training and certification in intervention procedures such as cardiovascicular system, nuclear medicine, and Magnetic Resonance Imaging (MRI).
- Registered and licensed by the Uganda Medical and Dental Practitioners Council
- Shall be a practicing Radiologist.

Duties and Responsibilities:
- Justification of radiological examination and interventional procedures
- Patient care
- Perform and interpret fluoroscopic studies, Ultrasonography (US) Computed Tomography (CT), MRI and Radionuclide imaging
- Carry out intervention procedures.
- Provide treatment or management using ultrasound, fluoroscopic and CT guidance
- Conduct managerial and administrative duties.
- Participate in education, training and research programmes
- Interpret radiological examinations and provide diagnostic therapeutic report
- Participate in quality assurance tests of equipment

4.3 Sonologist

Qualifications:
- Medical degree (MBCHB) and a Masters of science degree in ultrasound
- Additional training and certification for specialized areas like vascular, echocardiography and interventional ultrasound.
- Registered and licensed by the Uganda Medical and Dental Practitioners Council
- Shall be a practicing Sonologist.

Duties and Responsibilities:
- Justification of ultrasound examination and interventional procedures
- Patient care
- Perform, interpret, and provide diagnostic reports for general ultrasound, Vascular, Small parts and Interventional procedures.
- Provide treatment or management using ultrasound guidance
- Conduct managerial and administrative duties.
- Participate in education and training programmes
4.4 Medical imaging technologist /Radiotherapy Technologist

Qualification:
- Bachelors’ Degree in Medical Imaging/Therapy Science:
- Registered and licensed by the Allied Health Professional Council.
- Additional training and certification for specialized areas like vascular ultrasound and echocardiography, CT, MRI and Radionuclide imaging (RNI).

Duties and responsibilities:
- Prepare and use technology according to requests
- Optimization of Radiation dose
- Patient care
- Perform Radiography, Ultrasound, Fluoroscopy, RNI, CT, MRI and Radiotherapy.
- Provide quality diagnostic images and archive
- Participate in quality assurance tests on the equipment
- Participate in education and training programmes
- Pattern recognition and provide report on the findings to the referring clinician
- Assist physicians or radiologists during performance of interventional procedures.
- Perform managerial and administrative duties.
- To supervise all the subordinates under his/her unit
- To adhere to professional code of conduct and ethics

4.5 Radiographer

Qualification:
- Diploma in Medical Radiography
- Registered and licensed by Allied Health Professional Council.
Duties and responsibilities:
- Counseling of therapeutic or diagnostic patients
- Preparation of patients for radiographic investigation and treatment
- Ensuring that patients are protected from radiation and radioactive materials
- Managing and accounting for allocated resources
- Ensuring that processed films conform to set standards
- Ensuring that equipment is secure, functional and well maintained
- Requisitioning for equipment and necessary supplies for radiographic activities.
- Carrying out radiographic imaging
- Participating in research activities
- Adhering to professional code of conduct and ethics
- Compiling and submitting reports

Key outputs:
- Patients for radiographic imaging prepared
- Radiographic imaging carried out and formatted report submitted to Clinician
- Quality if radiographic imaging ensured
- Protection against radiation and radioactive materials ensured
- Patients needing specialized imaging referred
- Accountability for financial and other resource produced
- Periodic reports submitted.

4.6 Sonographer

Qualification:
- Shall have one of the following:
  - A Bachelors’ degree in diagnostic ultrasound
  - A diploma in diagnostic ultrasound in addition to a
basic training in health fields such as Medicine, Radiography, Nursing and Midwifery and Clinical officer

- Registered and licensed by the relevant professional council.
- Additional training and certification for specialized areas like vascular, echocardiographer and interventional ultrasound.

**Duties and responsibilities:**
- Perform ultrasound examination
- Patient care
- Perform general ultrasound investigations.
- Provide quality diagnostic images
- Provide a formatted report on the findings to the referring clinician
- Assist physicians or radiologists during performance of interventional procedures.
- Perform managerial and administrative duties.
- Participate in education and training programmes

### 4.7 Medical physicist

**Qualifications:**
- BSc. Physics plus Clinical training in Medical Physics of at least one year in an accredited institution.
- Or a Masters of Science (or a higher degree) in Medical Physics
- Registered and licensed by the relevant body

**Duties and Responsibilities:**
- Equipment specification, acceptance testing and commissioning
- Perform QA tests
- Ensure Radiation Safety at the workplace
- Ensure Optimization of equipment performances and
good maintenance
• Participate in education and training programmes
• Participate in treatment planning
• Participate in training and research
• Perform dosimetry on the equipment

4.8 Biomedical engineer
Minimum Qualifications:
• Degree in electrical or electronic engineering or Biomedical engineering

Duties and Responsibilities:
• Regular preventive maintenance of equipment
• Carry out Machine and equipment repair
• Carry out Quality Assurance tests
• Supervision of Maintenance Technicians
• Planning and budgeting for the maintenance unit
• Preparation of specifications for equipment and accessories
• Advise on procurement of equipment
• Ensure safety of equipment
• Prepare periodic reports on the status of the equipments

4.9 Biomedical maintenance technician
Minimum Qualifications:
• Diploma in electrical or electronic engineering or Biomedical engineering
• Additional training in medical equipment maintenance

Duties and Responsibilities:
• Regular preventive maintenance of equipment
• Carry out repairs on equipment
• Participate in installation and commissioning of new equipment
• Participate in Quality Assurance tests.
• Train/instruct users in equipment applications, care and maintenance
• Repair equipment and maintain the log book
• Participate in departmental/institutional planning and meetings and volunteer advice as and when required.
• Keep good custody any tools, software, spare parts etc. placed under his care.

4.10 Radiation oncologist
A clinician involved in the management of patients with cancer (and benign conditions occasionally) using ionizing radiation alone, or combined with other modalities.

Qualifications:
• Medical Degree (MBCHB)
• Postgraduate degree or diploma in radiotherapy, radiation oncology or clinical oncology.
• Registered by the Uganda Medical and Practitioners Council

Duties and responsibilities:
• Treatment of cancer patients using radiation
• Investigation of the biological and physical basis of radiation therapy
• Training of professionals in the field of radiation oncology
• Provide leadership in the field of radiation oncology
• To carry out research in Radiation Oncology

4.11 Radiotherapy / oncology nurse
A nurse specialized in nursing care of cancer patients.

Qualifications:
A registered nurse with Diploma or certificate in oncology nursing

Duties and Responsibilities:
• Receive patients referred to oncology units
• Counsel patients and explain effects of treatment modalities
- Manage simple adverse effects of treatment
- Administer drugs including cytotoxic chemotherapy
- Assist the clinician in management of the patients.

### 4.12 Mould room technician

**Minimum qualifications:**
- Diploma in Therapy Radiography
- Additional training in mould room techniques

**Duties and Responsibilities:**
- Make moulds for patients
- Take care of equipment and accessories
- Explain mould room procedures to patients
- Participate in patient simulation, positioning and irradiation

### 4.13 Darkroom attendant

A locally trained on job radiological personnel who handles film processing and other darkroom techniques.

**Qualifications:**
- A minimum of ordinary level certificate with passes in science subjects including biology.

**Duties:**
- Process radiographs (x-ray films)
- Ensure safety of radiation sensitive materials in the darkroom
- Prepare x-ray processing chemicals
- Ensure cleanliness of darkroom equipment and its accessories
- Ensure cleanliness of the darkroom
- Participate in training students in darkroom techniques
- Perform any other duty assigned to him/her by the
Standards on diagnostic imaging and therapeutic radiology for Uganda

4.14 **Image management specialist**
A specialist in managing radiological images from the modalities for use in teleradiology, on permanent or consultation bases.

**Qualification:**
- Bachelors Degree in Computer Science, Information Technology or Health related Sciences.
- Masters in information technology or health informatics

**Duties:**
- Perform administrative configurations
- Provide for problem solving and trouble shooting
- Initiate repairs and coordinate system wide maintenance programs
- Ensure sustainable high quality of system function
- Advise on appropriate technology
- Participate in planning and procurement of ICT equipment
- Participate in research and training programmes
- Supervise the IT staff

4.15 **Computer / Electronic Assistant**
Be manning the digital archiving system of the radiology information system and other related image management.

**Qualification:**
- Diploma in computer science

**Duties:**
- Manage the archive server
- Perform the system configurations
- Ensure authentication of the users and information confidentiality
- Store archive, retrieve and disseminate operation and application softwares
• Provide and submit reports

4.16 Radiation protection/safety officer

Qualification:
• Degree in Imaging or Medical physics.
• Registered with the Allied Health Professional Council

Duties:
• Managing the radiation safety programs
• Ensure compliance with regulations
• Carry out assessment of new equipment or practices involving radiation.
• Investigate and report to the Radiation Safety Committee
• Quality Assurance Management Programs.
• Ensure radiation protection workers are protected and monitored.

4.17 Radiopharmacist

Qualification
• Degree in radiopharmacy
• Registered with a relevant professional council

Duties and responsibilities
• Prepare radiopharmaceutical
CHAPTER FIVE

5.0 FACILITY DESIGN IN DIAGNOSTIC IMAGING AND RADIOTHERAPY

5.1 Requirements for administering Radiation

- The standard gives guidance to registrants and licensees and employers in the provision of suitable and adequate facilities, the nature and extent of which are commensurate with the expected magnitude and likelihood of the occupational exposure.

- No practice shall be adopted, introduced, conducted, discontinued sited, located, commissioned, operated, except in accordance with the appropriate requirements of the standards.

- The legal person responsible for any sealed source, unsealed source or radiation generator shall apply to the AEC for authorization, which could be either a registration or a license.

- Registrants and licensees shall notify the AEC of their intention to introduce modifications to any practice for which they are authorized, whenever such modifications could have significant implication for protection and safety and shall not carry out any such modification unless specifically authorized by the AERB.

- Employers, registrants and licensees shall ensure, for all workers engaged in activities that involve or could involve occupational exposure, that suitable and adequate facilities, equipment and services for protection and safety be provided, the nature and extent of which are commensurate with the expected magnitude and likelihood of occupational exposure.
5.2 Classification of areas

Registrants and licensees shall:
- Delineate controlled areas by physical means.
- Display warning symbols, such as that recommended by the International Organization for Standardization (ISO) and appropriate instructions at access points and appropriate locations within the controlled areas.
- Delineate the supervised areas by appropriate means.
- Display approved signs at appropriate access points to supervised areas.
- Periodically review the conditions to determine any need for protective measures and safety provisions or change to the boundaries of supervised areas.

Sources of external irradiation
Registrants and licensees shall ensure that, if a source of external irradiation can cause exposure to the public:
- Prior to commissioning, the floor plans and equipment arrangement for all new installations and all significant modifications to existing installations utilizing such sources of external irradiation be subject to review and approval by the AEC;
- Specific dose constraints for the operation of such a source be established to the satisfaction of the AEC.
- Shielding and other protective measures that are optimized in accordance with the requirements of the standards be provided as appropriate for restricting public exposure to the satisfaction of the AEC.

5.3 Dose Limits

Occupational Exposure: Dose limits
The occupational exposure of any worker shall be controlled that the following limits be not exceeded:
- effective dose of 20 mSv per year averaged over five consecutive years
• effective dose of 50 mSv in any single year
• equivalent dose to the lens of the eye of 150 mSv in a year; and
• equivalent dose to the extremities (hands and feet) or the skin of 500 mSv in a year.

For apprentices and students of 16 to 18 years the occupational exposure shall be controlled so that the following limits are not exceeded:
• effective dose of 6 mSv a year
• equivalent dose to the lens of the eye of 50 mSv in a year; and
• equivalent dose to the extremities or the skin of 150 mSv a year

Public Exposure: Dose limits
The estimated average doses to the relevant critical groups of members of the public that are attributable to practices shall not exceed the following limits:
• an effective dose of 1 mSv per year;
• in special circumstances, an effective dose of up to 5 mSv in a single year.

5.4 X-ray Room Design
Design of x-ray rooms shall
• Be such that persons in the room or in close proximity are protected to minimize exposure to ionizing radiation either from the primary beam or secondary (scatter) off the patient or the x-ray table.
• Outer walls shall be of materials that absorb radiation.
• In case of backed solid clay bricks, thickness not less than 230mm shall be required.
• In the case of mortar/concrete (density 2.35g/cubic cm) wall thickness shall be no less than 150mm.
• For hollow brick walls shall be covered with Barium
plaster of at least 6mm thick. Such walls shall be protected up to 2.2m from the floor level.

- Include thick enough barriers to offer protection to the radiation workers in the x-ray room and keep the workers’ dose within the accepted dose limit.
- Have protective barrier allowing enough space to accommodate staff while making an exposure.
- Location of the cubicle in the room shall be such that radiation, direct or scatter reaching the radiographer is kept to an absolute minimum.
- The cubical shall have at least one protective lead glass window.
- Height of the cubicle shall be at least 2m
- Bear Warning signs understood by both literate and illiterate persons displayed at entrances of the x-ray rooms.
- Have installed radiation-warning lights, which automatically light when x-rays are being produced (interlocked with the exposure switch) for the general-purpose x-ray room is not smaller than 16 square meters. Where an existing room size cannot be altered other protection measures become the more important.
- Have windows at least 2m above the floor level. In case of x-ray rooms above ground level, windows could be at normal height provided there is no link to corridors.
- Have doors located relative to the x-ray tube with no obvious risk of exposure to passers-by. As much as possible the door shall be a sliding door.
- Have doors that overlap each side of the opening by at least 100mm. Doors shall be lead lined with lead sheet of 2mm thickness.
Diagnostic X-ray Facility and Occupancy factors

Premises
However small an X-ray department is, it will need at least **three separate rooms** as shown in the layout in figure 5.1.
- X-ray room (including generator control area)
- Darkroom (this can be eliminated in case of digital radiography).
- Office/ viewing room

This can be applied on all imaging modalities using ionising radiation with small modifications with guidance from the AEC and the facility radiation safety officer to cater for; plain radiography, mammography, CT, and Fluoroscopy;
Figure 5.1: Example of layout of an X-ray facility with one imaging room showing room design and safety aspects that must be considered when designing an X-ray room. Some modifications can be made to suit other diagnostic imaging modalities and bigger facilities:

- **A**- Chest stand
- **B**- Patient examination table/ couch
- **C**- Air conditioner (AC)
- **D**- Hungers for lead aprons
- **E**- Lead glass viewing window (0.4 m × 0.4 m should be fixed in the control room)
F- Control room (should be constructed. using pure clay bricks of at least 25 cm to a height of 2.2 m from the floor). The control room should be close to the entrance door to control accidental exposure and limit illegal entry into the room.

G1- X-ray entrance hard wooden overlapping door with a one way lock and aligned with at least 2 mm of lead sheets.

H- X-ray machine

I- Well shielded patient changing cubical

G2- Through a corridor, entrance to the darkroom with a maze

G3- Entrance to reporting room/office

W- Window to reporting room/office

R- Reception adjacent to the reporting room

CO- Usable supervised corridor

The total net floor space of a one-imaging room department should be 40-50 m²

In addition to the three rooms, an X-ray department should have: toilets (these should be large enough to permit patient assistance), waiting area, dressing cubicles and extra storage pace. However, depending on the resources of the principle party, some of these functions may be shared with other departments.

Note, fluoroscopy should have an independent toilet attached and accessed from the imaging room

Examination room
An ideal X-ray room should have a room size between 18-24 m², including the control room area. For patients on beds, a parking space of 3 m² must be added.

The ceiling height of at least 2.5 m to permit machine movements.

The walls should be constructed of materials easily obtained locally. Concrete blocks or solid baked bricks are adequate for radiation shielding. Wall thickness of at least 24 cm to the
secondary barriers is adequate. Walls to the primary barriers should be reinforced to at least 25 cm.

Windows are acceptable only if positioned so that no body outside can be exposed to radiation (or look into the room, height to at least 2.0 m above the floor is acceptable.

The floor should be level and strong enough to support the X-ray tube stand, which weigh as much as 300 kg.

The examination room must be well ventilated, especially in hot climates. The use of an air conditioner mounted at least 1.2 m from the floor is adequate.

**Control area or control room**
Required area should be at least 5 m² may be located inside the X-ray room behind a lead screen with a lead-glass window (0.4 m × 0.4 m), or in a separate control room with a larger window (0.6m × 0.6 m) in a brick or concrete wall like in Computed tomography.

**Darkroom**
A darkroom for manual processing in a temperate climate may at least 6 m² with a minimum volume of 15 m³, unless it is permanently manned. A permanently manned darkroom must be at least 10 m². A ceiling height of 3 m is recommended and a total room volume of at least 25 m³.

**5.5 Protection of the Radiation Workers**
- The Licensee shall promote safe and cost effective radiation protection for the radiation workers.
- The Licensee shall design radiological facilities that provide maximum protection to the radiation worker.
- The Licensee shall ensure compliance to safety specifications of radiological equipment.
- The Licensee shall ensure that radiation workers adhere to set safety standards of practice.
- The Licensee shall develop and promote a safety culture.
in radiation protection
• The Licenser shall enforce compliance to safety standards by the licensee.
• The Licenser shall continuously update radiation workers on radiation protection and safety measures.
• The Licenser shall enforce radiation dose monitoring of all radiation workers and workplace by the licensee.
• Medical physicists following national laws and regulations shall calculate the safety of the rooms.
• For rooms above the ground, the floors shall comprise of solid concrete slab not less than 150 mm thick (2.35 g /cubic cm). If floors above are occupied, the ceiling slab is mandatory.

Occupancy Factor for Diagnostic X-Ray Facility

<table>
<thead>
<tr>
<th>Area</th>
<th>Occupancy factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control room</td>
<td>1</td>
</tr>
<tr>
<td>Waiting area</td>
<td>0.061</td>
</tr>
<tr>
<td>Toilet</td>
<td>0.25</td>
</tr>
<tr>
<td>Office space</td>
<td>1</td>
</tr>
</tbody>
</table>

5.6 Radiotherapy and Nuclear Medicine

Obligations
• No practice shall be adopted, introduced, conducted, discontinued sited, located, commissioned, operated, except in accordance with the appropriate requirements of the standard.
• Any person intending to carry out any of the actions specified in 1.1 shall submit a notification to the Regulatory Authority of such an intention.

Authorization: registration or licensing:
• The legal person responsible for any sealed source, unsealed source or radiation generator shall apply to the Regulatory Authority for an authorization, which could be either a registration or a license.
• Registrants and licensees shall notify the regulatory Authority of their intention to introduce modifications to any practice for which they are authorized, whenever such modifications could have significant implication for protection and safety and shall not carry out any such modification unless specifically authorized by the Regulatory Authority.

Responsibilities
• Employers, registrants and licensees shall ensure, for all workers engaged in activities that involve or could involved occupational exposure, that suitable and adequate facilities, equipment and services for protection and safety be provided, the nature and extent of which are commensurate with the expected magnitude and likelihood of occupational exposure.

5.7 Radiotherapy Room Design
• Persons in the room or in a close proximity shall be protected to minimize exposure to ionizing radiation either from the primary beam or secondary (scatter) off the patient. Outer walls shall be of materials that absorb radiation.
• In the case of mortar/concrete) density 2.35g/cubit cm) wall thickness shall be calculated by the physicist.
• Include thick enough barriers to offer protection to the radiation workers in the control room and keep the workers’ dose within the accepted dose limit.
• The control room shall have a CTV to monitor the patient in the treatment room.
• Bear Warning signed understood by both literate and illiterate persons displayed at entrances of the rooms
• Have installed radiation lights which automatically light when the beam is on (interlocked with the exposure switch)
• The radiotherapy treatment room shall have no windows
• Have lead lined doors with door interlock
• In choice of location of source, account shall be taken of:
  o factors that could affect, the safety of the source
  o factors that could affect the occupational exposure and public exposure including existing features such as ventilation, wall shielding and distance from occupied areas.
  o Feasibility of engineering design to take account the foregoing factors

• Nuclear medicine department shall have a dedicated toilet waste disposal. And a protected peat for solid waste disposal.

**Important Remark**
The safety of the rooms must be calculated by medical physicists following national laws and regulations.

For rooms above the ground, the floors shall comprise of solid concrete slab not less than 1500 mm thick (2.35 g/cubic cm). If floors above are occupied, the ceiling slab is mandatory.
Figure 5.2: Typical lay out of a Radiotherapy Bunker for Cobalt
(adapted from IAEA)
CHAPTER SIX

6.0 EQUIPMENT, ACCESSORIES AND CONSUMABLES
Provide high quality specifications in diagnostic imaging and therapeutic equipment for improved health management of patients. The objectives are

- To establish standard specifications of equipment to be used in Diagnostic Radiology, Radiotherapy and Nuclear Medicine Departments.
- To develop specifications for accessories to be used with imaging and radiotherapy equipments.
- To establish specifications of consumables to be used in imaging and treatment process.

6.1 Diagnostic X-Ray Equipment

Generator

- 30 kVA and above.
- Microprocessor controlled high frequency generator.
- Selectable work stations (at least 5)
- Exposure time range 1millisec to 6sec.
- Automatic exposure control (optional).
- Power supply - 240 Vac 50 Hz Single phase.
- 415 Vac 50Hz Three phase.

X – ray tube (Rotating anode )

- Anode rotation speed not less than 2800 rpm
- Total tube filtration not less than 2.5mmAl.
- Tube leakage not to exceed 1mSv/hr at 1 metre.
- Kilo voltage range - 40kVp up to 150kVp.
- Milliampere range - up to 800/1000mA.

Patient table

- A hard scratch resistant radiolucent floating table top with a moving bucky system
- Dimensions minimum 220 cm x 60 cm
- Height not less than 90 cm
- Transverse movement ±25 cm or more
• Longitudinal movement ±80 cm or more
• Electromagnetic locking system

Vertical Bucky
• For taking radiographs with patients in erect position
• Catapult type of cassette tray capable of taking up to 43 x 35 cm cassettes in both directions.
• Vertical movement of centre 50 cm to 130 cm
• Angulations -30° to 0° to 90°

6.2 Light Duty Mobile /Portable X-ray systems.
For carrying out bedside radiography on wards and theatres
• 3 kVA to 30 kVA.
• Microprocessor controlled high frequency generator.
• Single or dual foci stationary or rotating anode tube.
• Tube leakage not to exceed 1 msv/hr at 1 metre.
• Total tube filtration not less than 2.5 mm Al
• Kilo voltage range 40kVp up to 125 kVp
• Millliampere range up to 300mA.
• Exposure time range 0.02 sec - 6 secs.
• Power supply - 240Vac 50 Hz Single phase.
• Operator & Service manuals in English.

6.3 Accessories:
• Compression band.
• Head clamps.
• Lateral Cassette holder.
• Hand grips
• Foot stand (fluoroscopy or tilting tables)
• Lightweight plastic cassettes with window for printing patient identification particulars.
• Cassettes should be mounted with intensifying screens of speed not less than 200
• X-ray Cassettes with fast intensifying screens (speed 200-400) may be metallic or plastic (window optional) (cassettes with grid are also available). (Green sensitive intensifying screens are recommended)
• Format sizes & speed
  43 x 35cm, speed 200 - 400
  35 x 35cm, speed 200 - 400
  30 x 40cm, speed 200 - 400
  24 x 30cm, speed 200 - 400
  18 x 24cm, speed 200 - 400
  18 x 43cm, speed 200 - 400

• Hysterosalpingography set
  o Protective wear
    - lead goggles
    - thyroid shield
    - lead apron
  o Test phantom set for ultrasound, radiography, fluoroscopy, mammography, CT, MRI and SPECT in quality control testing for resolution and dose calibration.
  o Video printer
  o CD /DVDs
  o Digital camera
  o Video VHS cassettes
  o Ultra sound Printer (B & W / Colour)

6.4 Consumables
  o X-ray films (fast type) - blue or green sensitive of appropriate sizes up to 43 x 35cm.
  o Processing Chemicals - Suitable chemicals as recommended by manufacturer (either liquid concentrate or powder).
  o Contrast Media (water soluble non ionic, and insoluble)
  o Angiographic catheters
  o Foleys’ catheters
  o Drainage catheters
  o Guide wires
  o Drainage sets

• Enema giving sets
  o Biopsy kits
  o Lumbar puncture needles
6.5 Other major necessities and essentials

Manual processing unit
- Developer tank 10-25 L capacity (plastic or stainless steel).
- Fixer tank same as above
- Water jacket to maintain the temperature of the chemicals
- Wash tank plastic 40 - 60 L or more capacity.
- Stainless steel film hangers of appropriate sizes

Film dryer which could be
- A wooden rack ,
- An electric wall mounted hot air blower.
- An electric drying cabinet type or
- Roller type film dryer.

Auto film processor (medium)
- A Light duty film processor comprising of:
- A processor
- A Water filter
- 2 Replenisher tanks not more than 25 litres each
- Film size: Sheet film 10x10cm to 35x43cm
- Variable processing capacity (35x43cm film)
- More than 50 sheets/hour
- 90sec process: more than 15sheets/hour
- Power supply: 240V AC 50 Hz single phase with Auto Voltage Regulator (AVR) & Auto Voltage Switcher 13A
- Operator & Service manuals in English
**Auto film processor (large)**

A heavy duty film processor comprising of:

- Processor
- Water filter
- 2 Replenisher tanks not more than 25 litres each
- Film size: Sheet film 10x10cm to 35x43cm
- Variable processing capacity (35x43cm film)
- 60sec process: more than 200 sheets/hour
- 90sec process: more than 150 sheets/hour
- 120sec process: more than 100 sheets/hour
- Power supply: 240V AC 50 Hz single phase with Auto Voltage Regulator (AVR) & Auto Voltage Switcher 13A
- Operator & Service manuals in English.

**Laser imager**

- Large format “dry” laser imager for gray scale imaging.
- Dry printer to be used with 35x43 cm films.
- The printer should be able to take up interface, which can be video or digital.
- Pixel size approx: 100 microns
- Gray scale: more than 12 bits
- Input channels: 3 without external multiformat.
- Daylight film loading essential
- Acoustic noise less than 50 dB at 1m distance
- Density adjustment automatic on line densitometer for image quality
- Accessory: Extra Film Magazine
- Operator & Service manuals (in English).

**Film viewer**

- Film viewer wall mounted or table mounted
- Viewing area: 172 cm x 70cm
- Daylight fluorescent tubes with dimmer switch
- Acryl glass front panel
- Film retaining bar in stainless steel metal housing
- Power supply: 240V AC 50Hz single phase
Automatic film viewer
- Film viewing system to allow for rapid changeup of screens with mounted radiographs for viewing and teaching purposes.
- Must be able to take, 2 rows of 4 films of size 35x43cm in a row.
- More than 20 films holders motorized and exchangeable.
- Must be possible to switch off viewing lights selectively.
- Power supply: 240V 50Hz single phase with Auto Voltage Switcher (AVS) 13A.
- Operator & Service manuals in English.

Lead sliding door (top rail sliding type)
- Size: W 200cm x H 210cm
- Lead thickness not less than 2mm sandwiched in appropriate material
- Top-rail sliding type

Radiation protection shield
- 2 Foldable flaps hinged on a middle one with 6 or more casters
- Size:2( W60cm x H200cm) + W80cm x W60cm x H200cm
- Lead thickness: not less than 2 mm
- Lead window size: not less than W50cm x H40cm
- Lead window position: window centre is approx 155 cm from floor in middle shield.

Lead aprons of lead equivalent not less than 0.25mmPb
- Large size with a hanger
- Medium size with a hanger
- Small size with a hanger
- Thyroid shield

Lead gloves of lead equivalent not less than 0.25mmPb
- Large size
- Medium size
Lead gonad shield of lead equivalent not less than 0.25mmPb
- Large size (Adult)
- Medium size (Child)
- Small size (Infant)

Anti-scatter grids (stationary or moving type)
Parallel & Focused secondary radiation anti-scatter grids of:-
- Grid ratio 12:1,
- Grid lattice 36/40 lines per cm.
- Grid focus 100-110cm.
- Sizes 43x35 cm, 24x30cm and 18 x 24cm.

Patient ID printer (camera)

a) For window cassettes
- Daylight camera for automatic exposure of patient data onto the X-ray film with ID cards. (Automatically prints month, day, year and time in addition)
- Power supply: 240V 50Hz single phase
- Operator & service manuals in English

b) For non window cassettes
- Actinic Marker (Manually operated) Photographs patient data on to the film
- Window (10x150x15x50)mm
- 240Vac, 50Hz Single phase supply.

Anatomical markers
L and R (including any relevant lead letters and numbers) an opaque marker to indicate the side of the patient.

Safelight (direct or indirect type)
- 240Vac 50Hz, 15 w – 25 lamps with appropriate filter for blue sensitive or green sensitive films.
Contrast medium injector
This Medium Injector is designed to inject a radiopaque contrast medium into the vascular system for angiography procedures.
- X-ray generator synchronization:
- Flow rate: 0.1 to 30ml or more
- Volume: 0.1 to 150ml or more
- Pressure: Automatic stop to limit injection
- Power: 240V AC 50Hz single phase with Auto Voltage Switcher (AVS)
- Operator & Service manuals in English

6.6 Ultrasound Specifications

Ultrasound grey scale (small)
Compact ultrasound system with for obstetrics, Gynecology, Urology, general abdominal.
- Linear/Convex probes
  B-mode, B/M-mode and M-mode display
- 7 inch or monitor more with non-reflection screen
- Full-function keyboard, user definable text lines, 18 body makers, TGC controls and trackball
- Extensive pre-defined as well as programmable fetal age tables
- Electronics caliper with 2 measurements per image for distance, length, area/circumference, angle and volume.
- On screen annotation
- Transducers
  - Convex probe 2.0 – 7.0MHz (Broadband)
  - Linear probe 7.0 – 13.0MHz (Broadband)

Ultrasound grey scale (large)
Heavy-duty ultrasound system with 3 probe ports for Obstetrics, Gynecology, Urology, Cardiology, general abdominal and specialized applications.
- B-mode, B/M-mode and M-mode display
- More than 10 inch monitor with non-reflection
- Full-function keyboard, user definable text lines, body markers, TGC controls and trackball
- Extensive pre-defined as well as fetal age tables
- Electronic calipers with 4 or more measurements per image for distance, length, area / circumference, angle and volume.
- On screen annotation
- Transducer (Broad band)
  - Curvilinear 2.0 - 7.0MHz
  - Linear 7.0 – 13.0 MHz
  - Endo vaginal convex probe 5.0 – 10.0MHz
- Biopsy guide attachment to fit on appropriate transducer
- Image output to video
- Printer for recording B/W ultrasound images on thermal paper
- Operator & service manuals in English.
- AVR & AVS (13A) 240V ac
- Power 240V ac 50Hz

**Ultrasound color Doppler (medium)**

With Color Doppler System:
Multipurpose system with linear /convex/sector (curvi-linear) probes for Obstetrics, Gynecology urology, General abdominal and specialized applications including colour Doppler, vascular and echocardiography

- High definition imaging
- Broadband scan head
- 2D B-mode, M-mode, 2D Colour, 3D imaging
- Pulsed wave Doppler, continuous wave Doppler.
- Colour power angio
- Selectable 2D grey and colour maps
- Steered linear capability
- Triple mode simultaneity
- Dual imaging black and white/colour
• Scrolling history review
• Auto Doppler trace
• Dicom 3.0 compatible
• ECG capability
• Pan/zoom
• Foot switch
• Tissue Harmonic imaging capability
• Obstetric software analysis
• Vascular software analysis
• Cardiac software analysis
• Infant hip software analysis
• Body makers
• User defined presets
• Patient information management software
• Dicom 3.0 compatible
• Transducers
  o Convex probe 2.0 – 7.0 MHz broad band
  o Linear probe 7.0 -13.0 MHz broad band (High resolution)
  o Phased array sector probe 2.1-3.8 MHZ broad band
  o Endocavitary probe convex 5.0 – 10.0 MHz broad band
• Single 15” High resolution non interlaced monitor
• Operator & Service manuals in English.
• Colour printer
• Black and white thermal printer
• Videocassette recorder S-VHS multi-system
• UPS 2200VA 240V AC
• Power 240V AC 50Hz
• CD/ DVD drive (24xspeed)
• CD (Empty)
**Ultrasound color Doppler (heavy duty)**

A multipurpose Color Doppler system with linear and curvilinear broadband probes for Obstetrics, Gynecology, Urology, General abdominal and specialized applications including color Doppler vascular studies should also perform 3D/4D imaging studies

- High definition imaging
- Broadband digital beam former
- Broadband digital scan head
- 2D B-mode, 2D color, M-mode
- Pulsed wave Doppler, instant 3D/4D imaging, continuous wave Doppler.
- Colour power angio
- Selectable 2D grey and colour maps
- Cineloop imaging review
- Steered linear capability
- Triple mode simultaneity
- Dual imaging black and white/colour
- Tissue harmonic image capability
- Real time compound imaging capability
- Scrolling history review
- Auto Doppler trace
- ECG capability
- Pan/zoom
- Foot switch
- Obstetric software analysis
- Vascular software analysis
- Cardiac software analysis
- Infant hip software analysis
- Body markers
- Help function
- User defined equation and table
- User defined preset
• Patient information management software
• Dicom 3.0 compatible
• Intelligent ultrasound with voice activated settings
• **Transducers**
  o Curvilinear probe 2.0 – 7.0 MHz broad band
  o Linear probe 7.0 -13.0 MHz broad band (High resolution)
  o Phased array sector probe 2.1- 3.8 MHZ broad band
  o Endo-cavitary probe convex 5.0 – 10.0 MHz broad band
  o Biopsy Guide attachment to fit appropriate transducer.
  o Hockey Stick’ Linear probe with 7.5 -10.0 MHz with small foot point 1.5cm foot print.
  o Endoluminal transducer for endoscopic ultrasound
• Single 15” High resolution non interlaced monitor
• Operator & Service manuals in English.
• Color printer
• Black and white thermal printer
• Videocassette recorder S-VHS multi system
• UPS 2200VA 240V ac with Auto Voltage Switcher (AVS) 13A
• Power 240V ac 50Hz
• CD/DVD writer

### 6.7 Specifications for Mammography Equipment
Heavy duty compact dedicated equipment for breast imaging procedures.

**Generator:**
• Microprocessor controlled high frequency generator
• Kilo voltage range 22kVp to 49kVp
• mAs range 4mAs to 800 mAs
• Line power supply 208V - 250 Vac 50 Hz single phase
• Power rating 3 kVA to 15 kVA
X- Ray Tube:
- Rotating anode with dual foci (0.1 /0.3mm)
- Target material of Molybdenum Compound with Graphite or better
- Heat capacity 200kJ and above
- X-ray emission window of Beryllium
- Beam filters of Molybdenum and Aluminum

Collimator Cones:
- With inbuilt field light for conventional technique
- Motorised adjustable lead leaves or fixed cones of appropriate sizes (18 x 24cm or 24 x 30cm)

Film - object - table:
- Made of cast aluminum plate with stainless steel surface and an inbuilt Amplimat measuring chamber
- Automatic Exposure Control with density range -3 to +3
- Film - screen selection by pushbuttons
- Interchangeable cassette tray with carbon - fibre surface to accommodate 18 x 24 cm cassettes and 24 x 30 cm
- Magnifying table with carbon-fibre surface 16 x 21 cm and magnifying factor not less than 1.5 at 60 cm focus-film-distance

Breast Compressor:
- Footswitch operated Motorised precompression system with interchangeable compression plates to give (60 N – 300 N) adjustable pressure

Tube Support movements:
- Vertical 635 mm to 720 mm
- Transverse 250 mm to 265 mm
- Locks electromagnetic brakes operated by pushbuttons and Emergency Stop pushbuttons
Accessories:

- Film marking labels - radiopaque letters and symbols to indicate exposure side and direction of projection
- Special cone for magnification
- Interchangeable cassette holder - 24 x 30 cm
- Cone for 24 x 30 cm field size
- Adjustable patient stool / chair
- Lead protective glass shield of lead equivalent not less than 2.0 mm Pb

6.8 Specification for Dental X-Ray Equipment

Dedicated equipment for general dental imaging periodontal x-ray machine

Generator

- Micro processor controlled timer
- Single tube head with handle and suspended on a well balanced but easy to maneuver arm support
- Kilo voltage output 65KVp to 70KVp
- Milliampere output up to 8.0mA
- Exposure time range 0.06seconds to 2.50seconds.
- Digital display of selected time
- Soft touch time selector buttons.
- Total tube filtration not less than 2 mm Al equivalent
- Tube rotation about horizontal axial +45°
- Tube rotation about vertical axis +270°
- Collimator cones to give 60 mm diameter round field at the tip and 35x45mm rectangular field at tip respectively
- Source-to-skin distance(SSD) -20cm
- Exposure switch cable not less than 2 metres long
- Power supply-220V-240Vac 50Hz single phase.
- Operator and service manuals in English
6.9 Dental orthopanoramic equipment.
High output dental x-ray machine for topographic exposures of the teeth and jaws.

Generator
- Microprocessor controlled timer
- Kilo voltage range 60kVp to 85kVp
- Milliampere range 3mA to 15mA
- Exposure time range 0.06seconds to 2.5seconds
- Power supply 115V to 250Vac 50Hz single phase
- Operator and service manuals in English

Accessories
Dental film Auto processor
- Film processing equipment with day light hood and heater
- Film sizes 3 x 4 cm and 5.7 x 7.6 cm
- Film processing time - Not more than 7 minutes
- Power supply - 220V to 240Vac 50Hz single phase

Manual Dental film processor
- Processing troughs with covers of either stainless steel or plastic capacity 5 -10litres
- Water jackets to maintain uniform temperature of the processing chemicals in the troughs.
- Stainless hangers according to films size.
- Film dryer - wooden rack
- Electrical wall mounted hot air blower
- Electric drying cabinet
6.10 Specification for Digital Fluoroscopy X-Ray

**Patient Table**
- Tilting range: + 90° / - 90° degrees
- Tilting speed Variable
- Table top dimensions: min. 220 cm x 60 cm
- Table top should be radiolucent
- Maximum allowable patient weight: 200 kg
- Longitudinal movement range minimum 160 cm
- Longitudinal movement speed variable
- Lateral movement speed variable
- Lateral movement: minimum ± 30 cm
- Patient coverage of 185 cm (minimum).
- Tabletop to film distance maximum 110 mm
- Tabletop to image intensifier distance: max 110 mm

**X-ray tube**
- Rotating anode tube with 2 focal spots maximum 0.6 / 0.8 mm
- Heat storage capacity 8MHU
- Heat dissipation rate 5MHU/Min
- Tube rotation range ± 180° degrees

**Tube column**
- Angulations range minimum ± 40° degrees
- Angulations speed Minimum 4° - 8° deg / sec
- Source Image Distance 110 - 150 cm

**Serial Changer**
- Automatic loading / unloading of cassettes
- At least 4 subdivisions
- Park able grid
- Cross divisions possible
Collimator
- Iris shutter included
- Rotation 45 degrees
- Beam filtering to be included

Tomography (Optional)
- Complete body coverage possible
- 3 tomography angles with 2 speeds
- Layer height increments 1 - 25 cm

Camera
- Type CCD
- Matrix 1 KB
- Dynamic range minimum. 65 dB
- Depth bit minimum 12 Bit
- Configurable scan directions
- Automatic dose control capability
- Automatic gain control capability

Image intensifier
- Multi mode minimum 31 cm
- Input screen material:
  - specify spatial resolution
  - (Visible on output screen):
  - Conversion factor in largest mode:
  - minimum 400 cd/m2 / (mR/s)

Monitors
- Progressive display
- Diagonal dimension minimum 21 Inches
- Reference monitor should be included
- Automatic brightness and contrast control
Digital Imaging
- Acquisition matrix: 1 K
- Processing bit depth: minimum 16 bit
- Instant capture of digital fluoroscopic image
- Dynamic acquisition of digital fluoroscopic images
- Instant image review
- Last image hold (LIH)
- Digital high resolution fluoroscopy
- Installed RAM capacity
- Automatic transfer to hard disk
- Hard disk storage capacity minimum 60 GB
- Image annotations
- Zoom
  - Multitasking
  - Automatic electronic diaphragm
  - Real time fluoroscopic subtraction
  - Pixel shift
  - Remasking
- Land marking
- Road mapping
- Dicom compatible, Dicom Print

Accessories
- Stabilizer ±15 % to be included
- Radiation protection for staff
- Removable compression device
- Positioning devices to be included

X-Ray generator
- Microprocessor controlled high frequency type
- Nominal power: minimum 50 kW
- Connectable x-ray tubes: minimum 2
- Automatic voltage compensation:
- Automatic control of kV / mA during fluoroscopy
- kV variation between 40 - 150 KV
- mA range 10 - 800 mA or more
• Anatomic programs
• Tube overload protection
• Dose management

**Dicom Laser Camera**
• Dicom Laser camera dry system
• Dicom interface to be included with a minimum of 32 Mb Ram memory

### 6.11 Specification for a Multi-slice C.T. Scanner
The system should be a state of the art multi-slice C.T. scanner for whole body examination, comprising minimum 40 channel system architecture. It should have the capability for all advanced applications. The system should have a standard networking capability inbuilt in the system with DICOM 3.0 compatibility, which can be networked at any moment of time.
CT ROOM DESIGN

Gantry:

- Low voltage, multi-slice detector system.
- Gantry aperture not less than 70cm.
- Gantry tilting of at least ± 30° degrees.
- Remote tilting from console facility.
- It must be possible to scan either Head First or Feet First.
- Thinnest slice width of 0.5 mm axial mode, 0.67 mm in spiral mode.
- Minimum Field of View of 500mm, 250 mm Ultra High mode.
- Minimum scan speed should be 0.5 seconds at 360 degrees.
- Faster gantry rotations of 0.4 sec would be preferable.
- Minimal temporal resolution of acquisition should be 80 ms. A temporal resolution of 55ms or lower would be preferable.
- Triple laser lights for accurate patient positioning, external to aperture and at scan plane.
- Visual readout of gantry tilt, bed height and position of gantry to be available on gantry.
• Positioning controls to be located on both sides of gantry.
• Emergency stop switches to be available on gantry as well as the

**X-Ray Generator**
• Minimum Output of at least 60kW to facilitate angiographic procedures.
• 10 mA to 500mA with 10 mA step increments.
• Generator / tube output should be sufficient to guarantee full helical scan at low contrast resolution.
• mA max and 140 kVmax output.
• High frequency to obtain a helical scan for 100 seconds of continuous radiation at low contrast resolution.
• Mains power input stabilization device( standby generator and UPS with 30 minutes backup capacity)
• Mains input 240V ac 50Hz single phase and 415 Vac 50Hz 3 phase.
• Air conditioning the whole CT suite.

**X-Ray Tube**
• High speed rotating anode tube design.
• Dual focal spots( 0.8 x 0.5 mm; 0.8 x 0.7mm) or better
• Heat storage of at least 7MHU is required as a minimum. A heat storage capacity of 8MHU or higher is preferred.
• Anode heat dissipation of 5MHU/minute or higher.
• Heating and cooling curves to be included.

**Detector System**
• Detectors should be of solid-state design, stable and independent of air-condition fluctuations.
• Dose reduction of 30% or more
• Collimation of 0.5mm or better.
• Data acquisition system must have a dynamic range of 16 slices or more per 360° rotation.
• All service phantoms to be included

**Patient Table**

• Loading capacity of at least 200kg at full incremental accuracy of 0.25mm.
• Vertical range 45cm to 80cm
• Provision for manual table motion in the scan plane.
• Minimum longitudinal scan range of 1000mm or more.
• Table movement controls available on both sides of the gantry and on operators’ console.

Basic accessories to be included:

• Axial and Coronal head holders
• Immobilization straps
• Cradle cushions
• Knee support
• Infant Immobilizer
• Mattress

**Operators Console**

• Multi-tasking and easy interface on operators’ console
• Console must offer user-definable programmed protocols. 10,000 or more
• Facility to program scanning protocols for various anatomical regions.
• Sufficient hard disc storage for 500,000 images or more at 512x512 matrix.
• Dual 19 inch high resolution non-flickering/reflective flat screen monitors.
• CD/DVD writer to be available as standard.
• Facility for readout of dose for planned study prior to
scanning.
- Dose saving applications for pediatrics applications.
- Eight adjustable chairs on casters.

**Image Viewing**
- Programmable window settings
- Image rotation
- Multiple image display
- Image magnification
- Comment display
- Annotation
- Arrow insertion
- Distance and angle measurement
- Density measurements
- Simultaneous presentation of at least 3 ROIs, stating mean, standard deviation and area.
- Superimposition of scaled grid
- Multiplanar reconstruction of sagittal, axial, coronal, oblique and user defined projections.
- Combining of images
- Image subtraction
- Reconstructive filters to enhance specific imaging parameters
- Fusion imaging techniques for noise reduction.
- Cine display
- Dynamic analysis
- 3D Surface rendering
- 4D Volume rendering

Any other software available on the console should be detailed ie Cardiac and Perfusion studies.
Performance (All specifications to be applicable to 0.5second scan mode)

- Spatial resolution in the X, Y plane in lp/cm at 2% MTF for the following modes
  - Standard: minimum 13 lp/cm
  - High: minimum 16 lp/cm
  - Ultra High: 24 lp/cm at 2%MTF.
  - Indicate to what FOV the above are limited.
- Contrast resolution, must be stated including scanning protocol used, dose and phantom.
- The noise value of the system must be stated as well as the kV, mAs, surface dose, scan time and slice thickness used.
- A minimum slice thickness should be sub-millimeter.

Scanning Modes

- Scout view (scanogram)
- Single, axial scan mode
- Helical scan mode
- Multiple helical scan mode

Reconstruction Time / Matrix

- Minimum reconstruction time of 30 images / sec per 512x 512 matrix image
- Display matrix 1024 x 1024
- Volume mode allowing up to 100 seconds of continuous radiation with table movement of at least 100 rotations at sub second scan times.

Volume Scan Mode

- Possibility of a volume scan of 100 seconds.
- Possibility to program at least 10 different sequences.
- Reconstruction package providing full details of scan indexing, slice thickness, table speeds, helical pitch settings and flexibility afforded by the different
pitches
- Software package for bolus tracking.
- Integral interface connection to simultaneously trigger the contrast media injector and scan start.

**Independent Workstation**
- Doctors’ workstation linked to the main system having an independent console, allowing viewing, post processing and filming. The workstation with a dual monitor configuration and same user software interface as the CT scanner.
- Image transfer facility
- Workstation standard software for Viewing, MPR, 3D and Volume Rendering / surface shading, Maximum and Minimum intensity Projection, bronchoscopy and colonoscopy inspection packages.
- CD/DVD Writer for storing images.
- Two height adjustable chairs.
- A network connection of 1GB/sec.
- Main system and independent workstation Dicom 3 compliant - Print, store, and work list.

**Accessories**
- Dry laser printer
- Contrast medium injector and appropriate syringes
- Maintenance service phantoms
- Patient observation CCTV and or lead glass window
- Swivel height adjustable chairs on castors
- Desk/table with drawers
- Office chairs
- Operator and service manuals in English.

**Upgradeability**
- Provision for EC and FDA approved upgrade paths.
6.12 Specifications for whole body MRI scanner

The system shall be state of the art whole body MRI Scanner employing latest superconductive technology with low helium consumption. It should have facility for all advanced applications and parallel imaging technique should be quoted and applicable for all sequences. System should have standard networking capability inbuilt in the system with DICOM 3.0 compatible, which can be networked at any moment of time.

Magnet System

- **1.5 or more Tesla** ACTIVELY SHIELDED Superconductive.
- Magnet weight should be preferably less than 3.5 tons weight; easily installable on higher floors at low site costs.
- At least 60 cms. patient bore flared at both ends and a short bore length.
- Should be totally non-claustrophobic; ideal for MR Intervention/Interactive studies.
- The effective patient tunnel length 128cm or more.
- Exclusive Superconductive compensation for heavy iron objects moving in vicinity.
- Cryo-cooler (inbuilt). Typical Helium consumption <= 0.04 ltr/hr. Minimum refill interval of once in 2 years preferred.
- Homogeneity by VRMS method to be better than +/- 0.3 ppm Typical over 40 cms DSV with automatic correction for patient introduced in-homogeneity.
- Well ventilated and illuminated; with in-built 2 way intercom system for communication with patient.
- Music system with patient head set MR compatible for added patient comfort.

Shielded Gradient

- Strength: A true 32 mT or higher (not effective) and shorter rise times with very high linearity of less than 1.5%, to perform all fast sequences at 100% duty
cycle. Should be capable of producing any kind of waveforms and without hardware changes should be able to do all major future applications in both ultra fast and regular diagnostic imaging sequences.

- The system should have a minimum Slew Rate of 80mT/M/s.
- Special Noise Reduction package should be quoted in the offer and details to be mentioned.

**Patient Bed**

- Patient friendly, lowest height : 50 cms or lower
- Travel: at least 100 cm beyond magnet isocenter
- Halogen light beams: for accurate positioning
- Return-to-scan plane function: for easy administration of contrast.

**Advanced digital spectrometer and RF Amplifier**

- at least generate a transmit power of 20 kW or higher at 100% efficiency
- Accurate, flexible on-the-fly generation of gradient and RF waveforms.
- High Receiver Bandwidth of at least 1 MHz or above to complement the gradient system for optimal SNR for each receiver channel.
- At least 6 dedicated digital receiver channels to support 6 or more elements of Phased Array coils

**Computer System:**

- Fast & Powerful Computer based on Windows XP hardware or better
- 64 bit word length of the Host Computer and at least 256 MB RAM.
- should have an image storage capacity of 120,000 images or more (at 256 x 256) with 18 GB hard disk
- CD ROM DRIVE for current and future software upgrade
• 5.25” compact REWRITABLE Optical Disk for Archiving & storage: (at least 30,000 images per disk).
• At least 512 MB Array Processor. 2D fast fourier with Image Reconstruction times of minimum 400 images/sec or higher at 256 x 256 matrix.

Operator Console:
• 18” High Resolution LCD Color Monitor with 1280x1024 matrix display
• Ergonomically designed
• Mouse, Alphanumeric Keyboard
• Two way intercom system for patient communication

Patient Comfort Accessories:
• Soft mattress with head rest
• Knee support, positioning wedges
• Set of soft velcro immobilisation straps
• MR compatible sandbags
• Hand held nurse call device

Coils
• High Quality Quadrature / Circular Polarized (CP) Body Coil (integrated to magnet)
• Head Coil with integrated RF mirror for maximum RF sensitivity and homogeneity
• Optical mirror for patient to see out of the magnet
• Set of Flexible coils suitable for Shoulder, Extremity applications.
• Quad/PA Neuro Coil for MRI and MRA of the entire neck from the aortic arch up to and including the Circle of Willis.
• Quadrature / Phased Array spine coil for Thoracic and Lumbar Imaging.
• Multi-coil connection for up to 2 or more coils for simultaneous use, with decoupling of unselected coils for scanning without patient repositioning.
- Coils to have Built-in preamplifier in each coil to ensure high SNR (Signal to Noise Ratio)
- Additional Coils to be quoted separately

**Software for pulse sequence:**
- Spin Echo (SE); Modified Spin Echo (MSE); Fast Field Echo (FFE), Inversion Recovery (IR) and mixed SE-IR.
- Dynamic Study for pre and post contrast scans, Time intensity studies (Wash in and Wash out) and kinematics.
- Turbo Spin Echo (TSE) Package that generates superb images with conventional SE contrast in scan times typically 10 time shorter for faster MRCP applications.
- MRI Angio Software package including both 2D and 3D Angio’s with gated inflow to suppress artifacts from retrograde flow and pulsations; includes
  - MOTSA with the possibility of applying off-resonance and on resonance
  - MTC pulses and Phase contrast angio.
- System should be able for turbo 3D Phase Contrast Angio. Provide details
- Application of MTC pulses for enhancing contrast in non-angio applications should also be possible
- Quantification Flow to be quoted and measurements should be possible on the main console
- Gradient Echo technique, 2D and 3D mode, ideal for contrast agent wash-in and wash-out studies.
- EPI (Echo Planar imaging) in 2D, multi / single-shot selectable with all coils including phased array coils for very fast imaging of traumatic patients.
- Balanced FGRE (2D and 3D) (True FISP, FIESTA) combinable with any technique for superb contrast and ultra fast non-contrast Enhanced Angio’s.
- Single slice, Multiple single slice, Multiple slice, Multiple stack, Radial stack and 3D acquisitions for all applications.
- TONE Package for improved angio quality.
- Subtraction of 2 different dynamic scans should be possible
- Turbo Field Echo and Retrospective gating for cardiac imaging capabilities
- Variable Field of View (FOV), specify min to max.
- Reduction in Phase Encoding direction in 1% steps upto 75%.
- Acquisition Resolution from 64 x 64 up to 1024 X 1024 matrix variable in random fashion.
- Reduced matrix or half scan to reduce scan times
- Artefact suppression for Respiratory, motion, moving blood etc.,
- Special Package for Fat suppression for high quality images to be quoted.
- MULTITASKING: During scan operators console may be used for any viewing, post processing, archiving or hardcopy
- Black Blood Imaging should be possible to be done on the system & should be quoted application package for Diffusion Imaging should be quoted with the system Single Shot EPI and FLAIR EPI should be possible.
- Triggered TOF and Phase Contrast Angio should be possible.
- Clinical

**Parallel Imaging Technique**

- Parallel imaging technique should be possible & quoted standard in the system. The factor of 2 should be minimum
- The system should have functionalities for easy scanning wherein all sequences can be placed into one clinical scan. It should be user friendly and less cumbersome to operate.
DICOM Dry Laser Camera
- Workstation with Volume viewing s/w’s.
- Patient Observation Camera and Monitor
- Chiller (for the cryocooler)
- UPS cum Power Conditioner with power backup of at least 30 minutes or more.
- RF CAGE for the MR room

Accessories
- MR compatible Pressure Injector (FDA/CE Certified)
- HIS/RIS Integration software
- Paradigm Generator for audiovisual stimulation
- Hand held metal detectors
- MRI compatible Servo Ventilator with anaesthesia attachments
- MRI compatible oxygen cylinder
- MRI compatible pulse oximeter
- MRI compatible N20 cylinder
- MRI compatible patient trolley
- MRI compatible patient wheelchair
- Operator and Service manuals in English
Figure 6.1: Relationship between Control Room and Entrance to the MRI Scanning Room
CHAPTER SEVEN

7.0 STANDARDS FOR COMMUNICATION IN DIAGNOSTIC IMAGING AND THERAPEUTICS
Diagnostic radiology and therapy practice is primarily a consultative service. Official Communication is a critical component of the art and science of medicine. Communication for imaging and therapeutic services is achieved through formal request forms and/or softcopy communication. Interpretation record/report shall be generated following examination, investigation or consultation.

Direct communication between health providers, promotes optimal patient care, and focuses attention on selection of appropriate and cost-effective imaging studies, clinical efficacy and radiation exposure.

Elements of imaging and therapy consultation:
- Pre-examination evaluation by referring physician
- A request for radiological/therapy consultation
  - Clinical findings / symptoms and signs
  - Specific question to be answered by the radiology study / intervention/therapy
  - A working diagnosis.
- Reports

7.1 The Diagnostic Radiology Report
The Radiological report shall include the following: -

Demographics
- At least two names of the patient and other identifier, such as hospital and examination identification number.
- Type of examination (s)
- Date and time of examination(s)
- Name of referring physician or other healthcare provider.
- Age of patient
- Gender of patient
Relevant clinical information and ICD-9, ICD-10 as available

Body of the report
- Procedures and materials
- Description of studies
- Contrast Media, medications, catheters/ devices used
- Reactions or complications
- Findings - use precise anatomic, pathologic and radiologic terminology for accurate description.
- Potential limitations - factors for limitation of sensitivity and specificity of examination if any
- Answer clinical issues raised in request
- Comparative data
- Comparison with previous exams / reports

Impression (conclusion or Diagnosis)
- Precise diagnosis when possible
- Differential diagnosis when appropriate
- Follow-up or additional diagnostic studies to clarify or confirm impression suggested if appropriate.
- Report significant patient reaction.
- Particulars and signature of radiologist / healthcare provider

Important to note:
- Provisional report prior to preparation of final report
- Timeliness varies with the nature and urgency of the clinical problem.
- The reports shall be signed conventionally or by secure electronic signature.
- The reports shall be sent to the referring physician / health care provider by secure means
- Copy of report shall accompany images.
- Copy shall be kept as part of patient’s medical record (hard or electronic) and be retrievable for future reference in conformity with regulations of medical records achieve.
• Images from other facilities - formal report or other written documentation shall be made if image quality is optimal.
• Second opinion - an addendum should be rendered.
• A radiology information system (RIS) and Teleradiology shall be promoted for efficient and effective communication.

Verbal communication
• In person or telephone to referring physician or representative.
• Should be documented
• Preferred in emergency situations

Self-referred patients.
• Radiologist / Healthcare provider takes responsibility of care of patients who present themselves for imaging studies on a self-referred basis. Communicating the results of imaging studies to the patient and necessity of appropriate follow-up should be communicated.

7.2 Records keeping for an Imaging and therapeutics.

The records to be kept should include the following:
• Patients’ attendance register
• Patient’s request form
• Patient’s Report form
• Patient’s Consent form
• Patient’s films and sonograms
• Patient file
• Patient treatment chart

7.3 Standards for PACS and Teleradiology
Picture Archiving and Communication System (PACS) is a system for managing medical imaging and patient information utilizing digital data during acquisition, transmission, storage, display
interpretation and consultation. It is used alongside other information systems like radiology information system (RIS) and hospital information system (HIS).

A PACS should ensure the following:
- Initial acquisition or generation and recording of accurately labeled and identified image data.
- Transmission of data to an appropriate storage medium from which it can be retrieved for display for formal interpretation, review and consultation.
- Retrieval of data from available previous imaging studies to be displayed for comparison with a current study.
- Transmission of data to remote sites for consultation, review or formal interpretation.
- Appropriate compression of image data to facilitate transmission or storage without loss of clinically significant information.
- Archiving of data to maintain accurate patient medical records in a format that allows timely retrieval, meets institutional and ministry/government regulations and maintains patient confidentiality.

Teleradiology is the electronic transmission of radiological images from one location to another site for purposes of interpretation, management, consultation and/or storage. It allows more timely interpretation of radiological images and gives greater access to secondary consultation and improves continuous medical education.

Teleradiology is an evolving technology and therefore new goals will continue to emerge. The current goals of the technology include:
- Providing consultative and interpretative radiological services in areas of demonstrated need.
- Making radiological consultation available in medical facilities without on-site radiological support.
- Providing timely availability of radiological images and
report in emergency and non-emergency clinical areas.

- Facilitating radiological image interpretation in on-call situations.
- Providing super-specialty radiological support as needed.
- Enhancing educational opportunities for radiologists and imaging technologists.
- Promoting efficiency and for quality improvement.
- Sending interpreted images to the referring clinician.
- Proving direct supervision of off-site imaging studies.
- Promoting practice of telemedicine.

**Procedures:**

1. Acquisition or Digitization shall be performed in accordance with the modality used and standards of the examination.
   
   - **Direct image capture.**
     The image data produced by digital modality should be transferred to the teleradiology system. The most desirable mode of digital image acquisition for primary diagnosis
   
   - **Secondary image capture.**
     Film digitisation or video frame grab systems conforming to small or large matrix specifications
   
   - **General requirements.**
     The system must include annotation capabilities including patient name, identification number, date, and time of examination, name of site, type of examination, anatomic part orientation, amount and method of data compression.
     The capability that record a brief patient history is desirable

2. Compression
   Performed to facilitate transmission and storage of data, this may be reversible or irreversible techniques but with no reduction in clinically diagnostic image quality

3. Transmission
   The digital data received at the remote site must have no loss
of clinically significant information for interpretation purposes.

The transmission system shall have adequate and with error-checking capability.

4. Display capabilities

5. Archiving and Retrieval - should be efficient and reliable

6. Security mechanisms should be in place to ensure confidentiality of information.

7. Reliability and Redundancy

**Personnel**

A competent team of health providers should include:

- Radiologists / Physicians
- Medical imaging technologist
- Human Resource Managers
- Medical Physicist
- Electronic/Computer Assistant

**Equipment**

These shall vary depending on individual site’s needs but principally they should provide the desired image quality

Should be in compliance with the Digital Imaging and communication in Medicine (DICOM) standard.

Should be of two categories for rendering quality images for interpretation which shall be:

- Small matrix
  - Provide full-resolution data (512x512 resolution at minimum 8-bit depth) for processing, manipulation and subsequent display.
  - Used in Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Ultrasound (US), Radionuclide Imaging (RNI), Digital Subtraction
Imaging (DSI), Digital Radiography (DR) and Digital mammography.

- Large matrix
  - Provide spatial resolution at a minimum 10-bit depth
  - Used in Computed radiography (CR) and digitised radiographic films.

**Quality Control:**
A facility using teleradiology shall have documented policies and procedures for monitoring and evaluating the effective management, safety and proper performance of acquisition, digitization, compression, transmission, archiving and retrieval functions of the system.

Policies and procedures related to quality, patient education, infection control and safety shall be developed and implemented in accordance with the Ministry of Health standards.
CHAPTER EIGHT

8.0 INFECTION PREVENTION AND CONTROL

Infections acquired from health care facilities reflect a decline in the quality of delivery of health care services. When acquired they add a burden to the patients, their families, community, and the state at large in terms of costs, pain, trauma and sometimes death.

Studies carried out in Mulago hospital in 1990 showed 14% infection rate in general surgery and 30% in Obstetric surgery. These are high postoperative infection rates.

In view of the above and high prevalence of HIV/AIDS in the community, infection control guidelines need to be put in place and adhered to.

8.1 Policy statement

- All health units should have infection prevention and control committees in their management.
- Review of the Infection Prevention and Control guidelines should be done regularly to ensure a high standard of care.
- Training schools should be up dated incase of changes in the guidelines.
- Research should always be encouraged in this field.
- Injection safety and waste & disposal methods should be practiced.

8.2 Infection Protection and Control Guidelines

Personnel hygiene

This involves the general cleanliness of the whole body.

- Nails shall be short and clean, no wearing of artificial nails and varnish while on duty.
- Hair shall be kept short or pinned up and should be regularly washed.
- Beards and moustache shall be trimmed and cleaned.
• Freshly laundered uniforms should be put on daily, Street clothes should be covered by clinical coats or gowns. In case of exposure to blood or body fluids, clothes should be decontaminated before washing.
• Uniforms should be made of materials easy to wash and decontaminate. The material should not allow body fluids to seep through.
• Washing of hands is most effective method of preventing the transfer of microorganisms between personnel’s and patients within the health care facilities; it reduces resident and transient organisms significantly. These are in three types,
  o Social hand wash.
  o Hygienic hand wash.
  o Surgical.

**Equipments and Structures**
Surfaces, walls, trolley tops, doors and ventilators, beds and furniture, should be dump dusted with water and detergents. Leave surfaces dry and clean.

Ensure no wooden beds.

Floor daily wet scrubbing and whenever it’s dirty.
  • Use two buckets of soapy water and clean water
  • Color code label equipment according to different areas.
  • Cleaning rags should be washed and dried.
  • Decontaminate spillage before cleaning

**8.3 Management of waste**
Medical wastes are potentially infectious since they can be source of infections and injuries to patients, health providers and the community. These wastes should therefore be appropriately managed. Segregate wastes should at point of generation according to type.

Place each type of in separate bin, color coded according to type Bins should be well covered and emptied after when ¾ full. Waste handlers should be well protected with heavy-duty gloves, plastic aprons and boots.
8.4 Disinfection and Sterilization
Disinfection is carried out to render objects and surfaces free from most organisms and safe to hand use.

This can be achieved using heat or chemicals.

All objects and surfaces contaminated with body fluids must be treated with chlorine releasing agents before washing. Then can be boiled or sterilized.

For detailed information refer to the National Infection Prevention and Control Guidelines
9.0 STANDARDS ON CLINICAL PRACTICE IN RADIOLOGY AND IMAGING

9.1 Standard for General Radiography
Radiography is a proven and useful procedure that utilizes differences in x-ray attenuation to evaluate human anatomy and pathology. The radiographs shall be of high quality to meet the clinicians’ expectation and patient needs. The goal of Radiography is to establish the presence or absence and nature of disease by demonstration of the disease process on the normal anatomy.

The study should be done with the minimal radiation dose necessary to achieve an optimal study.

The following shall be taken into consideration in order to minimize the radiation dose to the patient, staffs and the environment:

- Equipment, accessories and consumables shall be of the right specifications.
- There should be a sufficient clinical indication to warrant performance of the study.
- All imaging facilities shall have policies and procedures to identify pregnant patients prior to the performance of any diagnostic examination involving ionizing radiation.
- There shall be regular quality control tests on the equipment to ensure consistence in radiation output.
- All radiographic studies shall be permanently labelled with patient identification and date of the examination.
- The side (right or left) of the anatomic site x-rayed shall be permanently labelled.
- All facilities performing radiography shall have protocols for standard views of each anatomic area that will be x-rayed. These shall be designed to optimize diagnostic information while minimizing radiation exposure.
- An appropriate collimation shall be used to limit exposure to the anatomic area of interest.
• All facilities performing radiography shall have technique charts listing exposure factors that will reliably produce diagnostic radiographs of anatomic parts of patients of different sizes to minimize the need for repeat exposure.
• Reject analysis (repeat rates) shall be part of the routine quality control process.
• Radiographs shall be reviewed for positioning and diagnostic quality at the facility before the patient is released. Repeat radiographs should be performed when necessary for diagnostic quality.
• Immobilization and assistance procedures appropriate for the age and size range of patients to be imaged shall be available to ensure that images of diagnostic quality can be obtained in patients who are unable to cooperate, or unable to be positioned in the usual manner due to age or physical limitations and without unnecessary irradiation of health care workers.
• All facilities performing radiography shall have policy on reporting equipment faults to ensure that remedial action is taken as soon as possible.
• All facilities performing radiography shall have a policy on equipment maintenance and repair to ensure that equipment is secure, functional and well maintained.
• Film processing equipment and accessories shall be checked regularly to ensure that processed films conform to set standards to avoid repeat exposures.
• Appropriate film screen and grid combination shall be used to obtain images of diagnostic quality of all anatomic areas.
• All facilities performing radiography shall have policies and procedures related to quality control, patient education, infection control and safety.
• Equipment performance monitoring shall be done regularly by medical physicist.
• For automated processing, carefully controlled temperature and regular processor maintenance shall be included in quality control program.
• For manual processing, a constant time and temperature
shall be maintained to ensure standard or uniform film processing.

- Plain film reporting shall be done by only trained qualified and certified personnel.

**Performance of adult chest**

Chest radiography is a proven and useful procedure for evaluation of airways, pulmonary parenchyma and vessels, mediastinum, heart, pleura and chest wall.

The common and accepted practice consists of postero-anterior (PA) view obtained in the upright positions. A lateral Chest X-ray may be done when indicated. Under certain clinical circumstances and in certain patient populations (e.g. critically ill, postoperative, and bedside) an antero-posterior (AP) may be performed. The goal of the chest radiographic examination is to help establish the presence or absence and nature of disease involving the thorax or to follow its course.

**Indications**

- Signs and symptoms potentially related to the respiratory, cardiovascular and upper gastro-intestinal system and the musculoskeletal system of the thorax.
- Evaluating diseases involving the thorax, including systemic and extra thoracic disease that secondarily involve the thorax.
- Staging of extra-thoracic as well as thoracic tumours (metastases).
- Follow up of already diagnosed thoracic disease process for evaluation of improvement, resolution or progression.
- Monitoring of patients with life support devices and patients who have undergone cardiac or thoracic surgery or other interventional procedures.
- Compliance with government regulations that may mandate chest radiography. Examples include immigration chest films, chest films for coal miners or other surveillance studies required by public health law as part of the medical examination.
• Preoperative radiographic evaluation is indicated if cardiac or respiratory systems are present or if there is a significant potential for thoracic pathology that may compromise the surgical result or had increased pre-operative morbidity or morality.

Contraindication
If the patient is known to be pregnant, the potential radiation risks to the fetus and clinical benefits of the procedure shall be considered before proceeding with the study.

Specifications of the examination
• The written request for the chest radiographic examination shall contain appropriate clinical history and the reason for the examination.
• A standard chest examination shall include an erect PA projection made during full inspiration (total lung capacity).
• The examination may be modified by the clinician or qualified technologist/Radiographer depending upon the clinical circumstances.
• Other techniques that may be used at times include Supine, lateral, Prone, Oblique, Decubitus, expiratory.

Features of a standard chest radiograph.
• Shall have proper patient identification by Name, patient identification No. and Date.
• Shall be properly marked left or right side of the film.
• Shall include both lung apices and both costophrenic angles.
• There shall be appropriate definition of the vertebral bodies and the left retro cardiac vascular pattern shall be visible.
• The scapulae shall be positioned outside the lung fields on the PA view and the arms elevated for the lateral view.
• The vertebral column shall be centred between the clavicles.
• The radiographic beam shall be appropriately collimated to include the area of interest while limiting exposure of the remainder of the patient and should not exceed the geometry of the image reception.

**Equipment Specification**

• The equipment shall be diagnostic machine having a rotating anode tube with a tube filtration sufficient to achieve a half valve layer (HVL) greater than 3mm of aluminum at 100.
• A grid shall be used for adult radiography (see specifications)
• Radiographs shall be exposed only with equipment having a beam-limiting device that provides rectangular collimation.
• There shall be at least 150cm to 200cm source-image distance to minimize magnification for routine erect position.
• For supine, stretcher, infants and young children at least 100cm source image distance shall be used.
• The nominal source (focal spot) shall not exceed 2.0mm (0.6 - 1.2mm) is the recommended range.
• Intensifying screens shall be used. Any film screen combination may be used that has a speed of at least 200.

**Performance of pediatric and adult bedside chest radiography**

The bed side chest radiography is the examination of choice for the investigation of cardio-respiratory diseases in critically ill, post-operative and new born.

Chest radiographs obtained in the radiology department are usually diagnostically superior and shall be obtained whenever possible. The goal of bedside radiography is to help establish the absence or presence, and nature of disease involving the thorax or to follow its course and to identify positions of clinical support devices. An optimal study shall be done with the required radiation dose.
Indications
- Evaluation of patients with cardio-respiratory symptoms following cardiac or thoracic surgery or trauma and of patients with monitoring and/or life support devices
- Newborns, infants and young children who, because of the age, clinical condition or need for immobilization, cannot undergo routine chest radiography.

Contraindication
If pregnant patients the potential radiation risks to the fetus and clinical benefits of the procedure shall be considered before proceeding with the study.

Specification of the examination
- The written request for the chest radiographic examination should contain appropriate clinical history and the reason for the examination.
- The radiographer should seek permission and assistance of the attendant or other personnel (preferably not radiation or health workers) to position unstable patients and adjust or remove support apparatus from the radiological field.
- In cooperative adults and older pediatric patients, fully upright radiographs at 180cm are preferred.
- Infants and young children or uncooperative patients may be imaged supine or semi-erect at 100cm.
- Young or uncooperative children should be immobilized to assure adequate patient positioning.
- The examination can be modified by clinician or qualified Radiographer in consultation with the requesting clinician as dictated by the clinical circumstances or the condition of the patient.
- Radiographic exposure may be made at full inspiration where possible.
- The radiograph shall include lungs apices, costo-phrenic angles, the upper airway and upper abdomen.
- On an optimally penetrated chest radiograph, the retro cardiac vasculature and lower thoracic spine should be
Technical Factors

- In adults without a grid, the kilo-voltage shall be between 70 and 100 kVp in order to optimize penetration and limit the effects of scattered radiation.
- If a grid is used, Kilo-voltage greater than 100 kVp may be employed.
- In new born, infants or small children lower kVp shall be used to optimize contrast.
- Exposure times shall be as short as feasible to reduce motion artifacts.
- Exposure parameters (including mAs, kVp, distance and patient position) should be recorded for each film as they may be helpful in future radiographs.
- In all patients, the beam shall be appropriately collimated to limit radiation outside the area of clinical interest.

Quality control (QC) procedures to all chest Radiography

- When the examination is completed, the radiographs shall be checked by a qualified radiographer or radiologist.
- Films shall be permanently marked with the patient’s name, identification number, right or left side, patient position and the date and time of the examination.

Equipment specifications

Portable/mobile x-ray equipment should have adequate kVp and mA capabilities to produce diagnostic quality radiographs of all patients (new born infants to full size adults) on whom it will be used at acceptable exposure times (100msec for adults and 30msec for newborns and infants).

Performance of Paranasal sinuses (PNS)

Radiography of the PNS is a proven and useful initial procedure for evaluation of maxillary antra, ethmoids; frontal and sphenoid sinuses which are air filled cavities within the facial bones and communicating with the upper respiratory tract. The goal of
radiographic examination of the PNS is to identify or exclude anatomic abnormalities or disease of PNS (air filled cavities).

**Indication**
- Trauma potentially involving the facial bones.
- Pain in the forehead.
- Mucosal thickening.
- Evaluation of primary malignancy of nasal cavity.
- Follow up previous PNS abnormality
- Current or prior surgery of PNS
- Evaluation of PNS abnormality seen on other imaging modalities.

**Qualifications and Responsibilities of personnel**
See chapter 3 on qualifications and responsibilities of radiation workers

**Specification of examination**
- Occipito- mental (OM), Occipito Frontal (OF) and lateral are the standard views in evaluating PNS.
- Submental-vertical (SMV) is an additional view to evaluate the base of the skull and ethmoid sinuses.
- The patient shall be x-rayed in the erect position.
- In accident and emergency departments the projections are taken with the patient erect or horizontal
- When fluid levels are to be demonstrated a horizontal beam must be used.
- A right or left marker must be included on every film.
- An 18cmx24cm cassette size is recommended.

**Equipment specification**
- A modern skull unit provides comfortable positioning and immobilization of the patient as well as accurate positioning of the tube.
- A universally erect bucky can also be used in the absence of the skull unit.
- Sinus radiographs must always be produced using a grid.
A localizing cone with a small aperture must be used or a coned beam to the area of interest shall be used.

**Documentation**

*See standards for general radiography.*

Quality control and improvement, safety, infection control and patient education concerns. *See standards for general radiography.*

**Performance of radiography of the cervical spine**

Radiography of the cervical spine is a proven and useful initial procedure for evaluation of the cervical vertebra, disk space, bony neural foramina and para-vertebral soft tissues. The goal of radiographic examination of the cervical spine is to identify or exclude anatomic abnormalities or disease processes of the cervical spine. The examination should be performed with the minimum radiation necessary to produce a diagnostic study.

**Indications**

- Trauma to or potentially involving the cervical spine.
- Neck pain.
- Current or prior surgery of the cervical spine.
- Evaluation of cervical spine abnormalities seen on other imaging studies.
- Suspected congenital abnormality of the cervical spine.
- Evaluation of primary and secondary malignancy.
- Populations at high risk of cervical spine abnormality e.g. down syndrome, certain skeletal dysplasia.
- Follow up previous cervical spine abnormality
- Arthritis.

**Specifications of examination**

**a) Cervical spine examination in adults**

- Shall include the entire cervical spine from the cranio-cervical junction to the superior endplate of T1.
- A standard examination includes antero-posterior (AP), lateral and open mouth odontoid views.
• Swimmers lateral view should be performed if necessary to assess C7-T1-alignment.
• In cases of trauma with significant clinical suspicion of cervical fracture (patient immobilized), cross table lateral, AP and odontoid (cooperative patient) views should be taken and viewed before the patient leaves the examination room in case of further examination.

b) Cervical spine examination in infants and children.
• In the paediatric population, AP, Lateral and odontoid radiographs are usually sufficient for most clinical indications of cervical spine imaging.
• For infants and very young children, only AP and lateral radiographs without a specific odontoid projection may be adequate depending on the clinical indication for the examination. In the event that open mouth odontoid or oblique views in young children cannot be performed due to lack of co-operation, the decision to obtain additional imaging such as a computed tomography (CT) scan should be based on clinical suspicion for fracture or mal-alignment.

c) Additional Evaluation
• Bilateral oblique views: When assessment of neural foramina is necessary, oblique views can be obtained.
• Flexion-extension lateral view: When assessment of cervical instability is necessary, lateral views in flexion and extension can be obtained. When the patient is capable, he/she should be solely responsible for head movement may be helpful.
• Articular pillar (facet) views: These angled oblique views should be considered if a facet fracture is suspected on the initial examination.
• Based on the clinical assessment and/or evaluation of the radiographs, further examination of the cervical spine with CT or MRI may be indicated.
Performance of radiography of the thoracic spine
Radiography of the thoracic spine is a proven and useful initial procedure for evaluation of the thoracic vertebrae, disc spaces and paravertebral spaces. The goal of the radiographic examination of the thoracic spine is to identify anatomic abnormalities or disease processes of the thoracic spine and paravertebral soft tissue.
The examination should be performed with the minimum radiation necessary to produce a diagnostic study.

Indications
- Trauma to, or potentially involving, the thoracic spine.
- Back pain in the thoracic region.
- Pain radiating around the chest wall.
- Evaluation of primary and secondary malignancy.
- Current or prior surgery on the thoracic spine.
- Evaluation of a thoracic spine abnormality seen on another imaging study.
- Osteoporosis, compression fractures.
- Follow up of previous thoracic spine abnormality.
- Suspected congenital anomaly of the thoracic spine, like syndromes associated with spinal abnormalities and evaluation of scoliosis and kyphosis.

Specifications of the examination
- Antero posterior (AP) and lateral are standard views in evaluating the thoracic spine.
- Addition views may be helpful in completing the evaluation in selected cases e.g. Swimmers, obliques, thoraco - lumbar or coned views.
- For evaluation of scoliosis, erect AP and lateral views of the entire thoraco-lumbar spine may be obtained. Postero-anterior technique may be used to decrease radiation exposure to critical organs, e.g. breast, gonads and thyroid.
- Lower cervical or upper lumbar anatomy should be visualized to assure accurate numbering of thoracic levels.
Performance of radiography of the lumbo sacral spine
Radiography of the lumbo-sacral (LS) spine is a proven and useful initial procedure or evaluation of the lumbo sacral vertebrae and disk spaces. The goal of the radiographic examination of the Lumbosacral spine is to identify anatomic abnormalities or disease processes of the LS spine.

The examination should be performed with the minimum radiation necessary to produce a diagnostic study.

Indications:
- Trauma to or potentially involving the LS spine.
- Back pain in the lumbar region.
- Pain radiating to lower limbs
- Evaluating of primary and secondary malignancy.
- Current or prior surgery on the LS spine.
- Arthritis.
- Osteoporosis,
- Follow up of previous LS spine abnormality.
- Evaluation of a LS spine abnormality seen on another imaging study.
- In children, limping or refusal to bear weight, suspected congenital anomaly of the LS spine and syndromes associated with spinal abnormalities as well as evaluation of scoliosis and kyphosis.

Specifications of the examination

Adult Lumbo-sacral examination
- Antero posterior (AP) and lateral views are standard but postero-anterior (PA) may be used.

Additional views when indicated:
- Both oblique views.
- Conned lateral view of the L5-S1 area.
- Flexion and extension lateral views.
- Angled AP view of L5-S1.
Paediatric lumbosacral spine.
In infants and children, AP and lateral views are usually sufficient. In older children and adolescents, oblique views and conned lateral views of the LS spine may be helpful.

Quality control procedure.
- The examination should completely demonstrate the entire LS spine or the level of clinical interest in limited exam.
- If prior LS films are available, they should be compared.

9.2 Standards for Performance of Contrast Studies

Barium Swallow:
The examination of the eosophagus using barium sulphate suspension. The examination is usually performed when specific signs are noted clinically. The purpose of the procedure is to establish presence or absence and nature of disease with radiological imaging at minimal radiation dose.

Indications:
- Dysphagia
- Cancer of eosophagus
- Inflammation of eosophagus
- Foreign body
- Metastasis
- Suspected congenital eosophageal lesions

Personnel:
- Radiologist
- Medical Imaging Technologist
- Radiographer
- Nurse

Procedure:
- Patient in erect position
- Paste of mixed barium sulphate is given orally
• Patient is made to swallow under fluoroscopy
• Various angles assimilate necessary
• Various spot films in varying positions are taken

**Equipment:**
• Fluoroscopy with tilting table provision is required
• Digital subtraction imaging technology is of added advantage
• Intermittent fluoroscopy timer capabilities are necessary
• Serial changer and multiple formatting cameras are required
• Cine or video recording is important

**Barium meal**

**Introduction:**
The examination of the stomach and the duodenum using barium contrast media to assess and investigate for any abnormal patterns. The barium sulphate suspension is administered orally.

**Indications:**
• Dyspepsia
• Peptic ulcer dyspepsia
• Duodenal ulcer disease
• Cancer of the stomach
• Vomitting blood
• Gastric outlet obstruction
• Duodenal atresia

**Personnel:**
• Radiologist
• Medical Imaging Technologist
• Radiographer
• Nurse

**Procedure:**
• Fluoroscopic survey of chest and abdomen
• Barium sulphate is administered to the patient orally while in a sitting position for single contrast study. Effervescent substance is administered to provide a double contrast
• A straw may be used for moribund recumbent patients
• Patient is made to rotate while lying down to provide adequate coating of the stomach mucosa.
• Oblique views in supine and prone of the stomach and duodenum or other necessary additional views are taken.

Equipment:
• fluoroscopy with tilting table provision is required
• Digital subtraction imaging technology is of added advantage
• Intermittent fluoroscopy timer capabilities are necessary
• multiple formatting cameras are required

Barium meal and follow-through
As in Barium meal study the examination is extended to image the small bowel.

Indication:
• Suspected or known small bowel obstruction
• Intestinal pseudo obstruction
• Inflammatory bowel disease
• Unexplained gastrol intestinal bleeding
• Malabsorption
• suspected enteric fistula
• Small bowel trauma
• Intramural haemorrhage with possible intussusceptions in children
• Ischemic bowel
• Follow up of known bowel diseases
• Failure to thrive in children.
• Suspected malrotation
• Necrotizing enterocolitis
• Post operative assessment for position, anatomy, and function of small bowel. Anastomosis leaks, strictures, adhesions and length of remaining small bowel after resection.

NB:
If there is any suspicion of leakage involving the small bowel
loops e.g (Fistula, Trauma, Anastomosis leakage) water soluble contrast media should be used.

**Personnel:**
- Radiologists
- Medical Imaging Technologist
- Radiographers
- Nurse

**Procedures**
- The study shall be performed only when there is an appropriate clinical indication,
- The patient shall have nothing by mouth prior to the examination the length of time for not eating shall depend on the age.
- Medical history shall be reviewed to determine whether he protocol shall be changed to meet specific needs.
- Preliminary radiographs are commended especially in acute abdomen.
- The Radiographs shall be assessed for calcifications, calculi, bony abnormalities, anomalies of situs, bowel gas pattern, pneumoperironeum evidence of prior surgery, catheters and monitoring electrodes.
- Pertinent prior studies/and or reports shall be retrieved and reviewed if available.

**Equipment:**
- Fluoroscopy with tilting table provision is required
- Digital subtraction imaging technology may be applied
- Intermittent fluoroscopy timer capabilities are necessary

**Barium Enema**
The examination of the colon by barium enema is a proven and useful procedure for evaluation of the large bowel; this standard is for performance of the barium enema in patients. The goal of the radiological examination is to establish the presence or absence and nature of the disease by producing the optimum quality study at the minimal radiation dose necessary.
Indications
- Chronic alteration of bowel habits
- Rectal bleeding
- Diverticular disease
- Inflammatory bowel disease
- Suspicion of or screening for colonic neoplasm
- Unexplained anemia
- Unexplained fevers and weight loss
- Screening for colorectal cancers

Personnel
- Radiologist
- Medical Imaging Technologist
- Radiographer
- Nurse

Procedures:

Colon Preparation
Preparation shall consist of any effective combination of dietary restriction, hydration, osmotic laxatives, contact laxatives and cleansing enemas. This preparation aims at achieving a colon that is free of fecal matter and excess fluid. In appropriate clinical situations, preparation may be limited or omitted.

Examination preliminaries
- Appropriate medical history to justify the examination should be available.
- A preliminary plain abdominal film is not necessary unless:
- Severe constipation renders the effectiveness of bowel preparation doubtful
- Toxic megacolon is suspected
- The barium enema tip should be inserted by a physician or trained assistant e.g. technologist, nurse or nursing aid.
- A physician shall be in the fluoroscopic area during cuff inflation.
- Medication may be administered to facilitate patient examination.
Examination Technique

Methods:
- Double contrast - method of choice to demonstrate mucosal pattern
- Single contrast is used in Children - since it is usually not necessary to demonstrate mucosal pattern and in reduction of intussusceptions

Single-contrast examination
- Sufficient volume of low density barium suspension is administered rectally to provide colonic distension.
- Kilovoltage of 100 kVp or greater depending on the patient size.
- Manual or mechanical compression of all accessible segments of the colon during fluoroscopy.
- Spot radiographs of suspicious findings.
- Overhead radiographs, should include frontal and oblique views of the entire filled colon, sigmoid colon and lateral view of the rectum.
- Post evacuation radiographs may be helpful.

Quality controls specific to this study
- Each accessible segment of the colon is seen with compression during fluoroscopy
- Each segment of the entire colon is seen without overlap if possible
- Radiographic technique shall attempt to penetrate all segments of the colon.

Double contrast examination
- Low density barium suspension
- Kilovoltage of 90 kVp or greater, depending on the patient size.
- Barium suspension and air are introduced under fluoroscopic control to achieve adequate coating and distension of the entire colon.
- The colon should be examined fluoroscopically during the
course of the examination.

- Radiographs should be taken to attempt demonstrate all segments of the colon in double contrast. Suggested views include the following:
- Spot radiographs of the rectum, sigmoid colon, flexures, and caecum in double contrast.
- Radiographs including prone and supine views of the entire colon, sigmoid colon and lateral view of the rectum.

Quality control measures specific to a double contrast barium enema

- Adequate barium coating of the entire colon should be achieved.
- The colon is well distended with air
- Each segment of the colon is seen in double contrast on at least two radiographs taken at different positions, whenever possible.

Documentation

The result of the examination should be communicated to the referring physician in accordance with National Standard on Communication in Diagnostic Radiology

Hysterosalpingography (HSG)

HSG is gynaecological radiographic examination aimed at imaging of the cervical canal, uterine cavity, fallopian tubes and pelvic peritoneal cavity by injection of water soluble contrast media under fluoroscopic visualization. Provide anatomical detail of the female gynaecological organs and adjacent structures.

Indications:

- Infertility,
- Pelvic pain,
- Irregular menstrual cycles,
- Recurrent miscarriages,
- Congenital and anatomical variants,
- Prior to or after uterine or tubal surgery,
- Post operative assessment of the uterine cavity for patients prior to assisted reproductive technologies.

**Contraindications:**
- Pregnancy
- Active pelvic infection
- Active vaginal bleeding

**Personnel:**
- Radiologist and/or gynaecologist
- Medical imaging technologist
- Radiographer
- Nurse

**Standard examination procedure:**
The examination shall be performed:
- Within 10 days of the first day of the menstrual cycle and after bleeding has stopped.
- Under aseptic technique, the cervical canal is cannulated and water soluble contrast media administered under fluoroscopy.
- Spot films taken to demonstrate cervical canal, uterine cavity, fallopian tubes and surrounding peritoneal cavity.

**Excretory Urography**
Excretory urography is the radiological imaging the kidneys and urinary tract before and after the administration of intravenous contrast media. Anatomic and physiological handling of contrast media may reveal abnormalities. Excretory urography is a diagnostic radiological imaging test that can provide information about kidney and urinary tract.

**Indications:**
- Evaluation of hematuria
- Pain suggestive of renal or urinary tract origin
- Recurrent urinary tract infection
- Clinical suspicion of a renal mass
• Lower urinary tract obstruction
• Voiding problems
• Bed wetting
• Complex anomalies of the upper urinary tract
• Ureterolithiasis

Personnel:
• Radiologist
• Imaging Technologists
• Radiographer
• Nurse

Procedures:
  Patient preparation
  • Appropriate history and pre-procedure screening for various risk factors
  • Appropriate history of allergic reaction
  • Bowel preparation is as same as in barium enema
  • Image acquisition
  • Preliminary image shall cover KUB (Kidney Urinary Bladder)
  • Sequential post intravenous films shall be taken to evaluate the KUB

  After care
  • Observe the patient for any reactions and bleeding from the site of injection

Cystourethrography (CUG)

A radiological investigation for imaging the urethra and urinary bladder to demonstrate the anatomical and pathological conditions by intracavitary introduction of water soluble contrast media under fluoroscopy. To detect functional or anatomical structures of the lower urinary tract.

Indications:
• Lower urinary tract obstruction and its complications
• Trauma
• Fistulæ
• Vesicoureteric reflux

**Personnel:**
• Radiologist
• Medical Imaging technologist
• Radiographer
• Nurse

**Standard examination procedures:**
• Done under fluoroscopic control
• Contrast media is introduced into the urethra using folleys catheters under sterile conditions.
• Water soluble contrast media is introduced either in retrograde or antegrade.
• Spot films are taken to demonstrate the urethra and urinary bladder
• Abnormalities of surrounding structures including ureters may also be demonstrated.

**Standard for the Performance of Arteriography**
Arteriogram is defined as a procedure involving percutaneous passage of a needle and/or catheter into an artery followed by injection of contrast material and imaging of the vascular distribution in question using serial film or digital imaging systems. An established, safe and accurate method of evaluating vascular disease. The accuracy of other vascular imaging modalities shall be dependant on arteriography. However, arteriography is an invasive procedure with a small but definite risk of complications. To demonstrate the anatomy of the vascular distribution and the pathological patterns.

**Standard examination procedure:**
• Under sterile conditions the area of interest is cleaned.
• Specific puncture needles are introduced into the vessel with or without a guide wire and a cannula is introduced to the
vessel of choice.
• 20 - 60 mls of contrast media is introduced
• Spot images are taken at sites of interest.
• Serial changers and multi formatting camera are required
• DSI is of added advantage

**Standard for the performance of diagnostic cervicocerebral angiography in adults.**

Diagnostic cervicocerebral angiography is a process by which the intracranial and extracranial head and neck circulation is evaluated. It consists of placement of a catheter selectively into extracranial cervical vessels using imaging guidance, followed by contrast injection to delineate anatomy. The goal is to evaluate the extracranial and intracranial circulation and better define occlusive morphology, cause, extent and nature of occlusive lesion, and coincident and/or contributory pathology.

**Indications:**

- Definition of the presence and extent of atherosclerotic occlusive disease and thromboembolic phenomena.
- Definition of the etiology of cervicocephalic hemorrhage.
- Definition of the presence, location, and anatomy of extracranial and intracranial aneurysms and vascular malformations.
- Evaluation of vasospasm related to subarachnoid hemorrhage or drug-induced vasculopathy.
- Definition of the presence, nature, and extent of injury to cervicocerebral vessels.
- Definition of the vascular supply to tumors.
- Definition of the presence, and extent of vasculitis.
- Diagnosis and definition of the nature and extent of congenital or acquired vascular abnormality.
- Definition of the presence of venous occlusive disease.
- Definition of the relevant vascular anatomy for determining the effect of therapeutic measures.
- Physiological testing of brain function
Contraindications:
- No absolute contraindications to diagnostic cerebrocerebral angiography.
- Relative contraindications include hypertension, severe hypertension, coagulopathy, clinically significant iodinated contrast material sensitivity, renal insufficiency, and congestive heart failure.
- Patient management should address these relative contraindications prior to the procedure. Every effort should be made to correct or control these clinical situations before the procedure, if feasible.
- If the patient is known to be pregnant, the potential radiation risk to the fetus and clinical benefits of the procedure shall be considered before proceeding with the study.

Procedure:
- The catheter is usually inserted via a common femoral arterial access site, but other access sites may be used in selected case.
- Aortic arch injections may be performed to delineate the origins and/or tortuosity of the extracranial cervical vessels prior to selective catheterization.
- A selective study shall be performed unless severe occlusive disease prohibits safe selective catheterization.
- Injection of contrast medium shall be at a rate and volume that safely and adequately opacifies the vascular territory of interest.
- Optimal positioning, magnification, and filming rates are necessary to provide sufficient information regarding the disease and vascular territory being studied.
- Several projections may be necessary to best demonstrate the targeted area, but a minimum of two orthogonal projections is essential.
- Findings are acquired and stored either on conventional film or digitally on computerized storage media.
- Imaging and image recording must be consistent with the ALARA principle of radiation safety guidelines.
Personnel:

- Radiologist

Shall be familiar with all of the following:

- Indications and contraindications for the procedure.
- Pre-procedure assessment and intra-procedural monitoring of the patient.
- Pharmacology of conscious sedation medications and recognition and treatment of complications and reactions associated with them.
- Appropriate use and operation of fluoroscopic and radiographic equipment, mechanical injectors, rapid film changers, digital subtraction, and other electronic imaging systems.
- Principle of radiation protection, hazards of radiation exposure both to patients and radiologic personnel, and monitoring equipments.
- Pharmacology of contrast agents and recognition and treatment of adverse reactions to these agents.
- Percutaneous needle and catheter introduction techniques.
- Technical aspects of performing the procedure, including the use of alternative catheter and guide wire systems, selective angiographic methods, appropriate injection rates and volumes of contrast media, and filming sequences.
- Anatomy, physiology, and pathophysiology of intracranial and extracranial vascular.
- Interpretation of intracranial and extracranial vascular studies.
- Postprocedural patient management, especially recognition and initial management of complications.

Maintenance of Competence

- Radiologists shall perform a sufficient number of cervicocerebral angiography procedures to maintain their skill. Continued competence should depend on participation in a quality improvement program that monitors these rates. Appropriate attendance at postgraduate advances, newer techniques, and equipment is necessary.
Continuing Professional Development
- The radiologists continuing professional development shall be in accordance with the Uganda Medical and Dental practitioners council Standard for Continuing Professional Development (CPD).

Imaging Technologist / Radiographer
- Shall have the responsibility for patient comfort.
- Shall be able to prepare and position the patient for the arteriographic procedure and monitor the patient during the examination.
- Shall obtain the imaging data in a manner prescribed by the supervising radiologist.
- If intravenous contrast material is to be administered, qualifications for technologists performing intravenous injection shall be specified in compliance with national guidelines.
- Shall also perform regular quality control testing of the equipment in consultation with the medical physicist.
- Shall be trained in the use of the arteriographic equipment.
- Shall assist in performing and imaging the procedure.
- Shall demonstrate appropriate knowledge of patient positioning, arteriographic image recording, angiographic contrast injectors, angiographic supplies, and the physiologic monitoring equipment.
- Competent in vascular and interventional Radiology.
- Shall be trained in cardiopulmonary resuscitation and in the function of the resuscitation equipment.

Nursing Officer
- Is an integral part of the team for pre-and post-procedure patient management and education and
- Shall be recommended for monitoring the patient during the procedure.

If the patient does not receive conscious sedation, one of the staff assisting the procedure should be assigned to periodically assess the patient’s status. If the patient is to undergo conscious
sedation, a nurse or other appropriately trained individual should monitor the patient as his/her primary responsibility. This person should maintain a record of the patient's vital signs, time and dose of medications given, and other pertinent information. Nursing personnel should be qualified to administer conscious sedation.

**Equipment and facilities:**

- A high-resolution image intensifier and television chain with standard angiographic filming capabilities (including serial film changers, if necessary).
- Digital subtraction angiographic system with high spatial resolution is ideal for reduction of contrast material dose and reduced examination time.
- Adequate angiographic supplies such as catheters, guide wires, needles, and introducer sheaths.
- An angiographic injector capable of varying injection volumes and rates with appropriate safety mechanisms to prevent over injection.
- An angiography suite that is large enough to allow easy transfer of the patient from the bed to the table and to allow room for the procedure table, monitoring equipment, and other hardware such as intravenous pumps, respirators, anesthesia equipment, and oxygen tanks.
- An area within the institution appropriate for patient preparation prior to the procedure and for observation of patients after the procedure. This might be within the radiology department, in a short-stay unit, or on a routine nursing unit.
- There shall be immediate access to emergency resuscitation equipment.
- There shall be physiological monitoring and Resuscitation Equipment.
- Sufficient equipment shall be present in angiography suite to allow for monitoring the patient’s suite to allow for monitoring the patient’s heart rate, cardiac rhythm, and blood pressure.
- For facilities utilizing conscious sedation, a pulse oximeter
shall be available.

- There shall be ready access to equipment and drugs for emergency resuscitation.
- The equipment shall include an emergency defibrillator with paper recorder and quick view capability, oxygen supply and appropriate tubing and delivery systems, suction equipment, tubes and delivery systems, suction equipment, tubes for endotracheal intubation, laryngoscope, ventilation bag-valve-mask apparatus, and central venous line sets.
- Drugs for treating cardiopulmonary arrest, contrast reaction, casovagal reactions, narcotic or benzodiazepine overdose, bradycardia, and ventricular arrhythmias should also be readily available.

**Patient Care**

The indications for elective diagnostic cervicocerebral angiographic studies should be documented as described below.

- For emergency procedures, a note shall be written summarizing the indication for the study, the pertinent history and physical findings, if available and the proposed procedure.
- Clinically significant history including indications for the procedure.
- Clinically significant physical examination including detailed neurological and vascular examinations and a general examination of sufficient depth to exclude concurrent acute illnesses.
- Informed consent is recommended for these procedures and must be in compliance with state law.
- Laboratory evaluation may be indicated, including, but not limited to, measurement of hemoglobin, hematocrit, creatinine, electrolytes and coagulation parameters.

**Intra-procedure care**

- All patients shall have monitoring continuously during the procedure with intermittent blood pressure monitoring. A record of vital signs should be maintained.
- All patients shall have intravenous access in place for the
administration of fluids and medications as needed.

- If the patient is to receive conscious sedation, pulse oximetry should be used. A registered nurse or other appropriately trained personnel shall be present, and his/her primary responsibility should be to monitor the patient. A record shall be to monitor the patient.
- A record shall be kept of medication doses and times of administration.
- All patients shall have frequent assessments of their neurological status throughout the course of the procedure.
- A medical doctor shall be available during the immediate post procedure period to ensure that there is adequate compression of the puncture site and that the patient’s cardiovascular status and neurological status are stable prior to transfer to the post procedure care area.

Post procedure care.

- A procedure note shall be written in the patient’s chart summarizing the major findings of the study and any immediate complications. This note may be brief if a formal report will be available within a few hours. However, if the typed report is not likely to be on the chart the same day, a more detailed summary of the study should be written in the chart at the conclusion of the procedure.
- In all cases, pertinent findings shall be communicated to the referring clinician in a timely manner.
- All patients shall be at bed rest and observed in the initial postprocedure period. The length of this period of bed rest will depend on the site and size of the arteriotomy and the patient’s medical condition.
- During the initial post procedure period, skilled nurses or other appropriately trained personnel should periodically monitor the puncture site and the status of the distal vascular distribution.
- The patient shall be monitored for urinary output, cardiac symptoms, pain, and other indicators of systemic complications that may necessitate overnight care.
- Initial ambulation of the patient must be carefully supervised.
Vascular perfusion, puncture site stability, and independent patient function and mobility must be assured.

- Since all diagnostic cervicocerebral angiography studies require catheter manipulation in the thoracic aorta and the brachiocephalic vessels, neurologic status shall be assessed frequently and at regular intervals.
- The operating radiologist or a qualified designee should evaluate the patient after the procedure, and these findings shall be summarized in a progress note. If conscious sedation was administered prior to and during the procedure, complete recovery from conscious sedation must be documented. The radiologist or designed shall be available for continuing care during hospitalization and after discharge. The designee may be another medical officer or a nurse.
- When the complication occurs in a small volume of patients (e.g., early in a quality improvement program). In this situation, the overall procedure threshold is more appropriate for use in a quality-improvement program.

**Pulmonary Arteriography**

**Indications**

- Diagnosis of pulmonary embolus (gold standard).
- Diagnosis of chronic emboli
- Preoperative planning for pulmonary thromboembolectomy
- Unusual indications include the evaluation of pulmonary arteriovenous malformations congenital anomalies, preoperative evaluation of pulmonary malignancies, and for the diagnosis of vasculitis and other primary abnormalities of the vessels.

**Bronchial arteriography**

**Indications:**

- Severe haemoptysis
- Evaluation of congenital anomalies of the pulmonary vasculature.
- Screening patients for pulmonary thromboendararterectomy.
Spinal Arteriography

Indications:
- Evaluation of vascular malformations
- Evaluation of primary and metastatic tumors.
- Preoperative evaluation prior to aortic or spinal surgery
- After spinal trauma
- A follow-up study is often needed to evaluate the results of therapeutic procedures.

Thoracic and Abdominal Aortography

Indications:
- Intrinsic disease such as traumatic transection, dissection, and aneurysm
- Preliminary study to evaluate the origins of branch vessels.
- Perform aortography prior to a selective study of the aortic branches.
- Surgical planning
- To diagnose congenital anomalies, vasculitis, and vascular manifestations of systemic diseases.
- Preoperative planning of endovascular or surgical bypass procedures.

Abdominal Visceral Arteriography

Indications
- Study of the abdominal visceral organs
- Evaluation for hemorrhage and tumors,
- Preoperative evaluation to determine respectability, vascularity, vessel anatomy, and the need for preoperative or chemotherapeutic embolization
- Postoperative evaluation
- Diagnosis of primary vascular abnormalities.
- Diagnosis and grading of portal hypertension,
- The evaluation of varices.
- The preoperative planning and postoperative evaluation of transjugular intrahepatic portosystemic shunt (TIPS)
• Surgically created portosystemic shunts
• Chronic ischemia (abdominal angina) and acute mesenteric ischemia of ten require arteriography for accurate diagnosis.
• Evaluation of blunt and penetrating abdominal trauma particularly in the planning of transcatheter or surgical intervention.
• Miscellaneous vascular pathology.

Renal Arteriography

Indications
• Evaluation of renovascular hypertension,
• Renal insufficiency,
• Trauma,
• Renal tumors
• Screening of renal transplant donors
• Renal artery stenosis
• Preoperative planning for angioplasty or surgery
• Aortography shall be performed prior to selective renal arteriography to evaluate for multiple renal arteries and to avoid vascular trauma in those patients with severe aortic and renal vascular disease.
• Diagnose vasculitis
• Evaluate haematuria when previous workup has been negative.

9.2.15 Pelvic Arteriography

Indications:
• Evaluation of the pelvic organs and the branches of the Hypogastric [internal iliac] arteries)
• Evaluation of gastrointestinal or genitourinary bleeding).
• Benign and malignant tumors, trauma, arteriovenous malformations, uterine bleeding and postpartum hemorrhage.
• Evaluation of embolotherapy
• Male sexual dysfunction for evaluation of hypogastric vessels,
as occlusive disease of the internal pudendal arteries is one cause of impotence.

- Evaluation of the lower extremities for vascular disease.
- Evaluation of atherosclerotic occlusive or aneurysmal disease.

**Lower Extremity Arteriography**

**Indications:**
- The study of the upper and lower limb extremities
- Atherosclerotic occlusive or aneurysmal disease,
- Vascular trauma,
- Entrapment syndromes,
- Tumours,
- Preoperative evaluation prior to reconstructive and plastic surgery,
- Evaluation of prior vascular bypass grafts or arteriovenous grafts
- Fistulas,
- Evaluation of vasculitis
- Primary vascular abnormalities.
- Evaluation of the extent and severity of atherosclerotic vascular disease. This may include occlusive, thrombotic, aneurysmal, or embolic disease. The clinical manifestations pain, skin ulceration, gangrene, and blue toe syndrome.
- Acute ischemia, embolism, aneurysm, and trauma,
- Diagnosis of vascular insufficiency and to determine the vessel segments involved.
- Provide a baseline for post procedure follow up and evaluation of suspected complications.

**Upper-extremity arteriography**

**Indications:**
- Evaluate the extent of atherosclerosis and the secondary effects of atherosclerosis, such as emboli.
- Extremity claudication, acute or chronic arterial trauma,
thoracic outlet obstruction, certain vasculitis, and subclavian steal.

- Dysfunction of dialysis fistulas and grafts, which may be manifested by abnormal physical examination,
- Low intra-access flow,
- High venous pressures,
- Inadequate dialysis,
- Thrombosis
- Arterial inflow and venous outflow.

**Contraindications to arteriography**

- Hypertension (relative)
- Coagulopathy
- Clinically significant iodinated contrast material sensitivity,
- Renal insufficiency,
- Congestive heart failure.

Patient management shall address these relative contraindications prior to the procedure. Every effort should be made to correct or control these clinical situations before the procedure, if feasible.

**Qualifications, Responsibilities for Personnel, pre, intra and post procedure care plus equipment**

The qualifications, duties, patient care and equipment are the same as those for cerebral angiography

**Quality Control and Improvement, Safety, Infection Control, and Patient Education Concerns**

Refer to the relevant chapters.

9.4 Myelography

Myelography is a diagnostic modality for the investigation of a wide range of spinal disease processes. Myelography can be performed in the cervical, thoracic, and/or lumbar regions.

- Conventional myelography
- Conventional myelography followed by a CT myelography
- CT myelography without preceding conventional myelography
Indications:
- TB spine
- Trauma
- PID (Prolapsed Intervertebral Disc)
- Tumour
- Post surgery

Personnel
- Radiologist
- Imaging Technologists
- Radiographer
- Nurse

Procedure:
Proposal patient care
- Review of clinical history and other findings
- Informed consent shall be obtained and documented
- Patient shall be adequately hydrated prior to investigation
- Life Support devices for securing the patient
- Post procedural care
- Patient shall adequately be hydrated
- Patient shall be observed following the examination
- For outpatients, instructions shall be given to limitations to drive or otherwise

Equipment
- Myelography Facility
- The minimum requirements for the facility are:
- High-quality imaging equipment, including an image intensifier, television chain, film or digital recording of the examination, and a tilt table. A CT scanner to perform post-myelogram CT studies must be available.
- An adequate selection of needles and appropriate non-ionic contrast agents approved for intrathecal use.
- Appropriate facilities and equipment for treatment of adverse reactions (e.g., seizures, vasovagal reaction and/or cardiorespiratory collapse).
- Appropriate trained personnel to provide proper patient care
and operation of the equipment.

- Surgical and emergency Support
- Although serious complications of myelography are infrequent, there should be prompt access to surgical and interventional management of complications.

**Procedures:**

**Procedural patient care**

- The clinical history and findings are to be reviewed by the performing physician. Specific questions with respect to relevant medication, prior seizures, prior allergic reactions and clotting ability should be asked of the patient.
- Informed consent should be obtained and documented.
- The vital signs and neurological level of consciousness should be recorded.
- The patient should be adequately hydrated prior to and following myelography.
- Administration of sedation should be in accordance with the National standard for adult Sedation/ Analgesic.

**Relative Contraindications to myelography**

- Known significant intracranial process with mass effect.
- Historical or laboratory evidence of coagulopathy.
- Previous myelography performed within 1 week
- Generalized septicemia
- History of significant adverse reactions to iodinated contrast media.
- History of seizures (patient may be premeditated).
- Grossly bloody spinal tap (may proceed when benefit outweighs risk).
- Localized infection at region of puncture site.
- Pregnancy.

**Procedure**

- Proper support devices for securing the patient on the table should be available.
- For myelography, pertinent findings should be documented on film or digital media.
Post-Procedural Care

- The patient should be adequately hydrated following myelography.
- The patient should be observed following the examination.
- If the myelography is performed on an outpatient basis, the patient should be properly instructed regarding limitations following the procedure (e.g. driving).
- Instructions regarding post-procedural care, including warning signs of adverse reactions, should be given to the patient by a trained professional.

Documentation

A written report should be generated and communicated to the referring physician in accordance with the National Standards on Communication in Diagnostic Radiology.

Please note that all reports of special contrast studies shall be written by a Radiologist according to the standard format recommended by these standards.

9.5 Standard for Interventional Radiology

Intervention radiology is defined as use of radiological imaging techniques in guiding diagnostic and therapeutic procedures. The imaging modalities used for guidance include ultrasound scan, fluoroscopy, computed tomography and magnetic resonance imaging. The choice depends on the availability of the imaging modality, their applicability in the patient condition and cost effectiveness. The diagnostic and therapeutic procedures include biopsies, drainage of cysts, abscesses and effusions, placement of balloon angioplasty, stents, embolizations and tumour ablation therapies, plus any other diagnostic and therapeutic procedures requiring image guidance. The goal is to provide safe and quick diagnostic and therapeutic procedure to patients.

This reduces on morbidity, mortality and hospital stay, thus being cost effective.
Indications:
- To obtain material for cytological histological, microbiological and biochemical analysis.
- Staging of patient with known or suspected malignancy
- Determine nature and extent of diffuse parenchymal diseases.
- Delivery of medical, chemo, and surgical therapy
- Relieve of obstruction e.g. Stone, thrombus
- Removal of foreign bodies

Contraindication:
- Uncorrectable severe coagulopathy e.g. Patients with liver or multi system failure.
- Terminally ill patients for whom death is imminent
- Non consent
- Uncooperative patient (relative contra indication)

Personnel and Administration:
- Radiologists or Medical Officer with training and experience who has performed at least 15 similar procedures successfully under supervision of the radiologist - To perform the procedure.
  Anaesthesiologist - for sedation and monitoring the patient vital signs
- Nurse - Preparation of trolley and assist during the procedure
- Radiographer - Planning and executing all radiographic techniques.
- Medical Physist - For functioning and maintenance of the equipment
- Sonographer for assisting in imaging and documentation

Procedure:
- Ultrasound machine, fluoroscopy, CT and MRI
- Disposables: Needles, catheters, cannulas, guidle wire, cotton, gauze, plaster etc.
- Drugs: Analgesic, sedatives, antibiotics, contrast medium
etc. Oxygen cylinders

- Others: Blood Pressure and stethoscope machines

9.6 Quality Control, Improvement and Safety, Infection Control and Patient Education

Patient Education:
- Patient selection
- Patient preparation - physical preparation / psychological preparation
- Physical preparation:
- Do coagulation parameters and other relevant laboratory tests.
- Admit if applicable
- BP / pulse and other vital physical assessment
- Giving instructions (if any)
- Psychological preparation:
- Explain the procedures
- Benefits
- Risks
- Duration of procedure
- Type of sedation
- Patient consent - informed consent for elective patients
- Emergencies - Relative / attendant / physician in case of no attendants
- Consent form - name of doctor / team performing the procedure
- Date and time
- Sign of patient and witness

Infection Control:
- Dedicated intervention suite
- Sterile equipment
- Disposable needles and syringes
- Antibiotic cover (pre-medication) if applicable
Quality control and improvement:
- Success rates
- Complications

Documentation / Records
- Procedure
- Equipment used
- Type of biopsy
- Condition of patient after procedure till discharge
- Post procedure care
- Medications

9.7 Standards for Computed Tomography (CT SCAN)
Computed tomography is a high imaging modality that uses highly
collimated x-ray beam, detectors and computer system to produce
cross sectional imaging of any body part. This calls for trained staff
to operate the equipment and interpret the information generated
and the examination must be justified based on medical reasons put
forward by referring clinician.

Personnel and responsibilities:
Personnel involved in CT imaging are the following:
- Radiologists
- Medical imaging technologist
- Radiographers
- Medical physicist
- Biomedical engineer

See chapter 3 for qualifications and responsibilities of Radiation
workers.

Equipment specifications:
See chapter 5 for specifications on CT.

Specific examinations:
- Brain CT:
  Contiguous or overlapping axial slices of not greater than 10mm
  in older children and adults and 5mm for infant. Posterior fossa
be imaged with 5mm slice thickness or less. For measuring foil
2D reformatting and 3D reconstruction 2mm slice thickness or
less shall be used. Viewing shall be optimized for both soft and
bone window especially in trauma cases.

Head and Neck CT:
- Lateral scanogram view is acquired
- Contiguous 5mm slices in children and adults, and 3mm in
infants and these are viewed in both soft and bone windows.
- Orbital CT scan 3 - 5 mm slice thickness axial and coronal and
some with paranasal sinuses. For 3D reconstruction 2mm
slice thickness in advised.
- Facial bone CT scan 2 - 5 axial or coronal scans and for 3 D
reconstruction 1 - 2 mm slice thickness. The smaller the slice
thickness the better the resolution especially for thin bones.

Spinal CT scan:
- Lateral scout view/scanogram is acquired
- Axial 3 - 5 mm slices which are contiguous are optimal for
trauma and degenerative disease with scan planes parallel to
endplates in mid position. Axial and 2D reforming as well as
volume rendering should be done where possible. Axial and
reformatted images should be viewed in soft and bone
window.
- Focused scans for discs will require changing gantry for each
disc especially in cervical and lumbo-sacral spine for scan
planes to be parallel to endplates
- Bone algorithm should be used if osseous disease is
suspected.
- Cerebral Spinal Fluid (CSF) contrast administration to
improve delineation of thical space to ease visualization of
the cord is done using non-ionic contrast medium.
- For pituitary fossa coronal scans of 2mm or less slice
thickness will be employed. Failure of patient to conform to
the position in respect to maximum gantry till to obtain true
coronal plane or case of severe beam hardening artifacts
form dental fillings, axial 2mm slices are employed and
retrospective reconstruction to 2mm collimation then done.
Cerebral CT Arteriography:
Rapid uniform IV injection of 100 - 120 mls of non-ionic contrast medium of 60-75% iodine concentration using pressure injection at rate of 3-7 mls and a 20 gauge cannula in medium antecubital vein with delay of 15-20 seconds with spiral CT acquisition at 1mm collimation. Soft tissue window viewing and reformatting and 3D reconstruction images are done. For various phases, repeat scans are done at 40 seconds delay using some protocol above.

Chest CT scan:
The approaches vary according to indication.
Axial non enhanced images of 5-10mm slice thickness with patient in supine position is preferred followed by high resolution CT through areas of interest which entails thin slices (1mm) at high maximum resolution (512 x 512) matrix with narrowed field of view and using high kV and mAs to improve signal to noise ratio. Breath holding is necessary and viewing is optimized at -700 window level and 650 window width for lung fields and 20 window level with 400 window width for mediastinum.

Contrast medium (40-60mls) administered to characterized masses but for study of vessels automatic injection of 120 - 150 mls at a rate of 24mls/second using an 16-20 gauge needle in antecubital vein with a 20 seconds delay are done at 3-5 mm slice thickness. Images are displayed in mediastinal window and 2D reformatting as well as 3D reconstructions done.

Chest wall and pleura will be covered during a conventional chest CT as long as the thoracic inlet down to adrenal areas are included.

Abdominal and pelvic CT scan:
- AP scout views/scanography is acquired.
- Contiguous 10 mm slices are optimal for the abdomen and pelvis.
• The additional 5mm slices shall be done depending on area of interest.
• Pre contrast and contrasted Imaging is required.
• Oral contrast for opacifying the Gastro Intestinal Tract (GIT) in the following proportions 500ml, 300 ml, and 200 ml for lower, mid and upper GIT respectively. The time intervals are in the form of intervals of 45 minutes at 1 hour respectively.
• Enhanced scans protocol vary according to area of interest and the pathology
CHAPTER TEN

10.0 STANDARDS FOR PERFORMANCE OF ULTRASOUND

10.1 Obstetric Scan
This represents the minimum standard required for the performance and documentation of obstetrical ultrasound. Adherence to the proposed standards will increase the benefit ultrasonography offers in the management of obstetric patients and maximize the possibility of detecting many foetal anomalies. Foetal ultrasound shall be performed only when there is a valid medical reason. A limited examination may be performed in clinical emergencies or used as a follow-up to a complete examination. Additional and/or specialized examinations may be necessary. The goal is to perform diagnostic imaging of the body organs using ultra sound equipment and detect any abnormalities.

Personnel:
- Radiologists
- Sonologists
- Medical Imaging Technologists
- Radiographers
- Sonographers

Equipment
Obstetric sonography shall be performed with real time ultrasound equipment using a transabdominal and/or transvaginal approach.

A transducer of appropriate frequency should be used. A lower frequency transducer (2.5MHZ) may be used in obese patients. A 5 to 7.5MHZ transducer is recommended for vaginal ultrasound.

The lowest possible ultrasonic exposure settings should be used to gain the necessary diagnostic information. 3.5 to 5MHZ abdominal transducers allow sufficient penetration in most patients while providing adequate resolution.
Standards for examination procedures:

a) First Trimester Sonography

Indications:
The indications for first trimester ultrasound examination include but not limited to the following:

- To confirm the presence of an intrauterine pregnancy
- To evaluate a suspected ectopic pregnancy.
- To define the cause of vaginal bleeding of undetermined aetiology.
- To estimate gestational age.
- To confirm suspected multiple gestation and their chorionicits.
- To confirm embryonic life.
- To evaluate pelvic masses.
- To detect uterine abnormalities.
- As an adjunct to chorionic villus sampling, amniocentesis, embryo transfer, and intrauterine device (IUD) localisation and removal.
- To detect embryonic abnormalities

Procedures:

- Scanning in the first trimester may be performed either abdominally or vaginally.
- Transabdominal examination is performed and if it fails to prove definitive information then a transvaginal scan should be performed whenever possible.
- The uterus and adnexae shall be evaluated for the presence of a gestation sac and if a gestation sac is seen its location shall be documented.
- The embryo, yolk sac, amniotic fluid, amnion and chorion shall be studied and the gestation sac wall shall be
evaluated.

- The presence or absence of an embryo shall be noted and the crown-length (CRL) recorded. When the embryo is not identified, the mean diameter of gestational sac shall be evaluated for presence and size of the yolk sac.
- The CRL is a more accurate indicator of gestational age than is gestational sac diameter.
- Presence or absence of cardiac activity shall be documented. If embryo less than 5mm in length is seen with no cardiac activity, a follow up scan may be needed to document embryonic life.
- At late first trimester, biparietal diameter and fetal femoral length measurements may also be used to establish age.
- Fetal number and chorionicity shall be documented.
- Multiple pregnancies should be reported only in those instances in which multiple embryos are seen.
- The nuchal translucency may be measured.
- Limited examination may be performed to follow up growth, estimate amniotic fluid, check cervical length and assesses viability.
- Evaluation of the uterus, adnexal structures, and cul-de-sac shall be performed.
- The correlation of beta HCG and/or progesterone levels with ultrasound findings is helpful in differentiating normal pregnancy from abnormal pregnancy / ectopic pregnancy

b) Second and Third Trimester Sonography

Indications:

- All pregnant women should undergo at least one obstetric scan during the pregnancy (best done at 18 - 22 weeks) to identify and monitor those at risk.

Other indications for second and third trimester ultrasound include but are not limited to:

- To estimate gestation age for the patients for patients
with unsure of clinical dates or verification of fetal age for patients scheduled to undergo caesarean section, termination of pregnancy or induction of labour

- Assessment of liquor volume, placental site, cervical length, maternal pelvis and kidneys.
- To determine fetal presentation.
- To evaluate uterine size and clinical dates discrepancies
- To evaluate fetal growth e.g. where intrauterine growth retardation or macrosomia is suspected.
- To estimate fetal weight
- As an adjunct to an amniocentesis, percutaneous umbilical blood sampling or cerclage placement
- To evaluate a suspected uterine abnormality such as a leiomyoma or uterus didelphis
- To evaluate abnormal maternal serum alpha feto protein values
- To evaluate suspected polyhydramnios or oligohydramnios
- To evaluate suspected abnormalities of the placenta, including placenta abruption, placenta previa or placenta accrete
- To evaluate vaginal bleeding or suspected amniotic fluid leakage
- To evaluate and follow up of suspected fetal anomalies
- To evaluate patients with a history of prior congenital anomalies
- Biophysical fetal profile for evaluation of fetal well being including fluid volume, fetal tone and body movements fetal breathing, and heart rate patterns

**Procedures**

Fetal life, number, presentation and activity should be documented.

- Abnormal heart rate and / or rhythm shall be reported.
- Multiple pregnancies require the documentation of addition information, placental number, sac number, comparison of fetal size, presence or absence of an interposed membrane, amount of amniotic fluid
standards on diagnostic imaging and therapeutic radiology for Uganda

- An estimate of the amount of amniotic fluid (increased, decreased or normal) shall be reported.
- The placental location, appearance and relationship to the internal cervical os shall be recorded.
- The umbilical cord shall be imaged, and the number of vessels in the cord should be evaluated when possible.
- Apparent placenta position early in pregnancy may not correlate well with its location at the time of delivery.
- An over distended maternal urinary bladder or a contraction in the lower uterus can give the examiner a false impression of placenta previa.
- Transabdominal, transperineal or transvaginal views may be helpful in visualising the internal cervical os and its relationship to the placenta.
- Assessment of gestation age shall be accomplished at the time of the initial scan using a combination of femur length (FL) and biparietal diameter (BPD), corrected BPD or head circumference. Fetal weight (os opposed to age) shall be estimated in the late second and in the third trimester and also requires abdominal diameters or circumferences.
- Estimated fetal weight shall be compared with the weight expected for the fetus’ estimated gestation age. If previous studies have been performed, an estimate of the appropriateness of interval growth should be given.
- Third trimester measurements may not accurately reflect gestation age. Initial determination of gestational age shall therefore be performed prior to the third trimester whenever possible. If one or more previous studies have been performed, the gestational age at the time of the current examination shall be based on the earliest examination that permits measurements of CRL, BPD, HC and/or FL by the equation: current fetal age-estimated age at time initial study + number of weeks elapsed since first study. The current measurements should be compared with norms for the gestational age based on
standard tables. If previous studies have been performed, interval change in the measurements should be assessed. Fetal weight should be estimated and compared with expected fetal weight for the fetus assigned gestational age using standard tables or calculation programmes.

• BPD shall be measured at a standard level, typically an axial plane that includes the thalamus, falx and cavum septum pellucidum.

• When the fetal head is dolichocephalic or brachycephalic, the BPD alone may be misleading.

• The computation of the cephalic index, a ratio of the BPD to fronto-occipital diameter may be necessary.

• The head circumferences is measured at the same level as the BPD, around outer perimeter of the cranium.

• Femur length shall be measured routinely and recorded after the 14th week of gestation. The measurement of the long axis of the femur shaft is most accurately performed with a linear array transducer with the beam perpendicular to the shaft excluding the distal femoral epiphysis.

• There is considerable biological variation in normal femur length late in pregnancy.

• Abdominal circumference shall be determined on a transverse view at the level of the junction of the umbilical vein, portal sinus, and fetal stomach when visible.

• Abdominal circumference measurement is necessary to estimate fetal weight and may allow detection of growth retardation and macrosomia.

• Evaluation of uterus (including the cervix) and adnexial structures shall be performed.

• The presence, location and size of myomas and adnexal masses shall be recorded.

• The study shall include, but not necessary be limited to, assessment of the following fetal anomalies:

• Cerebral ventricles, choroids plexus, posterior fossa (including cerebellar hemisphere and cisterna magna), four-chamber view of the heart (including its position
within the thorax), spine (longitudinal and transverse views), stomach, urinary bladder, fetal umbilical cord insertion site and intactness of the anterior abdominal wall and the kidneys.

- It is recognised that not all malformations of the above mentioned organ systems (such as the spine) can be detected using sonography.

**Documentation**
Adequate documentation of the study is essential for high quality patient care. This shall include where possible a permanent record of the ultrasound images, incorporating whenever possible the measurement parameters and anatomical findings proposed in this document.

Image shall be appropriately labelled with the examination date, patient identification, and appropriate, image orientation. A written report of the ultrasound findings should be included in the patient’s medical record. The ultrasound examination shall be consistent with both clinical need and relevant legal and local healthcare facility requirements.

**Quality Control and Improvement, Safety, Infection Control, and Patient Education Concerns**
Policies and procedures related to quality, patient education, infection control, and safety should be developed and implemented in accordance with the Ministry Of Health Policy on Quality Control and Improvement, Safety, Infection Control, and Patient Education Concerns appearing elsewhere in the Standard manual.

**10.2 Female Pelvic scan**
Examination of the female pelvis using ultra sound to detect abnormalities.

**Goal:**
To assist or to provide practitioners with appropriate modality to detect every abnormality within the female pelvis.
Indications:
- Evaluate the size shape and location of the uterus.
- Evaluate the endometrium, myometrium and cervix
- Identify ovaries in the Adnexia
- Evaluate free fluid in the cul-de-sac
- Detect fluid in the fallopian tubes
- Detect adnexial abnormalities
- Establish cause of PV bleeding
- Evaluate the causes of acute lower abdominal pain
- Evaluate the presence and size of myomas

Personnel:
- Radiologists
- Sonologists
- Medical imaging technologists
- Radiographer
- Sonographer

Procedure:
- The patient’s urinary bladder shall be adequately distended for transabdominal pelvis scan. Not necessary for transvaginal scan.
- A second female persons’ presence is recommended when performing transvaginal scans.
- The recording of the uterine length is taken from the sagittal (long axis) plain of the uterus from the fundus to the cervix, the depth of the uterus AP is measured from anterior to posterior wall.
- Endometrium shall be analyzed for thickness, echogenicity and its position within the uterus.
- The myometrium and cervix shall be evaluated for contour changes, echogenicity and masses.
- Document the size and position of ovaries in relation to the uterus.
- Dilated tubular structures shall be documented.
- Doppler ultrasound may be used in some cases to identify
the vascular structures from tubular structures.
- Transvaginal scan may be useful to distinguish a suspected mass from fluid and faeces within the normal rectosigmoid.
- Vaginal probes shall be covered by a protective sheath (condom) prior to insertion.

**Equipment:**
- A real time scanner, preferably using sector or curve linear or transvaginal transducers (probes).
- High frequency shall be used keeping mind the trade-off between resolution and beam penetration.
- Transabdominal shall use 3.5 MHz or higher while transvaginal shall use 5MHz or higher.

**Documentation:**
- A permanent record of ultrasound examination shall be performed and included on the patient medical record in form of sonogram
- Reporting shall be done by the listed personnel above.

### 10.3 Abdominal ultrasound scan

It is a procedure for the evaluation of many structures within the abdomen and the retroperitoneum using real time ultrasound scanners. The goal is to detect abdominal abnormalities using ultrasound.

**Indications:**
Abdominal and retroperitoneal indications include but are not limited to:
- Abdominal flank and or back pain
- Abdominal mass (es)
- Abnormal laboratory results suggestive of abdominal or retroperitoneal pathology
- Follow up of known pathology of the abdomen or retroperitoneum
- Search for metastases or occult primary lesions.
- Evaluation of suspected congenital abnormalities
- Establishing Abdominal trauma
Contraindications
There are no absolute contraindications but otherwise a valid medical reason shall be required.

Personnel:
- Radiologists
- Sonologists
- Medical Imaging technologists
- Radiographer
- Sonographer

Equipment:
- Transabdominal scanning is the most recommended.
- Curvilinear, sector and linear probes are used depending on the type of examination being performed.
- Low frequency transducers are preferred for adults and thicker body parts.
- High frequency is recommended for small superficial structures.

Procedures:
Liver
- The examination of the liver shall include sagittal and transverse use.
- Evaluate liver parenchyma for focal and/or diffuse abnormalities
- Compare the liver spleen and kidney echogenicity
- Assess tubular structures within and adjacent to the liver.
- Evaluate Hepatic lobes (right, left and caudate)
- Evaluate Hepatic fissures if possible
- Right hemi diaphragm and pleural space.

Gallbladder
- Patient preparation shall be necessary for examination of Gallbladder and biliary tract such as fasting for 8-12 hours prior to the examination
- Evaluation of the wall thickness, intrahepatic duct dilatation
wall thickening, filling defects and other abnormalities.

- Pancreas
- Evaluate the size of the bile duct at the porta hepatis and distal common bile duct at the pancreatic head if possible.
- The preparation for pancreatic examination shall require orally administered water five minutes prior to the examination
- Evaluate the head, uncinate process, body and tail of pancreas for parenchymal abnormalities.
- Doppler scanning studies shall be used to differentiate pancreatic vascular structures.

**Spleen**
- The examination of the spleen shall include sagittal and transverse views
- Evaluate the parenchyma for focal and/or diffuse abnormalities
- Compare the spleen and the kidney echogenicity if possible
- Spleen size (measure)
- Evaluate the Left hemidiaphragm and pleural space

**Kidneys**
- The examination of the kidneys are performed by sagittal, transverse and coronal scans
- Evaluate the position, size, shape and echogenicity to the kidney where possible.
- Evaluate perirenal regions.
- Doppler shall be used to differentiate renal vascular from nonvascular structures whenever indicated.

**Urinary bladder**
- Requires fully distended urinary bladder, before examination
- Evaluate the urinary bladder wall and lumen for abnormalities
- Evaluate distal ureter for dilation (reflux) or any abnormalities
- Quantify and report on the post-void residual urine.
• Prostrate

**Adrenal glands**
• Usually seen in newborn and young infant and less frequently seen in adults.
• When visualized document the size, shape, presence of hemorrhage, masses, or other abnormalities.

**Aorta**
• Shall be imaged in axial and transaxial planes.
• Document size at the proximal, mid, distal aorta and proximal iliac arteries.
• Measurements shall be from outer wall to outer wall both in the axial and transaxial sections
• Evaluate aorta patency for stenosis and aneurysm
• Doppler scan shall be used to establish vascularity and velocity flow.
• Surrounding soft shall be assessed for any abnormalities.

**Inferior vena cava**
• Performed in transverse and longitudinal planes
• Evaluate the patency and abnormalities with doppler
  o Small parts scan
  o Doppler /vascular studies

**10.4 Thyroid Ultrasound**
• Assist us to develop safe and effective use of diagnostic ultrasound
• Maximize probability to detect most abnormalities
• Not all abnormalities may be detected but additional and/or specialized examination may be necessary.

**Indications of Thyroid / Parathyroid ultrasound**
• Palpable neck masses
• Abnormalities detected on thyroid scintigraphy ie. Area of abnormal uptake of radio-isotope thyroid examination.
• Evaluate, presence, size and location of thyroid gland
• Evaluate regional nodal metastases with proven thyroid gland carcinoma.
• Evaluate high risk patients for occult thyroid malignancy
• Follow up thyroid nodules on suppression therapy
• Localize parathyroid glands in suspected primary and secondary hyperparathyroidisms (not reliable)
• Assess the number and size of enlarged parathyroid glands in patients with previous parathyroid surgery or ablative therapy in recurrent hyperparathyroidism.
• Interventional procedures eg. US guided Biopsy

Personnel:
• Radiologist
• Sonographer
• Medical Imaging Technologist
• Sonologist

Procedure:
• Patient position: Supine, neck extended and pillow under the shoulder
• Scans done in longitudinal and transverse views and if necessary oblique projections for RT, LT lobes and isthmus.
• Transverse views should demonstrate superior mid and inter positions
• Longitudinal views should demonstrate media, mid and lateral positions
• Comparison of both lobes should be done
• Thyroid abnormalities should be documented ie. Location, size and number.
• Demonstrate abnormalities of the adjacent soft tissues ie. vessels, muscles, and lymph nodes.
• Doppler sonography may be employed to localize masses, distinguish cysts from vessels and identify vascular abnormalities.
• Ultrasound guidance may be used to biopsy thyroid masses.
Equipment:
- High frequency linear array probe 5 - 12 MHz
- Lower frequency for larger thyroids.

Documentation:
- There should be a permanent record of ultrasound examination and interpretation.
- Images of normal and abnormal areas should be labelled with examination date, patient identification and image orientation date, patient identification and image orientation.
- A report of ultrasound should be included in the patient’s medical records
- A copy of the ultrasound examination report it recorded and retained. It should be consistence with the clinical indication relevant medico-legal requirements.

Quality control improvement, safety, infection control and patients’ concerns
- Abide to policies and procedures related to quality control
- Abide to infection control measures as per UNSDITR
- Address patient’s concerns and patient education.
- Normal parathyroid glands not usually visualized on ultrasound.
- However, when enlarged and can be visualized document then document the number, size and measurements in 2 or 3 dimensions.
- Radioisotope scan imaging is recommended for correction.
- Ultrasound may be used for interventional procedure

10.5 Shoulder ultrasound:
These standards assist us to develop safe and effective use of diagnostic ultrasound for shoulder pathology
- Assists the practitioner to maximize detection of
abnormalities of the shoulder
• Not all abnormalities are detected hence additional or specialized examinations are necessary.

Indications:
• Shoulder pain
• Shoulder dysfunction
• Rotator cuff tears
• Biceps tendon abnormalities
• Tumors around the shoulder joint
• Interventional procedures

Personnel:
• Radiologist
• Sonologist
• Sonographer
• Medical Imaging Technologist

Equipment:
• 7-13 MHz linear array transducer
• When the rotator cuff is much deeper than normal 5MHz, transducer may be required
• Colour Doppler application are required to differentiate inflammatory from degenerative process.

Procedure:
• Patient should be in the sitting position
• The radiologist stands behind the patient to scan

Biceps Tendon:
• The forearm should be in a supinated position on the thigh
• Transverse and longitudinal views are done

Subscapularis tendon
• The arm is placed in external rotation
• Transverse and longitudinal view are done
Supraspinatus tendon and infraspinatus tendon
- Shoulder extended and neutral rotation (hand in ipsilateral back pocket)
- Shoulder extended and internally rotated (hand touching contra lateral scapula)
- Transverse and sagittal views are done
- Infraspinatus and teres minor: The arm across the front chest and the hand resting on the opposite shoulder.
- Transverse and sagittal views are done.
- Comparison views with contralateral shoulder should be observed.
- The glenohumeral joint motion should be assessed
- There should be a permanent record of u/s examination and interpretation.
- Images of normal and abnormal areas should be done
- Documentation of size with corresponding measurement should be done.
- Images should be labelled with examination date, patient identification and image orientation.
- A report of US findings should be included in patients medical records
- Permanent record of US examination should be retained and consistent with clinical indication and relevant medical legal requirements.

Quality Control and Improvement Safety and Infection Control
- Abide to policies and procedures related to quality control
- Abide to infection control measures as per UNSDITR
- Address patient’s concerns and patient education

10.6 Knee ultrasound examination:
These standards assist us to develop safe and effective use of diagnostic ultrasound for knee pathology
- Maximize probability to detect most abnormalities
- Not all abnormalities may be detected, but additional and/or specialized examination may be necessary.
Indications:
- Evaluate soft tissue and bony structures of knee lesions
- Evaluate extra-articular structures of the knee ie. ligaments, tendons and bursae
- Diagnose Baker’s cysts and its complications
- Evaluate intra articular structures of the knee ie. femoral condyle, cartilage for traumatic and degenerative lesions.
- Evaluate cruciate ligaments
- Characterize synovial disease
- Used for screening, diagnostic, follow-up and interventional procedures in disease of the knee.

Personnel:
- Radiologist
- Medical Imaging Technologist
- Sonographer
- Sonologist

Equipment specification:
- Choice of transducer is 7.5MHz linear array
- For deeper penetration a 5MHz transducer is required.

Procedure:
- Patient lies supine. A pillow or a form wedge is used to prop up the knee
- Both knees must be exposed to make use of advantage of us for comparison

Anterior knee:
- Transverse and longitudinal views are done
- Demonstrate suprapatella bursa, pre-femoral fat pad, femoral cortex, patella, quadriceps tendon, patella, tendon, infrapatella bursa.

Medial and lateral knee
- Patient alternates in the decubitus position
- Transverse and longitudinal views are done
• Demonstrate medial and lateral menisci
• Medially, pes anserinus and adductor magnus and laterally biceps femoris and iliotibial band.

**Popliteal fossa/posterior knee**
• Patient lies prone and transverse and longitudinal views are done

Demonstrate the following:
• Semimembranosus/semitendonosus bursa
• Cruciate ligaments
• Popliteal vessels
• Condylar cartilage
• Intercondylar fat pad
• Doppler studies are applied where necessary to exclude vascular lesions, ascertain absence of cystic structures, differentiate degenerative from inflammatory conditions.

**Documentation:**
• A permanent record of US examination and interpretation is done.
• Image both normal and abnormal areas
• Measurements of the normal and abnormal structures should be done.
• Images should be labelled with the examination date, patient identification and image orientation.
• A report of the US findings should be included in the patient’s report.
• A permanent record of the US examination consistent with the clinical indication and relevant legal requirements should be retained.

**Quality Control and improvement, safety infection control, patients concerns**
• Abide to policies and procedures related to quality control
• Abide to infection control measures as per UNSDITR
• Address patient’s concerns and patient education.
10.7 Scrotal and Testicular ultrasound

These standards assist us to develop safe and effective use of diagnostic ultrasound for scrotal pathology

- Maximize detection of abnormalities
- It is not possible to detect all abnormalities hence additional or specialised examination is necessary.

Indication:

- Swelling of the scrotum
- Trauma
- Infection
- Pain
- Absent testicle
- Hematospermia
- Infertility
- Torsion

Personnel:

- Radiologist
- Sonologist
- Medical Imaging Technologist
- Sonographer

Equipment:

- Choice of transducer is 7-12 MHz linear array probe
- For deeper penetration a 5 MHz transducer is required.

Procedure:

- Ideally there is a male chaperone
- Patient position: Supine and lifts the penis upwards towards the abdomen and cover with a towel.
- Apply warm coupling agent to cover the scrotum
- Scan both testes from different angles
- Do transverse and sagittal views.
- Compare the testes at each projection
- Doppler studies are applied to ascertain viability
Documentation:
- A permanent record of US examination and interpretation is done
- Image both normal and abnormal areas
- Measurements of the normal and abnormal structures should be done
- Images should be labeled with the examination date, patient identification and image orientation.
- A report of the US findings shall be included in the patient’s report
- A permanent record of the US examination consistent with the clinical indication and relevant legal requirements shall be retained.

Quality Control:
- Abide to policies and procedures related to quality control.
- Abide to infection control measures as per UNSDITR
- Address patient’s concerns, and patient education.

10.8 Orbital ultrasound
These standards assist us to develop safe and effective use of diagnostic ultrasound for Orbital pathology
- Maximize detection of abnormalities.
- It may not be possible to detect all abnormalities hence additional or specialised examinations are necessary.

Indications:
- Trauma
- Intraocular hemorrhage
- Inflammatory conditions
- Tumours
- Brain lesions affecting the eye
- Ocular biometry
- Localize foreign bodies.
- Differentiate rhegmatogenous and non rhegmatogenous retinal detachment
• Proptosis
• Doppler investigation for orbital vascular disease and tumours

**Personnel:**
• Radiologist
• Sonologist
• Medical Imaging Technologist

**Equipment:**
• Choice of transducer is 7 - 12 MHz linear array probe
• For deeper penetration a 5 MHz transducer is required.

**Procedure:**
• Patient is scanned in supine position for stability and support of the head
• No anesthesia is needed
• The transducer is angled to cover the entire orbit
• Examination is done in transverse and longitudinal planes
• Examination of the anterior structure may require a standoff pad.
• Doppler US is applied to further access abnormalities seen at B-mode scan

**Documentation:**
• A permanent record of US examination and interpretation is done.
• Image both normal and abnormal areas
• Measurements of the normal and abnormal structures shall be done
• Images shall be labeled with the examination date, patient identification and image orientation.
• A report of the US findings shall be included in the patient’s medical record.
• A permanent record of the US examination consistent with the clinical indication and relevant legal requirement should be retained.
Quality Control:
- Abide to policies and procedures related to quality control
- Abide to infection control measures as per MOH and UNSDITR
- Address patient’s concerns and patient education.

10.9 Intracranial ultrasound
These standards assist us to develop safe and effective use of diagnostic ultrasound for intracranial pathology
- Maximize detection of abnormalities
- It is not possible to detect all abnormalities hence additional or specialized examination are necessary

Indications:
- Hydrocephalus
- Intracranial bleeding
- Hypoxaemic damage
- Meningocele and congenital abnormalities
- Convulsions
- Microcephaly
- Trauma
- Bulging fontanelle
- Intrauterine infections
- Raised intracranial pressure / bulging fontanelle

Personnel:
- Radiologist
- Sonologist
- Medical Imaging Technologist
- Sonographer

Procedures:
- Sagittal scan.
- Centre the transducer over the anterior fontanella.
- The scan plane should be aligned with longitudinal axis of the head.
• Angle the transducer to the right and left to demonstrate the right and left ventricle respectively.

**Equipment:**

• Choice of transducer is 7.5 MHZ otherwise use a 5 MHZ transducer for deeper penetration.

• Coronal scan. Rotate the transducer 90 degrees so that scan place is aligned transversally. Angle the beam forward and backward.

• Axial scan: Centre the transducer just above the ear and angle the beam towards the vault and down towards the skull base. Repeat on the opposite side.

**Documentation:**

• A permanent record of ultrasound examination and interpretation is done.

• Image both normal and abnormal areas

• Measurements on the normal and abnormal structures should be done

• Images should be labelled with the examination data, patient identification and image orientation.

**Quality Control:**

• Abide to policies and procedures related to quality control

• Abide to infection measures as per MOH guidelines

• Address patient’s concerns and patient education

**10.10 Breast ultrasound**

These standards assist us to develop safe and effective use of diagnostic ultrasound for Breast pathology

• Maximize detection of abnormalities

• It is not possible to detect all abnormalities hence additional or specialized examinations are necessary.

**Indications:**

• Breast lump

• Breast pain
• Breast discharge
• Equivocal signs on mammography
• To detect micro-calcification
• Diagnostic and therapeutic aspiration of cysts and other breast masses eg. Fine needle aspiration biopsy
• Application of Doppler studies
• Evaluation of augmented breasts

Personnel:
• Radiologist
• Sonologist
• Medical Imaging Technologist
• Sonographer

Equipment:
• Choice of transducer is 7 - 10 MHZ
• For deeper penetration use a 5 MHZ transducer.

Procedures:
• Patient position: Supine oblique or sitting erect in the supine oblique position the ipsilateral arm is extended and placed under the head.
• Breast survey: Begin the scan at 12 o’clock position. Orientate the transducer so that the breast is viewed in sections from the nipple outward. Scan the breast in a clockwise manner (spoke wheel), covering all anatomy including the axillary region. Transverse and longitudinal views are done.
• A report of the ultrasound findings shall be included in the patient’s medical report.
• A permanent record of the ultrasound examination consistent with the clinical indication and relevant legal requirements should be retained.

Documentation:
• A permanent record of US examination and interpretation is done.
• Image both normal and abnormal areas
• Measurements of the normal and abnormal structures should be done
• Images should be labelled with the examination fate, patient identification and image orientation.

Quality control
• Abide to policies and procedures related to quality control
• Abide to infection control measures as per MOH guidelines
• Address patient’s concerns and patient education.

10.11 Peripheral Arterial Pulsed Doppler Ultrasound
Non-invasive evaluation of the peripheral arterial system using pulsed Doppler. Sonographic examination will complement physiologic tests such as pulse measurements and pulse recordings.

Personnel
• Radiologist
• Sonologist
• Imaging Technologist
• Sonographer

Indications
• Detection of haemodynamically significant stenoses in specified segments of the peripheral arteries in symptomatic patients with suspected arterial occlusive disease. These patients could present with clinically recognized claudication, rest pain ischemic tissue loss or suspected arterial embolizations.
• Monitoring of previous surgical interventions, including sites of previous bypass surgery with either autologous or synthetic vein grafts.
• Monitoring of the use of various percutaneous interventions including angioplasty, thrombolysis
/thrombectomy, atherectomy or stent placements.
- Evaluation of suspected vascular and perivascular abnormalities, including such entities as masses, aneurysms, pseudoaneurysms, or various communications between arteries and veins.

**Examination Procedures**

**Arterial occlusive disease**

For arterial occlusive disease, the following considerations apply.
- The full length of the arterial segment(s) of interest should be sampled.
- The velocity waveform and the location of all sites of with haemodynamically significant stenoses and occlusions should be recorded.
- A record should be made of the velocity waveforms in the arterial segment situated 2-4cm proximal (upstream) to the abnormality.
- The location and the length of any segment that was not visualized should be recorded. Every attempt should be made to acquire velocity waveforms with the angle between the direction of moving blood and the direction of the ultrasound beam kept at less than 60 degrees.
- Velocity estimates made with larger angles are less reliable yet may hold diagnostic information.
- An evaluation of the following arterial segments should include:
  - Iliac arteries
  - Femoro-popliteal arteries
  - Tibio-peroneal arteries
  - Subclavian/axillary/brachial artery

**NB:** An attempt should be made to evaluate the full length of these arterial segments. A record should be made of the velocity of the iliac, femoro-popliteal, tibio-peroneal, subclavian, axillary, and brachial arteries.

**Evaluation of surgical and/or percutaneous interventions**
• By-pass grafts
• Sites having undergone percutaneous interventions

10.12 Suspected soft tissue abnormalities in proximity to arteries

Equipment Specifications
A real time scanner, preferably one with a linear array or curved array transducer, equipped with pulsed Doppler capability and preferably with color Doppler whenever possible. (Power Doppler may be used as necessary.)

The transducer should operate at the highest possible clinically appropriate frequency, recognizing that there is a trade off between resolution and penetration. A frequency of 5 to 12 MHz or greater should be used. Evaluating the flow signals originating from within the lumen of the vessel should be conducted.

10.13 Peripheral venous ultrasound
These standards have been developed to provide assistance to practitioners performing non-invasive ultrasound evaluation of peripheral venous structures. Occasionally, an additional and/or specialized examination may be necessary. Adherence to these standards will maximize the probability of detecting most venous abnormalities in the extremities and other superficial veins.

Indications
• Evaluation of possible venous obstruction or thrombus in symptomatic or high-risk asymptomatic individuals.
• Assessment of venous insufficiency.
• Assessment of dialysis access grafts.
• Venous mapping prior to harvest for arterial bypass or reconstructive surgery.
• Evaluation of veins prior to venous access.
• Evaluation for deep venous thrombosis. DVT in patients with suspected pulmonary embolism.
• Follow up for patients with known venous thrombosis.
Examination Procedure

- Techniques for Evaluation of the peripheral venous system
- For lower extremity evaluation, the common femoral vein, (superficial femoral vein), proximal deep femoral vein, proximal greater saphenous vein and popliteal vein should be examined using appropriate duplex technique and the patient position.
- A complete examination consists of imaging with selective Doppler evaluation, as appropriate.
- The presence or absence of blood flow signals in a non-compressible segment may be interrogated with pulsed or color Doppler.
- Calf veins and iliac veins may also be evaluated.
- When indicated, the greater and lesser saphenous vein and the contra lateral extremity should be evaluated.
- The femoral and popliteal veins should be imaged to the fullest possible extent, and images should be recorded at each of the following levels: common femoral, mid-femoral (superficial femoral) and mid popliteal veins.
- Views should be included to clearly demonstrate any abnormality of the veins or adjacent tissues (e.g., lymph nodes, haematoma, pseudoaneurysm, or other masses). Views of areas of focal tenderness should be obtained as well.
- When using compression as a diagnostic criterion for deep venous thrombosis, real time imaging in the transverse plane along the whole length of the femoral and popliteal veins, with and without pressure applied to the skin in an effort to completely oppose the walls of the veins should be done. Images with and without compression should be recorded each of the above levels. The extent and levels where there is failure of compression should be recorded.

Documentation

- Adequate documentation is essential for high quality in patient care.
• There should be a permanent record of the ultrasound images and interpretation.
• Images of all appropriate areas both normal and abnormal are should be recorded in any image format.
• Variations from normal size should be accompanied by measurements.
• Images are to be labeled with the identification, examination date, and image orientation.
• A report of the ultrasound findings should be made.

Equipment
• 5 MHz or higher, with the occasional need to lower frequency of the transducer.
• 2.5 MHz or above. A display of the relative amplitude and direction of moving blood should be available.
• Color Doppler can be used to facilitate the examination.

10.14 Echocardiography
Echocardiography is Ultrasonography of the heart. The basic principles of ultrasonography of other body parts are the same except that useful information gathered depends on collecting adequate information using the various modalities of examination.

Indications:
Early diagnosis of cardiac dysfunction or disease can substantially prevent morbidity and mortality. Such cases include:-
• Penetrating cardiac injuries
• Non traumatic cardiac rupture which occurs with acute myocardial infarction.
• Non traumatic pericardial effusion and cardiac tamponade.
• Pulmonary embolism
• Pulseless electrical activity e.g. in severe hypovolemia, tension pneumothorax and pulmonary embolism.
Clinical indications for emergency echocardiography include:
- Penetrating trauma
- Blunt trauma
- Hypotension
- Pulseless electrical activity (i.e. presence of ECG tracing but patient has no recordable pulse or BP)
- Patients requiring CPR
- After acute myocardial infarction
- Atypical chest pain
- Syncope in young adults
- Iatrogenic complications e.g. after pericardial tap or pleural tap
- Evaluation of the unstable patient

Other non-emergent conditions include:
- Congenital heart disease
- Hypertensive heart disease
- Acquired valvular heart disease e.g. Rheumatic heart disease and Endomyocardial fibrosis.
- Chronic heart failure from any cause

Contraindications:
Echocardiography is noninvasive and uses sound waves and as such is a very safe test with no specific contraindications.

Personnel:
- Cardiologists
- Physicians who have undergone training in Echocardiography
- Echo Technologist, radiographer who has undergone training in Echocardiography.

In view of the highly technical nature of the examination, most countries require that Echocardiograms performed by an Echo technologist must be read and certified by a Physician with training in Echocardiography or a Cardiologist.
Procedures:
Echocardiography is performed mainly by a transthoracic approach;

Three basic “Echo” windows used are the: -
- Parasternal long axis
- Parasternal short axis
- Apical 4 chamber view

A fourth window the subcostal view is useful in children and also for initial screening for mechanical activity.

To obtain a Parasternal view, the transducer is placed in the left parasternal area between the second and fourth intercostal spaces with the plane of the beam parallel to a line drawn from the right shoulder to the left hip. This view is good for visualizing the aortic valve, proximal ascending aorta, assessing left ventricular chamber size and posterior pericardium.

To obtain a parasternal short axis view maintain the transducer in the left parasternal area between the second and fourth intercostal spaces but rotate the transducer 90° clockwise. This view will, at various levels of tilting, give you views of the aorta, mitral valve, left ventricle as well as the lateral and posterior left ventricular pericardium.

Three types of examination are done for each of these windows and include: -
- 2D or B-mode technology, which actually views cardiac activity in real time.
- M-mode technology mainly done for chamber measurement and calculation of systolic function.
- Doppler, which is either color, flow mapping or by doing continuous or pulse wave Doppler that assists one in assessing flow over valves and septal defects.
- Another less commonly used approach is the transoesophageal approach.
CHAPTER ELEVEN

11.0 STANDARDS OF NUCLEAR MEDICINE

11.1 Nuclear Medicine Imaging
Nuclear Medicine is defined as “the medical specialty, which utilizes the nuclear properties of radioactive nuclides for the diagnostic evaluation of the physiologic conditions of the body and provides therapy with unsealed radioactive Sources”.

To practice Nuclear Medicine one needs detection devices and proper radiopharmaceuticals. The imaging detectors used for guidance are the planar gamma camera, the Single Photon Emission Computed Tomography Camera (SPECT camera), Positron Emission Tomography camera (PET camera). The counters are Scintillation well counters, the Dose Calibrator, the Survey Meters, and the Hand-held Monitors, e.t.c. Radiopharmaceuticals are formulated in various chemical and physical forms to deliver their radioactivity to different parts of the body. The goal is to diagnose specific disease conditions basing on the pathophysiology of the system.

Indications:
- To demonstrate the pathophysiology of body organs;
- To treat specific diseased organs.

Nuclear Medicine Diagnostic Procedures
Types of procedures routinely performed in Nuclear Medicine

In-vivo procedures (Imaging):
Imaging procedures provide diagnostic information about organs or body systems based upon the distribution pattern of radioactivity in the body. Imaging procedures are either dynamic or static.

Dynamic studies provide functional information through measurement of the rate of accumulation and the removal of radiopharmaceutical by the organ.
Static studies provide morphologic information regarding organ size, shape, position, or presence of space occupying lesions, and in some cases relative function.

Detection and measurement of organ radioactivity is usually made by the Planar Gamma camera or the SPECT camera or PET camera depending on what study is required.

**In-Vivo procedures (Non-imaging):**
In-Vivo function tests measure the function of a particular organ or body system based upon the absorption, dilution, concentration or excretion of radioactivity after administration of radiopharmaceuticals. These studies require analysis and interpretation based on counting radioactivity either directly from the organ within the body or from blood or urine samples.

**In–Vitro studies:**
In-Vitro studies do not involve administration of radioactive material to the patient. The studies only require a small sample of blood that contains a drug or chemical substance to be measured. The blood is subjected to specific tests using radioactive reagents to measure the unknown amount of substance present.

**Policy Issues Governing Diagnostic Nuclear Medicine**

**Responsibilities:**
In the practice of nuclear medicine focus has to be projected on the following responsibilities:

- No patient should be administered a diagnostic or therapeutic medical exposure unless the exposure is prescribed by a medical practitioner.
- The patient’s protection and safety should be ensured in the prescription of and during the delivery of medical exposure.
- Medical and paramedical personnel should be available as needed, and either be health professionals or have
appropriate training adequately to discharge assigned tasks in the conduct of the diagnostic or therapeutic procedure that the medical practitioner prescribes.

- For diagnostic uses of radiation, the calibration, dosimetry, imaging and quality assurance requirements of the standards should be conducted by or under the supervision of a qualified Nuclear Medicine Physicist/Nuclear Medicine Technologist.
- The exposure of individuals incurred knowingly while voluntarily helping (other than in their occupation) in the care, support or comfort of patients undergoing medical diagnosis or treatment should be constrained so that the absorbed dose does not exceed 5 mSv during the period of patient’s diagnostic examination or treatment.
- The training criteria should be specified or be subject to approval, as appropriate by the regulatory authority in consultation with relevant bodies.
- Any deficiencies or needs regarding compliance with the standards with respect to protection and safety of patients should promptly be reported to the authorities who shall take action as may be appropriate to ensure the protection and safety of patients.

**Justification of medical exposure:**

- Medical exposures should be justified by weighing the diagnostic or therapeutic benefits they produce against the radiation detriment they may cause taking into account the benefits and risks of available alternative techniques that do not involve the medical exposure.
- The medical practitioner should examine the patient and justify that the specific type of examination requested is expected to provide useful information on the health of the individual diagnostic objective.

**Precautions during medical exposure:**

- Relevant information from previous examinations of the patient should be taken into account in order to avoid unnecessary additional examinations.
• In order to get acceptable image quality of the patient, appropriate selection of best available radiopharmaceutical and its activity should be done.
• Special requirements for patients with impairment of organ function should be noted before administration of radiopharmaceutical.
• Methods for blocking the uptake in organs not under study and for accelerated excretion when applicable will be used.
• Administration of radionuclides for diagnostic procedures to women pregnant or likely to be pregnant should be avoided unless there are strong clinical indications.
• For mothers in lactation, discontinuation of nursing will be recommended until the radiopharmaceutical is no longer secreted in an amount estimated to give unacceptable effective dose to the nursing.
• Administration of radionuclides to children for diagnostic procedures will be carried out only if there is a strong indication, and the amount of activity administered reduced according to body weight, body surface area or other appropriate criteria.
• The technologist or other imaging staff should ensure that proper image acquisition and processing is done.

Calibration:
Unsealed sources for nuclear medicine procedures should be calibrated in terms of activity of radiopharmaceutical to be administered, the activity being determined and recorded at the time of administration.

Quality Assurance for Medical Exposure:
There should be established a comprehensive quality assurance program for medical exposure with the participation of appropriate qualified expert in relevant fields such as Nuclear Medicine physicians, physicists, radiopharmacists or trained technologist.

The quality assurance programs should include:-
• Measurement of physical parameters of imaging devices at the time of installation and periodically thereafter.
• Written records of relevant procedures and results
• Verification of appropriate calibration and conditions of operation of dosimetry and monitoring equipment
• Verification of the appropriate physical and clinical factors used in patient diagnosis or treatment
• Regular and independent quality audit reviews of the quality assurance program in nuclear medicine procedures.

Personnel and Roles:
• Nuclear Medicine Physicians: Interpret acquired images and report on patients
• Medical Imaging Technologist/Radiographer: Acquire patients images by the SPECT camera
• Radiopharmacist: Makes, compounds and dispenses radiopharmaceuticals
• Medical laboratory technologist: Carries out RIA tests, images patients
• Medical Physicist: Performs periodical radiation safety check ups
• Nuclear Medicine Sister: Patient scheduling for various tests and administers radiopharmaceuticals to patients.
• Cleaner: ensures a clean atmosphere in the unit.

Safe Handling Of Radioactive Materials
The objective of radiation safety practices should be not simply to keep radiation sources within legal limits, but to keep them “as low as reasonably achievable” (ALARA).
ALARA principles can be applied to the handling of radiation sources, to storage and shielding techniques, and to the design and layout of the nuclear medicine unit.

The basic principles for handling radiation doses from external sources are described by the “TDS” rules for time, distance and
shielding:

- Decrease the time of exposure (work in vicinity of radiation source as rapidly as possible)
- Increase the distance from the source (use tongs to handle vials)
- Use shielding where necessary (shield with lead pots, lead glass syringes etc)

Some basic rules for avoiding internal radiation

- No eating, drinking, smoking, or applying cosmetics in areas where open sources may be present (e.g. “hot labs” and patient study areas,
- Lab coats and gloves should be worn while handling radioactive sources,
- Absolutely no pipetting by mouth,
- Personnel should wash their hands after working with radioactive sources (a sink should be available in the hot lab) and they should be checked for contamination by the monitors in the unit. Hands should also be monitored before going for lunch break or home,
- Work should be performed on absorbent pads to catch spills and prevent spattering of liquids,
- Radioactive gases or other volatile materials e.g. concentrated iodine solutions should be handled and kept in a well ventilated fume hood,
- Work areas should be kept tidy, radioactive trash, contaminated pads etc should be kept in the radioactive waste room till the radiation in them decays to zero,
- Radioactive storage areas e.g. the hot room should not be used to store other materials such as office supplies or linen, and
- Contamination of light switches, doorknobs, etc which could result in unsuspected contamination of personnel should be avoided.
Nuclear Medicine Rooms Design:
Work surfaces and floors should be constructed using smooth, non absorbent materials free from cracks and crevices unit for ease of management of spillage.

The Hot Lab
- The hot lab and radioactive storage areas should be located away from other busywork areas, public corridors, secretarial office etc and away from imaging and low level counting rooms.

The surface on which radiopharmaceuticals are compounded should be equipped with the following:
- Compounding and dispensing tray covered with a bloating paper for absorption of spillage
- Lead shielding: lead pots for vials, lead glass to protect one when compounding radiopharmaceuticals, Lead glass syringe covers Lead blocks for shielding the area housing the generator,
- A dose calibrator for determining the activity of the radionuclide
- Work benches should therefore be sufficiently sturdy to support lead shielding
- Wash basins and sinks should be conveniently available where unsealed radioactive materials are handled. It is desirable that sinks in the hot lab have foot or elbow-operated controls
- There should be a separate storage glass ware and working tools used with radioactive material from those not used to prevent contamination.

The imaging Room:
- Radioactive sources either than the patient should be kept away from the imaging room to allow the camera acquire only the radiation coming from the patient.
- Adsorbent material and spare linen should be kept in the imaging room as a precaution to manage any radioactive soiling accruing from the patient.
• A wheel chair for the extremely sick should be available.

**Procedures for handling spills**  
The steps to follow in dealing with a radioactive spill are to:  
• Inform  
• Contain  
• Decontaminate

**Disposal of radioactive waste**  
There are three general techniques for disposing of radioactive waste:  
• Dilute and disperse  
• Store and decay  
• Concentrate and bury

**Radiation monitoring**  
• Survey meter and monitoring of the unit:  
  Survey meters are used to monitor radiation levels in and near the unit in which radioactive material or other radiation sources are present.  
  Laboratory monitors are very similar to survey meters but they are designed to be used at a fixed position rather than as portable units.  
• Personnel Dosimeters  
  Personnel dosimeters are devices worn by nuclear medicine staff to monitor radiation doses from external sources. The most commonly used dosimeter is the thermoluminescent badge (TLD) which is composed of a lithium fluoride chip, a material that gives off light when heated after it has been exposed to ionizing radiation. The amount of light given off is used to estimate the radiation dose received.  
  Thermoluminescent badges should be worn always by staff working in Nuclear Medicine unit  
• Small contamination monitoring by Wipe Test.  
  This test is used to detect small amounts of radioactive contamination on the bench surfaces, on the outside of shipping packages, etc. The surface is wiped with an
alcohol soaked patch of gauze which is then counted in a
scintillation counter in case of gamma ray emitters and in
the liquid scintillation counter in case of beta particles.

11.2 Radiopharmaceutical Therapy
Radiopharmaceutical therapy is the administration of unsealed
radioactive material designed to elicit a therapeutic response as
a result of internal irradiation of a target tissue. Algorithms for
patient-specific dosimetry suitable for radiopharmaceutical
therapy treatment planning are not yet widely practiced. As a
result, “dose prescription” algorithms in radiopharmaceutical
therapy remain relatively simple and empiric: either
administration of the fixed activity or administration of activity
corrected for body weight or surface area to all patients or
administration of the patient-specific activity corresponding to
some empirically determined maximal tolerated dose (e.g., 2 Gy
to the blood, as a bone marrow surrogate, in 131I sodium-iodide
treatment of metastatic thyroid cancer. A well nuclear medicine
trained team is required to expeditiously follow the procedures.
The goals of radiopharmaceutical therapy are:

- Treatment of thyroid diseases namely hyperthyroidism
  using $^{131}$I.
- Treatment of malignant pheochromocytoma, neuroblastoma and medullary thyroid cancer by meta-
  $^{131}$I-iodobenzylguanidine intravenous infusion.
- Bone pain palliation due to secondary to skeletal
  metastases using bone-seeking radiopharmaceuticals
  such as $^{32}$P, $^{89}$Sr, $^{153}$Sm ethylenediamene tetramethylene
  phosphonate (EDTMP).
- Radiosynevectomy by intra-articular radiocolloid therapy
  for benign joint disease using $^{90}$Y as citrate or silicate,
  $^{153}$Sm hydroxyapatite, and $^{169}$Er citrate.

Principles of safety
Therapeutic procedures in nuclear medicine involve therapy the
use of relatively toxic radionuclides. There are both internal and
external radiation hazards, and potential effects on the patient
and their family, as well as for treating personnel, which must be
considered.

Stringent precautions must be taken by staff at all phases of the treatment to avoid accidents.

**Choice of Radionuclides**
Selection of the optimal radionuclide is clearly critical to successful therapy. A therapeutic radionuclide should emit principally non-penetrating (beta, alpha) radiation and little or no photon (x or gamma ray) radiation. The use of beta-emitting radionuclides simplifies certain radiation safety issues in radionuclide therapy. There is no need to isolate or otherwise limit access to patients who have received radiopharmaceutical therapy with a beta emitter unless contamination is suspected. Standard precautions should be adequate for such patients. Besides the foregoing dosimetric considerations, the selection of a therapeutic radionuclide depends on several circumstances including its availability, the cost of the radionuclide and the regulatory approval of the radiopharmaceutical.

**Instrumentation**
A medical facility performing radionuclide therapy *should* have instrumentation for measuring activity *in vivo* for the procedures performed. Typical instrumentation may include an *uptake probe* and one *gamma camera*, preferably one of which has the capability of performing single photon emission computed tomography (SPECT) imaging. Instrumentation, typically a scintillation *well counter* system, *should* also be available to measure activity in patient samples, such as blood or urine.

**Administration of Activity**
Immediately prior to administration of a therapeutic radiopharmaceutical, the following information, as applicable, *should* be verified by two individuals:

- dose on the radiopharmaceutical label matches the prescription;
- identification of the patient by two independent means;
- identity of radionuclide;
- identity of radiopharmaceutical;
- total activity;
- date and time of calibration; and
- precautions to be followed.

Considerations in Patient Confinement
If the nuclear-medicine physician determines that a patient, despite difficulties, may nonetheless be safely treated with appropriate and reasonable medical supervision while hospitalized, patient treatment may proceed.

The nuclear-medicine physician can determine that such patients can and should remain hospitalized beyond the period of time dictated by any other criteria. As an example, for an incontinent patient, the nuclear-medicine physician may determine that hospitalization of the patient be extended to ensure safe collection and disposal of radioactively contaminated urine. Both the radiological and clinical considerations shall be given due weight by the nuclear-medicine physician.

Special Considerations for Female Patients
Signs alerting female patients and containing wording similar to, “If you are pregnant or if it is possible you may be pregnant, please notify the staff before the beginning of any procedure,” should be prominently posted throughout the nuclear medicine areas, particularly in waiting and dressing areas. A pregnancy test shall be performed before radionuclide therapy in any female patient of childbearing age. Pregnancy is a contraindication to radioiodine therapy.

Breast feeding is generally a contraindication to radiopharmaceutical therapy and shall be discontinued prior to radiopharmaceutical therapy. Signs alerting women with language such as, “If you are breastfeeding, please notify the staff before the beginning of any procedure,” should be prominently posted in the nuclear medicine areas, particularly in waiting and dressing areas.

For female patients who may be menstruating during or immediately after a therapeutic administration, there may be
detectable contamination on pads or tampons. It is recommended that these items be collected for the first 1 to 3 d post-administration and be held for decay to background levels prior to proper disposal.

**Radiation Safety Procedures**

The nuclear-medicine physician *should* convey the date of the treatment, the radionuclide, the radiopharmaceutical, and the prescribed administered activity to the RSO as far in advance as possible. The nuclear-medicine physician and the RSO *should* decide in advance whether or not the patient is suitable for release on the same day that the radiopharmaceutical therapy is administered. Any limitations for same-day release will depend on facility and medical decisions but can include consideration of:

- type of dwelling;
- presence in the household of pregnant or breastfeeding women;
- sex and age of each household member;
- sleeping partner information;
- information on children in the household;
- workplace information and schedule;
- presence in the workplace of pregnant women or minors;
- means of transportation from hospital to home;
- physical challenges;
- incontinence or ostomy care; and
- ability to comprehend instructions.

Any contaminated items from the procedure *should* be labeled with the radionuclide, a radiation precaution sticker, and held for complete decay in storage in an appropriately shielded and secure area. In practical terms, this will mean holding material until there is no measurable activity.

Anterior exposure rates at the surface of and 1 m from the patient *should* be measured at the level of the patient's umbilicus, using a calibrated radiation monitor, such as a portable ionization chamber. These initial measurements *should*
be performed within 1 h of administration of the radiopharmaceutical therapy and prior to any post-therapy excretion by the patient. The radionuclide, the radiopharmaceutical, and the activity administered shall also be recorded in the patient's medical record. A “radiation precautions” sign should be posted on the door to the patient's room.

Food and beverages for the patient should be provided using disposable trays, cups, utensils, etc. The patient may use the toilet and dispose of urine and feces as usual, flushing the toilet several times after each use. The patient’s linens and gowns may also be contaminated and should be held for checks by the radiation safety staff before being placed in the facility laundry. In practical terms this will mean holding linen until there is no measurable activity. Each day following administration of the therapeutic radiopharmaceutical, the patient should be resurveyed. The point at which these surveys are made should be the area of maximal uptake of the radiopharmaceutical. Scans of the patient’s body with a survey meter may be necessary to find the area of maximal uptake. For example, in the case of thyroid treatments in patients with intact thyroids, this area may correspond to the patient’s neck or chest. The exposure rate measured can then be used to determine release instructions for the patient, if any. Removal of contaminated items from the patient’s room should be done on a daily basis. Upon discharge of the patient, the RSO should arrange for removal of all remaining waste and contaminated items from the patient's hospital room. All items should be placed in plastic bags, using separate bags for disposable and for nondisposable items (e.g., linens and bedding). All radioactively contaminated items should be labeled with radiation precaution stickers and with the radionuclide, date and time, and held for decay-in-storage in an appropriate shielded and secure area until there is no measurable activity. All waste and other items being held for decay in storage should be reassayed periodically using a calibrated radiation monitor. Waste should then be discarded appropriately and bedding and linens may be treated as usual.
The patient's room *shall* be surveyed and checked for removable contamination. Initially, this check *should* be performed using a handheld survey meter, such as a GM counter or scintillation survey meter.

A list of names and 24 h telephone numbers of individuals to contact in the event of a radiation emergency *shall* be available. Personnel to be contacted may include the RSO and responsible nuclear-medicine physician or the nuclear-medicine resident or fellow on-call. These lists *shall* be available to medical personnel caring for the patient. In the event of a large volume spill of blood, urine or vomitus, nursing personnel *should* cover the spill with a plastic-backed absorbent pad and immediately call the designated radiation safety staff. Medical personnel *should not* attempt to clean up a major spill without radiation safety instruction.

**Patient-Release Criteria**

The release criteria for patients receiving therapeutic amounts of radiopharmaceuticals are based on the prevailing national recommendations. Regulatory agencies have published criteria for patient release and these criteria *shall* be reviewed by the RSO and the nuclear-medicine physician(s) in facilities administering therapeutic amounts of radiopharmaceuticals to determine which criteria apply to the facility-specific program.

**Travel by Radiopharmaceutical Therapy Patients**

An important practical issue with radiopharmaceutical therapy patients is limitation of travel, because this will typically involve exposure from the patient to one or more individuals at relatively close distances in a confined space. Thus, travel for 1 h immediately post-treatment in a private automobile large enough for a patient to maintain a distance of 1 m or greater from the other occupant(s) is generally permissible. However, a case-by-case analysis will be necessary to determine the actual travel restrictions for each patient, especially for longer trips and for travel by public bus or train, commercial airliner, or other conveyance in which travelers may be crowded together.
Other Radiopharmaceutical Therapies
Potentially debilitating bone pain resulting from skeletal metastases is a common feature of many advanced cancers, such as prostate and breast cancer. While External Radiation Therapy (ERT) remains the principal approach for pain palliation for solitary skeletal lesions, bone-seeking radiopharmaceuticals are widely used for treatment of multiple painful osseous lesions. Although 32P was used for many years, its associated myelosuppression has led to the ongoing development of other bone-seeking radiopharmaceuticals, including 89SrCl, 153Sm-EDTMP, 186Re-HEDP, etc. Currently, 89SrCl and 153Sm-EDTMP have been approved by authorities for the treatment of painful osseous metastases.

Personnel involved in the Radiopharmaceutical Therapy
The Nuclear medicine specialists involved include;
- Medical Physicist
- Physician
- Radiopharmacist
- Technologist
- Nurse
CHAPTER TWELVE

12.0 STANDARDS IN CLINICAL PRACTICE IN RADIOTHERAPY
Radiation oncology (Radiotherapy) is a branch of medicine that focuses on the management of cancer either alone or in combination with surgery and/or chemotherapy. It involves the diagnosis, staging, planning of treatment, and actual treatment and follow-up of patients after treatment.

12.1 Diagnosis of cancer
a) Patients may present with symptoms. For example:
   - Haemoptysis in bronchial carcinoma.
   - Altered bowel habits in colo-rectal carcinoma.
   - Vaginal bleeding/Discharge in cancer of the cervix.
   - Pelvic mass in cancer of the ovary.
   - Swollen lymph nodes in Lymphoma.
   - Hoarseness of voice in cancer of the Larynx.
   - Neck masses in nasopharyngeal cancer.

b) Patients may be asymptomatic and the cancers are diagnosed coincidentally. For example:
   - Hepatocellular carcinoma may be noted on ultrasound scan of the abdomen
   - Cancer of the bronchus on chest x-ray
   - Cancer of the ovary on pelvic ultrasound.

c) Patients may present with para-neoplastic syndromes
   For example:
   - Diabetes insipidus, Diabetes mellitus, Hypercalcaemia, Hypertension and erythrocytosis.

d) Patients may present with metastases. For example:
   - Bone fractures
   - Spinal cord compression
   - Chest pain and a cough.
• Convulsions.
• Ascites.

e) Roles of Investigations
• Confirm diagnosis of cancer. e.g. Biopsy and histology
• Narrow the differential diagnosis e.g. Radiology and imaging.
  o Computer tomography/Ultrasound of liver may show evidence of hepatocellular carcinoma or metastases.
  o Special stains in histopathology.
  o Tumour markers: CA-125 is raised in ovarian cancer, CEA in GIT tumours, β-hcg in trophoblastic diseases & teratomas.
• Detection of recurrence after treatment.
• Staging

12.2 Staging
The purposes of careful staging of tumour are.
• To give appropriate planned treatment to the individual patient.
• To be able to give the best estimate of prognosis.
• To compare similar stages in assessing and designing clinical trials.
• To accurately document the initial tumour.
• To assist our understanding of tumour Biology.
Staging combines all available data; clinical, pathological and radiological to give an overall categorisation of the extent of malignant disease.

Staging systems in use
• TNM classification.
  T - Extent of direct (local) spread of the tumour
  N - Extent of regional lymphnodes involvement.
  M - Presence or absence of distant metastases.
Standards on diagnostic imaging and therapeutic radiology for Uganda

- FIGO - Gynaecological cancers
- Dukes system- For colo-rectal Cancer.
- Lymphomas have their own systems.

Staging Techniques
Many techniques are available they include:
- proper history taking
- physical examination
- radiology and imaging
- examination of body fluids
- invasive procedures like bone marrow biopsy
- Full blood counts / bone marrow examinations
- radionuclide bone scans and skeletal surveys are some of the investigations to show presence of distant metastases.

Radiology and Imaging
i) Abdominal-pelvic Ultrasound
   Useful in showing primary tumours of abdominal organs, tumour ascites and abdominal lymphadenopathy. Metastases to liver and spleen may also be shown. Demonstration of other invisible hydronephrosis due to tumour obstruction in the pelvis (useful in staging of e.g cacx)

ii) Computer Tomography and Magnetic Resonance Imaging.
   Useful in staging many tumours. May show:
   - Brain metastases
   - Lung metastases
   - Liver, lymph node and spleen involvement.
   - Useful in assessing primary of tumours of:
     - Brain
     - Spinal cord
     - Lungs/mediastinum
     - Bones
     - Soft tissues
     - Abdomen.
iii) Nuclear medicine
- Technecium 99m bone scans for metastases.
- Gallium-68 scintigraphy for lymph node involvement and recurrence in lymphoma.
- Thalium scans in Kaposi Sarcoma
- Positron Emission Tomography primary and secondary brain Tumours
- Differentiation of native tumour from sclerosis in a mass / fibroids
- Radioactive iodine: 131I Scans for residual thyroid and metastatic thyroid cancer, 123 MIBG is used in staging of Neuroblastoma in children. It is also taken up by pheochromocytoma and medullary thyroid cancer.
- Staging laparotomy has largely been replaced by CT. MRI and PET scans.

12.3 Radiotherapy in the management of cancer

Important considerations before Radiotherapy treatment.
a) Tumour radiosensitivity compared to tolerance of adjacent normal structures.
b) The cancer extent i.e. the tumour is localized or metastatic.

Radical treatment
1) Radical treatment has curative role as sole treatment for localised disease e.g:
- Head and neck cancer
- Cancer of the cervix.
- Anal and skin cancer.
- Bladder cancer
- Prostate cancer.
- Early lung cancer.
- Seminoma
- Hodgkin’s and NHL
- Medulloblastoma and some other brain tumours.
- Thyroid cancer.
2) As component of multi-modality treatment approaches.
   • Breast cancer.
   • Rectal cancer
   • Soft tissue sarcomas
   • Advanced head and neck cancers
   • Whole body radiotherapy before bone marrow transplants.

Palliative radiotherapy
Radiotherapy has an important palliative role in patients who go on to develop recurrent or metastatic disease particularly in the relief of pain, bleeding or symptoms from compression of vital structures.

Radiotherapy has an important role in palliative care. It is used for control of:
   • cancer pain
   • bleeding from tumour ulcers
   • discharge from cancers
   • haemoptysis
   • haematuria.
   • convulsions due to brain metastases.
   • It may prevent spinal cord compression caused by the tumour.
   • It may reduce venous or lymphatic obstruction e.g superiari vene cava syndrome.

Dose prescription.
The prescribed dose is determined by:
   • Tumour radiosensitivity.
   • Tolerance of adjacent normal tissues.

The rate of delivery of this dose is governed by:
   • Aim of treatment; radical versus palliation.
   • Probability of tissue damage especially the late occurring effects.
• Fractionated treatment spares normal tissues because sub-lethal damage is repaired between daily fractions.
• Fractionated treatment allows re-oxygenation of hypoxic cells in tumour. The cells are also allowed to redistribute into more radio sensitive phases of the cell cycle.
• Conventional fractionation
  • Conventional fractionation is 2 Gray daily.
• For an epithelial tumour the dose is of the order of 60-70 Gray in 30-35 fractions over 6-7 weeks.
• Accelerated radiotherapy
  • Aims to over-come tumour repopulation. The same dose per fraction and total dose of radiation maybe used, but aims at delivering more than 5 fractions in a week e.g by treating twice per day or giving a sixth fraction on an appropriate day or days so as to reduce overall treatment time.
• Hyperfractionated radiotherapy
  The dose per fraction is reduced and total number of fractions is increased. Two or more treatments are given per day separated by at least 6 hours. Advantages are that the late occurring side effects are reduced. With this technique, it is possible to reduce overall duration of treatment.
• Hypofractionated radiotherapy
  Large doses are given per fraction. Over all treatment time is reduced
  This is suitable for palliative radiotherapy.
  It may be associated with more severe late occurring side effects.

12.4 Radiotherapy planning
Radiotherapy planning is a set of processes that starts with confirmation of diagnosis, staging of the tumor, delineation of the area to be treated and ensure that maximum radiation dose is delivered to the tumor while minimizing dose to the critical organs and surrounding normal tissues.
Radiotherapy field arrangements.
The aim is to deliver a homogeneous dose of radiation to an accurately localised tumour volume and to minimise the effect on the surrounding normal tissues. This is done by choosing the best combination of beams (energy) and suitably arranged.

Examples of radiotherapy treatment fields
- Direct fields. These are single fields. One hundred percent of the dose is calculated to the centre of the target volume.
- Two parallel opposed equally weighted fields. 100% of the dose is calculated to the mid plane
- Unequally weighted fields. 100% of the dose is calculated to the centre of target volume.
- Multiple fields: This is whereby 3 - 6 fields are used, all of them centered to the tumor.
- Conformal treatment: This is a 3 D treatment whereby many fields from a radiotherapy unit using multi-leaf collimators and controlled by the computer, all of them centered on the tumor.
- IMRT (intensity modulated radiation therapy): This is an advancement of conformal treatment implemented by setting constraints like total tumor dose, critical organ dose, number of fields, and the computer modulates the intensity of radiation to maximise dose to the tumour and minimise dose to surrounding normal tissues.
- Image guided radiotherapy: This is where radiotherapy is delivered guided by the movement of the relevant body organs eg. Lung, prostate, etc.

Tumour Volume Definitions
Staging attempts to define the site, size and extent of the tumour and policies for local radiotherapy are determined by such staging.
- Gross tumour volume (GTV): The demonstrable macroscopic extent of tumour, palpable, visible or detectable by other investigations e.g. X-rays, U/S, CT,
MRI, Nuclear medicine etc.

- **Target Volume**: The target volume is defined from clinical, radiological and pathological assessment.
- **Clinical target volume (CTV)**: GTV and margin to include microscopic spread. It is subjective and based on knowledge from surgical and post-mortem specimens as well as clinical experience.
- **Planning treatment volume (PTV)**: CTV and margin to cater for involuntary movements e.g. respiratory, and possible positioning errors.
- **Critical organs**: These are organs in the vicinity of the tumor volume that either have to be protected or if radiated their dose should not exceed tolerance of that tissue.

**Simulation:**
This is a procedure whereby the planned radiation fields are checked with a specialized fluoroscopic x-ray machine (simulator) to ensure that the targeted area is included and critical organs excluded /protected. Immobilization devices where applicable should be done and checked at this time.

**Tolerance of normal tissues; examples**
- Optic chiasma 55 Gray
- Spinal cord 45 Gray
- Lens (cataract) 6-8 Gray
- Gonads (testis) 0.5-3 Gray.
- Sterility 6 Gray permanent.
- Testicular production of Testosterone 30 Gray
- Ovaries: 6-15 Gray sterility, 8-12 Gray hormone production is affected
- Liver - 36 Gray
- Kidneys- 23 Gray
- Lung - 20 Gray. Pneumonitis
- irreversible fibrosis 40-50 Gray.
- Thyroid 30 Gray. Hypothyroidism.
12.5 Methods of administering radiotherapy.

Teletherapy
Radiation source is outside the body. Commonest technique used.
- X-rays: Orthovoltage, Megavoltage.
- Electrons from linear accelerators.
- Gamma rays e.g. cobalt -60 machines.
- Protons.

Brachytherapy
Radiations sources are in contact with the patient’s body e.g. in cancer cervix, oesophageal, conjunctiva cancers, etc. Typical radiation sources may include Co-60, Cs-137, Ir-192, Sr-90, etc.

Irradiation from unsealed sources (nuclear medicine)
Those following metabolic pathway: The radionuclides are systemically administered. For example cancer of the thyroid, neuro endocrine tumours, polytythemia rubravera, osteoblastic bone metastases from cancer of the prostate.

Non- metabolic pathway: These act locally e.g. Phosphorous 32, Gold 198 for malignant ascites

12.6 Personnel in Radiotherapy
- Radiation Oncologist
- Medical physicist
- Radiotherapy Technologist (RTT) / Therapy Radiographer
- Oncology nurse
- Maintenance technician / Engineer
- Mouldroom technician

12.7 Quality Assurance in Radiation Oncology
Quality assurance in radiation oncology attempts to prescribe consistent, safe, and optimal delivery of radiation to treat disease. It encompasses three major areas of treatment aspects and these are clinical, physical and technical.
A team of highly trained individuals is required to obtain the optimal results with radiation therapy treatment. The minimum number of health care professionals for any center administering radiation therapy should include a radiation oncologist, a radiation therapy physicist, a radiation therapy technologist and an oncology nurse. The manpower needs for each category in clinical radiation therapy and their roles in quality assurance are shown in the staffing ratios below.

It is important to note that even if national approaches and guidelines on quality assurance in radiation oncology are available, they usually are not adequate to deal with the particular needs of individual institutions, nor are they adequate to ensure uniform standards of diagnosis and treatment among institutions. Therefore, it is important for individual institutions to develop and implement strict quality assurance standards, based on national guidelines as well as their own strengths and needs, to ensure that patients receive the highest quality of radiotherapy and that the successes and failures of treatment are statistically reliable.

**Staffing Ratio (IAEA recommendation)**

Radiation Oncologist: 4 per 1000 new patients per year  
Medical Physicist: 2 per 1000 new patients per year  
Radiotherapy Technologist/ Radiographer: 6 per 1000 new patients per year  
Teletherapy equipment e.g (Cobalt-60): 1 per 500 new patients per year

**Recommended steps to follow to ensure success QA in radiotherapy Depending on available facilities and resources may include:**

- Morning rounds / chart reviews: 2-3 mornings each week, the staff meets to discuss patients seen the previous days. Physicians present the cases and their recommendations for peer review.
- Chart rounds: each week, the entire staff meets to review
the portal films and progress of each patient under treatment.

- Plan checks: before a treatment course begins, a physicist checks the accuracy of dose calculations and the details of the setup instructions.
- Chart checks: each week, a physicist reviews the chart of every patient under treatment for continued agreement with the treatment plan.
- Treatment machine checks: each morning, the radiation output from the linear accelerators is measured and checked for consistency. Physicists use additional equipment at monthly and annual intervals to maintain the calibrations.
- Patient dose measurements: the radiation dose applied to individual patients is measured with Diodes to verify the calculations.
- Portal films: when the treatment begins and at least weekly thereafter, films are taken with the treatment beams to verify the positioning of the treatment field and the patient to ensure the treatment is delivered to the correct location.
- Verification computer system: for each beam and for every treatment, a dedicated computer system verifies the detailed settings as set by the therapists against the original plan.
- Monthly Quality Improvement Meeting: these meetings are attended by nurses, therapy radiographers, physicists, radiation oncologists, administrators and support staff to ensure the highest levels of patient care are maintained and or formulate corrective action where necessary.

**Operating and Safety Procedures for External Beam Irradiation of Patient in Radiotherapy**

To assure a maximum safety of patient treatment, the following operational and safety measures must be followed by all involved personnel in the treatment:

- Protection and safety measures:
Each operator of the Co-60 / Linac has to know the name of responsible person (RSO) for the machine, in the radiotherapy department.

Each operator must know the location of the table and treatment room emergency stops, the console key, the emergency stop button and main switch for the machine.

The operator must know how to manually open the treatment room door.

The operator must know how to manually close the source. For this procedure a training / induction by radiation protection officer or head radiographer is performed when the person is newly employed and annual refreshing training is given to all employees. Responsible is RSO.

Closing panels or machine casings must not be opened or removed by radiographers. Only person responsible for maintenance or repair can do it.

The video and intercom system linking the operator to the treatment room must be permanently observed when the patient is being treated.

Before closing the room the operator must be sure that nobody else other than the patient is in the treatment room.

The operator must monitor all indicators on operation console showing proper function of the machine. In case of any malfunction he or she has to stop the treatment immediately and inform the responsible person, i.e. medical physicists and RPO.

After any technical intervention, i.e. repair or maintenance, the operator must check, with the person responsible for installation, that the system is in proper working condition. Re-calibration may have to be carried out before the new use.

At the end of the day, power supply to the machine must be switched off. The key must be removed from the control console and stored in safe place.
• **Handling of patients**
  o Before setting the patient for treatment, check his (her) identity according to the patient treatment chart.
  o Positioning of any accessories used for the treatment must not be carried out over the patient. The radiographer setting up the patient must clear the patient by moving the table top or prepare accessories before the patient is set up.
  o Once the accessory or tray or proper applicator is installed, check that they are properly secured.
  o Before treating the second fields, placement and withdrawal of shielding blocks must be performed with care so that nothing falls on the patient.
  o The shielding blocks must never be put on the treatment table as they may fall down.
  o Once the accessory is positioned all gantry movements must be carefully monitored.
  o During the table movements, you must check that there is adequate space available to move the table without any collisions.
  o If any wedge is used, check that wedge position matches the position shown on the treatment plan (collimator angle rotation) and that proper wedge is used (check code wedge).

• **Treatment**
  o Check that you are using a treatment plan which coincides with patient's identity.
  o Systematically check that the treatment chart corresponds with the patient to be treated, and that all prescriptions for treatment are all fulfilled.
  o Before starting irradiation you must check that treatment parameters (fields size, field position, gantry angle, collimator angle, accessory, dose, etc. correspond to the treatment prescription.
  o During irradiation, observe constantly the patient by monitoring video monitor screen.
o Irradiation must be immediately stopped if the patient moves, or if you hear abnormal noises.

o At the end of irradiation, check that the delivered time corresponds to number set (primary timer).

o If the machine stops due to some technical reasons do not restart irradiation again without informing responsible person (medical physicists). The only exemption is when the pressure falls down to the lower limit and stops the treatment. Then you can switch on the compressor and restart the treatment.

• Patient safety
  o Make sure that the patient cannot fall from the table.
  o The table must be in the lower position and cleared from collimator when the patient is getting on and off the table.
  o Avoid stepping on the release pedals unintentionally. Make sure that the patient does not step on them.
  o Check that there is nothing obstructing the patient during the treatment.
  o Make sure that no object can fall on to the patient (shielding blocks).
  o Avoid all possible collisions with the patient.
  o Inform patient not to move during the treatment.
  o Inform patient about audio and video system and about the treatment procedure.
  o No one except the patient is allowed to stay in the treatment room.
  o Only authorized persons are allowed access to the control panel.
  o Enter detail of the treatment in the patient's treatment record and record treatment in the treatment machine logbook.
12.8 **Emergency.**

- Should the Co-60 source fail to return after delivering the prescribed treatment follow the instructions given in Emergency plan to deal with this situation.
- Quickly remove patient from under the beam.
- Remove patient from the treatment room and close the room.
- Call immediately qualified personnel (radiation safety officer).
- Secure the treatment room and the treatment console till the source is safe again.

**Emergency Instruction for External Beam Therapy.**

Stucked source in Co-60 unit.

Should the Co-60 source fail to return after delivering the prescribed treatment observe the following procedure:

- **Radiographer:**
  - Press the force source button (FSB) and if it also fails, enter the treatment room
  - move patient with treatment table as far as possible from the beam
  - close fully collimator openings using hand control unit
  - remove patient from the treatment table and treatment room
  - do not try to return source back
  - close the treatment and operator rooms securely
  - make provision that nobody can enter to treatment area
  - call immediately radiation safety officer and/ or medical physicists, maintenance engineer who will solve the problem.

- **Radiation safety officer, medical physicist or maintenance engineer:**
  - wear directly reading personnel radiation monitors to monitor obtained exposures
  - decide about the strategy of pushing the stuck
source back
- make provision that nobody except the person dealing with incident can enter treatment room
- try first to push source using pneumatical system or force source back (FSB) system
- if it fails use emergency rod to push it back
- analyze the reason(s) for stuck source and make necessary repair
- after the repair check a few times that the source is moving smoothly
- in case that the reason for stuck source were not found, secure treatment room and call manufacturer
- during the whole operation stay as far as possible from the source
- record doses which were obtained by individuals taking part in operation
- make detail report about the incident estimating also a possible extra dose to patient
- send a copy of report to AEC.

Emergency Instruction for Brachytherapy.
Stucked source in brachytherapy unit.
Should the radioactive source fail to return after delivering the prescribed treatment follow the following procedure:

Radiographers or nurses;
- enter the treatment room and remove quickly applicators from the patient
- remove the patient from the treatment room
- do not try to return the source back
- close the treatment rooms
- make provision that nobody can enter in to the treatment room
- Immediately call the radiation safety officer and/ or medical physicists, maintenance engineer who will solve the problem
**Radiation safety officer, medical physicist or maintenance engineer:**

- wear directly reading personnel radiation monitors to monitor exposures
- decide about the strategy of pushing the stuck source back
- make provision that nobody except person dealing with incident can enter the treatment room
- try firstly to push the source back using mechanical movement system
- if it fails cut the cable with strong pliers and leave the source train in the emergency container
- secure the container with the source or move it to the source storage bunker.
- immediately inform the manufacturer and ask for replacement
- in case that source train went back analyze the reason(s) for stuck source and make necessary repairs
- after repair check few times that the source is moving smoothly
- during the whole operation stay as far as possible from the source
- record doses which were obtained by individuals taking part in operation
- make detail report about the incident estimating also a possible extra dose to patient
- send a copy of report to AEC.

### 12.9 Clinical procedures in radiotherapy

Clinical procedures should ensure the following:

**Identification of the patient**

It is crucial that mechanisms be in place to ensure that the correct patient is being treated to the correct anatomical area; otherwise risk of radiotherapy misadministration increases. The precise system e.g. an ID document and/or a photograph if
economically feasible, patient confidentiality taken into consideration.

a) Identification of the patient at the start of treatment. 
Name / Gender / Address/Tel. Number / Age (date of birth, if known) / National Identification Number (if applicable) / Hospital / Departmental Identification Number

b) Identification of the patient on a daily basis. 
Name / One or more of the above Identification Numbers / Photograph I.D. (face) / Photograph of the treatment site or field marks / Anatomical sketch (diagram) showing location of treatment fields to be applied other (e.g. code bar, etc) / Patient confidentiality assured / Children handled differently from adults.

Diagnosis and staging
Investigations leading to tumour diagnosis and staging are necessary before delivery of radiotherapy. The available infrastructure should be adequate for patient’s diagnosis, staging and planning. The following checklists will document the existence and use of these tools.

a) Clinical records
Filing system / Clinical history / Physical examination.

b) Pathology services
Location of pathology services in the hospital/ Out of hospital / Pathology reports should be in all patients’ files / Ability to obtain outside pathology consultation / Access to special stains, immunohistochemistry, hormonal receptors, etc.

c) Access to radiological, ultrasonographic and nuclear medicine imaging
X rays / Mammography / Ultrasound / Computer Tomography / Nuclear Imaging (scintigraphy) / Access to
PET, etc / Access to MRI / Delay (days) for diagnostic procedures / Reports of significant radiological findings in the patient file.
Comment on the quality of service (related to national resources), i.e. waiting times or any other impairment in access to staging procedures.

d) Access to laboratory facilities
Haematology / Biochemistry / Access to immunology, genetics, etc / Reports of significant laboratory findings in the patient folder
Comment on quality of service (related to national resources)

e) Endoscopy procedures
Comments on endoscopy procedures / Availability of specialists and procedures
Reports in chart.

f) Staging
Patients must be staged and documented / Staging system (TNM, AJCC, FIGO, Institutional, etc.) / Consistency of documentation / Consistency of reporting of surgical staging when appropriate / Consistency of reporting of prior chemotherapy when appropriate / Performance status (WHO, Karnofsky, ECOG)

Indications and decision to treat
Indications and decision to treat are based on clinical assessment and existing guidelines. Any patient in the radiotherapy department must have had a treatment decision taken by a radiation oncologist.

Multidisciplinary medical approach
- Recommended that decisions to treat should be based upon meetings of multidisciplinary teams (tumour boards) If yes, comment on meetings for:
  - Every patient / Specific tumours / Frequency / Meeting
location (radiotherapy department, hospital)

- If yes, comment on meetings for:
  - Every patient / Specific tumours / Frequency / Meeting

location (radiotherapy department, hospital) If no multidisciplinary team, who generally refers the patient to the radiotherapy department (general practitioner, specialist)? If yes, comment on meetings for:

- Every patient / Specific tumours / Frequency / Meeting

location (radiotherapy department, hospital).

- Is the decision to treat inappropriately affected by outside factors? (economical, other specialties, etc.)

**Practice guidelines**

- Written department protocols should be available for the most common clinical management situations.
- Source of guidelines followed by the department. (Hospital protocol manuals, national, international, textbooks, evidence based medicine)
- Tumour/site-specific protocols should be applied consistently within the department
- Tumours of a particular site and stage should be treated the same way Regular meetings should be held to verify adherence to protocols
- Coverage for absences of physicians from the department Research protocols should be ratified by an institutional / national ethics committee

**Patient information and consent**

- Risks and benefits of radiation therapy should be explained to patients How? (leaflet, brochure, verbally).
- A formal consent and agreement form shall exist on file

**Treatment preparation - instruction for planning**

Preparation and planning phases must precede delivery of treatment and be completed in a precise and reproducible way. The checklist will assess the equipment and procedures used for localization, simulation and immobilization, including mould room devices and procedures.
Localization, simulation and immobilization;
Major equipments used for localization (depending on resources):
- Fluoroscopic simulator
- CT simulator
- CT dedicated for planning
- Diagnostic films taken on the treatment machine
- Portal films taken on the treatment machine
- Other (e.g. bone scan image) Film processor
- View boxes near simulator / Electronic imaging

During simulation/localization the following shall be present;
- Radiation oncologist
- Medical physicist
- Radiotherapy technologist (RTT)/ Radiographer

Role of the RTT/medical physicist/radiation oncologist, if present shall be specified;
- Procedure manual shall be available for simulation
- An exposure chart shall be available (kV and mAs)
- X-ray film geometric parameters shall be available
- Clinical tumour/site-specific protocols shall contain instructions for immobilization

Field marking;
Fields shall be marked
Marks should be maintained during treatment
Contouring method (machine, wire, etc) Data transfer from imaging to planning

Manual transfer / Automatic transfer;
Data transfer
Mould room and beam modification devices
Use of Multi-Leaf Collimator (MLC)
Standard blocks
- Sufficient inventory ,Comment on standard blocks
- Customized (individualized) blocks
• Mould room technician should be appointed
• QA procedures shall be performed on hot wire cutter
• If customized blocks are fixed to shadow trays
• Sufficient shadow trays for clinical load
• Blocks shall be verified prior to treatment with first portal
• Comment on customized (individualized) block production and use
• Comment on QA in mould room procedures
• Compensators usage

**Prescription and planning**

In teletherapy planning;
There should be an interaction between different members of the staff and work well together as a functional unit.
There should be means for ensuring the reproducibility of radiation administration.
QA procedures documented.

*Treatment prescription;*
Specify type of TPS
There should be a procedure manual (treatment guidelines or protocols) for planning including site-specific geometric arrangement of beams
2D procedures (beam arrangements) / 3D procedures (OAR, definition of volumes, etc.)
Tumour volumes should be delineated / For curative (radical) patients / For palliative patients
Which of the following target volumes is / are used (ICRU 50 & 62)? / Gross Tumour Volume (GTV) / Clinical Target Volume (CTV) / Planning Target Volume (PTV)
Margins between CTV and PTV for each site/tumour technique should be documented
Modality (photons, electrons) should be stipulated / Beam energy should be stipulated / Beam modifiers (e.g. wedges, blocks) should be stipulated / Patient position (e.g. supine, prone) should be stipulated / Dose per fraction should be stipulated / Total dose should be stipulated / Number of
fractions should be stipulated / Total treatment time for schedules other than once daily 5 times per week should be stipulated / Prescription should be signed by the radiation oncologist / Reporting system used - ICRU / Other

*Treatment planning;*
Treatment planning technique used should be stated:
Isocentric, Source Axis Distance (SAD)
Source Skin Distance (SSD)
Calculation
  Manual / Computer
2D TPS / 2D+ TPS / 3D TPS
Treatment calculations should be rechecked by another person before first treatment
Beams data in TPS:
Generic / Specific
Treatment machines should be uniquely identified in TPS
Has the TPS the capacity to generate dose-volume histograms (DVH)?
If so, are DVHs used by radiation oncologist / medical physicist / RTT / other / unused
A policy on maximum and minimum doses to PTV should exist
Treatment planning should be endorsed (signed) by the radiation oncologist
Treatment planning should be endorsed (signed) by the medical physicist

Procedure, if planning not endorsed

There should be a planning review meetings / Participants /
Comments on the quality of treatment planning
From planning to delivery
  Data transfer from planning to delivery
Simulation or virtual simulation images should be agreed upon prior to treatment course.
Data transfer from planning to delivery may be by manual transfer / Automatic transfer / Record and verify system.
Data transfer should be double-checked / Person in charge should be endorse

Comment on QA

**Treatment delivery: Teletherapy**

It is recommended to have more than one treatment unit. If the department treats children, need to consider any necessary differences (general anaesthesia, immobilisation, etc).

**Treatment delivery procedures**

Patient logbook should be kept at each individual machine

First treatment session

Some time shall be allocated for verification

Portal films shall be obtained prior or at time of first treatment

Physicist’s presence shall be mandatory but not an option

There shall be psychological preparation for the patient

Patient set-up (positioning and immobilization)

Skin marks / Tattoos / Immobilisation devices / Diagram/ photos of treatment position / Laser set-up

Portal films shall be verified / If yes, when and how frequent

Procedure for reviewing portal images shall be documented

Monitor units and treatment time

There shall be a Monitor units and treatment time

There shall be an independent daily check of treatment times

This shall be crosschecked with a calculator on treatment day 1

Independent daily check of treatment times

This shall be crosschecked with a calculator on treatment day 1

Routine check of treatment chart should be exist

Patient monitoring during exposure / Video system / Audio system / other:

In vivo dosimetry

TLD / Diodes

All patients shall be clinically reviewed during treatment

Weekly review is recommended by physician, nurse practitioner, RTT
There shall be a policy for handling interruptions in treatment / no-shows

There shall be a policy for handling acute medical emergencies?

**Brachytherapy**
Gynaecological cancer is the most frequent indication for brachytherapy.

Brachytherapy infrastructure;
Location of the brachytherapy treatment area relative to teletherapy
Type of brachytherapy Intracavitary / Surface / Intraluminal / Intraoperative / Interstitial
Intention to use brachytherapy Boost after external beam / Alone / Intraoperatively
Mode of operation Manual / Remote
Isotope and system used for intracavitary brachytherapy CS-137 LDR / CS-137 MDR / IR-192 HDR / CO-60 HDR / Other (specify):
Verification system should be in place? X-ray / Endoscopy / Ultrasound / MRI
Treatment planning system should be used
Application room design (space, shielding, etc) Comment.

Brachytherapy procedure;
State what types of applicators are used.
State whether there is direct loading or after loading (manual or automatic).
There must be aseptic conditions for the insertion of applicator.
Applicators must be sterilized between users Single use applicators.
State what type of anesthesia/analgesia is generally used for: Cervix / Vagina / Other.
For cervix cancer, state what is the method of dose prescription/calculation Dose to point A or point B Other reference points - Rectum / Bladder / Other.
ICRU guidelines for dose and prescriptions should be used.
The application should be done under supervision of a radiation oncologist.
In vivo dosimetry for cervix cancer treatment. Doses to Rectum / Bladder should be specified. Insertion time pre-calculated or individually calculated. Transfer of TPS calculation in afterloading unit. Radiation oncologist should validate the prescription. Physician should be present through or part of the procedure. State who removes the applicators (preferably physicist, RTT or a trained oncology nurse).

The responsible physician should sign the dose calculation. The responsible physicist should sign the dose calculation. There should be a cross-checking of dose calculations. There should be a procedure for ensuring there is no source loss during treatment.

If low dose rate, non-automatic brachytherapy, the concerned medical and nursing staff should be informed of the time for source removal. There should be a procedure for unloading (handling, transportation, storage of sources etc). Safety training of staff (loading, unloading, handling, transportation, nursing, control of visitors). There should be an emergency procedure protocol. There should be repeated safety drills for HDR.

There must be a coordination between brachytherapy and teletherapy units.

Treatment summary (documentation)
This section refers to the recording and reporting of a treatment after its delivery. In many countries there is a legal requirement for record keeping. Also, internal audit and clinical research requires access to previous treatment data.

Documentation of treatment summary
The treatment sheet after treatment should be stored with the patient file. There should be a treatment summary. The file kept should be kept / easily accessed / available. The treatment films be kept / easily accessed / available. Communication of cancer data to a national/regional cancer registry.
12.10 **Follow-up**

Follow-up of patients is the essential source of information on treatment outcomes (cancer control, side effects, misadministration). It is an important tool for internal and external audit. Consistency of follow-up policy throughout the department is essential.

Radiotherapy patients should get a follow-up appointment after treatment. State at what intervals Curative / Palliative

There should be a follow-up policy for the different cancers

Comment:
State how long the patients are followed up: one year / two years / five years / excess of five years
Is the follow-up done in the radiotherapy department / elsewhere?
Is follow-up done by physicians other than radiation oncologists?
If carried out elsewhere, the reports on the outcome of patients should be availed to the radiotherapy department
Tumour control, failure and complications at follow-up should be recorded
Is radiation toxicity graded and documented?
Follow-up data should be analysed in terms of the above
There should be a policy of systematic review of serious complications

12.11 **Radiotherapy Medical physics QA checklists**

Procedures and their documentation, and records, where appropriate, should be reviewed for all medical physics items.

Important to note who routinely performs the medical physics activities eg a resident medical physicist(s), a contracted medical physicist or whether duties are delegated to other personnel.

**Imaging (X-ray unit, CT, MRI, other)**
Specification of the equipment Type / Date of manufacture / Date of installation Manual of operation.
Training of personnel for use of Imaging procedures, physics involvement QA programme Quality Assurance Manual / Acceptance procedures / Commissioning procedures QC
programme (tests, frequencies, responsible persons, action levels, actions) warm-up procedure / geometry accuracy, couch and lasers / image quality (low and high contrast resolution etc) / data display, data transfer, data manipulation / accuracy and stability of CT numbers Incident logbook should be in place Repair and maintenance programme Logbook / frequency / person in charge of repair / procedure to accept repair General condition of equipment and room.

Localization and simulation
Specification of the equipment Type / Date of manufacture / Date of installation / Manual of operation / Training of personnel for use / Localization/simulation procedure, physics involvement / QA programme manual / Acceptance procedures / Commissioning procedures QC programme (tests, frequencies, responsible persons, tolerance and action levels, actions) Warm-up procedure

Mechanical and geometry tests
Lasers / distance indicator (ODI) / central axis indicators / field size indicators / light and / radiation field coincidence / angle indicators (GA,CA) / collimator axis of rotation-isocentre / gantry axis of rotation -isocentre / couch movements (vertical, lateral, rotation) / coincidence of simulator and couch isocentres / compatibility of couches and scales between simulator and treatment unit / field wires, contouring devices

Image quality (dose rate, kVp & mAs calibration, high and low contrast resolution; film processing) Radiation protection, Data transfer, Incident logbook, Repair and maintenance programme Logbook / frequency / person in charge of repair / procedure to accept, repair General condition of equipment and room

Immobilization
Role of physicist/RTT
Acceptance, commissioning and QC of devices
Dosimetry checks, when appropriate
Communication
Mould room and beam modification devices
Role of physicist/RTT
Dosimetry checks, when appropriate
Equipment and devices available
Acceptance, commissioning and QC of devices
Repair procedures where appropriate
Data transfer and verification
Communication

Treatment planning
Specification of the TPS Type / Date of manufacture / Date of installation / acceptance Latest upgrade
Manual of operation/documentation of algorithms / Training of personnel for use / QA programme manual / Acceptance procedures/reports / Commissioning procedures/reports /
Methods to obtain beam data / Verification methodology
Participation in external audits
Control of consistency of TPS data with other departmental dosimetry data sets
QC programme (tests, frequencies, responsible persons, tolerance and action levels, actions) Test calculations/ sample plans / checks of single field / checks isodose distributions / reproduce dose distribution for input data / monitor unit calculation / hardware input/output devices / data transfer
Incident logbook
TPS upgrading Logbook / frequency / person in charge / procedure to accept changes
Support from manufacturers (assistance in trouble shooting) /
Communication with manufacturers / Links to user groups
TPS PC/Workstation should not be used for any other software other than the TPS (increased chances of corrupting the TPS files)

Patient dose calculation procedures
Responsibility for planning / Manual of procedures / Verification of introduction of new methods / Request for planning and information provided / Interaction with the requesting physician / Plan and chart check methodology (tolerance and action levels) / Storage and back-up of plans / Independent MU calculation
system and method / Approval of plan / Methodology for transfer of data to treatment delivery / Procedures for plan changes during treatment

**Treatment delivery:**
Teletherapy (cobalt units and linear accelerators)

Specification of equipment Type / Date of manufacture / Date of installation

Manual of operation / Training of personnel for use / QA programme manual / Acceptance procedures/reports / Commissioning procedures/reports / Participation in external audits / Radiation safety surveys

QC programme (tests, frequencies, responsible persons, tolerance and action levels, actions) / Warm-up procedures

Safety tests Door interlocks / radiation warning lights / area monitor (cobalt unit) / emergency on/off switches / manual means to shut off machine (cobalt unit) / exposure at room in “beam off” condition / collision avoidance / other safety interlocks

Mechanical/geometric tests Lasers / distance indicator (ODI) / central axis indicators / field size indicators / light and radiation field coincidence / angle indicators (GA,CA) / collimator axis of rotation - isocentre / gantry axis of rotation - isocentre / couch movements (vertical, lateral, rotation) - isocentre / coincidence of collimator, gantry and couch isocentres / coincidence of mechanical and radiation isocentres / table top weight

Beam dosimetry Output constancy (daily test) / dosimeter for daily test - calibration (certificate) & Constancy / beam calibration / field size factors / depth dose dependence / beam uniformity / other systems (e.g. MLC,...)

Clinical dosimetry Beam dosimetry data / depth dose-data / OAF / isodoses / monitor units/timer set calculation

wedge and tray factors / SSD variation / timer (Co-unit; linearity, timer error) / monitor (linearity, proportionality) / GA dependence / asymmetric jaws / special gadgets (e.g. stereotactic equipment)

Additional parameters for electron beams (cone ratios, gap factors, others)
Special techniques, if any (TBI, others)
Advanced techniques where appropriate (e.g. IMRT)
In vivo dosimetry Equipment and methodology / calibration and QC / practical use / acceptance levels and actions if checks outside the limits
Portal imaging Equipment and methodology / acceptance, commissioning and QC / practical use / acceptance levels and actions if checks outside the limits
Record and verify, information network etc as appropriate
Equipment and methodology / acceptance tests’ reports / practical use / actions if deviations occur
Machine fault logbook Procedure on occurrence of a fault / Incident logbook/ reporting
Repair and maintenance programme Logbook / frequency / person in charge of repair / procedure to accept repair
General condition of equipment and room

Treatment delivery: teletherapy (orthovoltage X-rays)
Specification of equipment Type / Date of manufacture / Date of installation
Manual of operation / Training of personnel for use / QA programme manual / Acceptance procedures/reports /
Commissioning procedures/reports /
QC programme (tests, frequencies, responsible persons, tolerance and action levels, actions)
Safety tests Door interlocks / radiation warning lights / other safety interlocks
Mechanical/geometric tests Applicators / filters
Beam dosimetry Output constancy (daily checks) / dosimeter for daily checks - calibration (certificate) & constancy / beam calibration / timer / HVL check
Clinical dosimetry Beam dosimetry data / depth dose data / cross-beam distribution / methods of treatment calculation
Machine fault logbook / Procedure on occurrence of a fault Incident logbook/ reporting
Repair and maintenance programme Logbook / frequency / person in charge of repair / procedure to accept repair
General condition of equipment and room
12.12 Brachytherapy

Specification of equipment and systems

Type / Date of manufacture / Date of installation

Manual of operation / Training of personnel for use / QA programme manual / Acceptance procedures/reports / Commissioning procedures/reports / Source calibration - certificate & traceability / Participation in external audits

Commissioning procedures/reports

QC programme (tests, frequencies, responsible persons, tolerance and action levels, actions)

Safety tests Door interlocks / radiation warning lights and alarms / area monitor / portable survey meter / emergency on/off switches (LDR & HDR units) / emergency container and emergency kit for source handling / movable lead shields (manual LDR) / exposure at room in “beam off” condition

Source dosimetry Dosimeter (well-type chamber or equivalent) - calibration (certificate) & constancy / source calibration / uniformity of a batch of sources / uniformity of linear activity

Clinical dosimetry Imaging for source reconstruction / accuracy of source positioning / coincidence of dummy and active sources / timer function / dose calculation algorithms and methods

Other items source storage and disposal / transfer of sources / inventory of sources / source replacement policy / checking of contamination / source guides / mechanical integrity of applicators

Machine fault logbook / Procedure on occurrence of a fault

Incidents Procedures for stuck source, damaged source, lost source Logbook / reporting

Repair and maintenance programme Logbook / frequency / person in charge of repair / procedure to accept repair

General condition of equipment and room

Brachytherapy treatment planning and verification

Responsibility for planning / Treatment planning equipment and methods / Manual of procedures / Verification of introduction of new methods / Request for planning and information provided /
Imaging, localization and source positioning / Interaction with the requesting physician

**Dosimetry equipment**
List of dosimetry equipment available (including barometers and thermometers, other)
Manual of operation / Acceptance and QC programmes (each item) / Local standard ionisation chamber calibration, traceability, certificate / Calibration of field dosimeters / Repair and maintenance programme
General condition of equipment

**Radiation protection**
Responsibilities for radiation protection e.g. persons identified; radiation safety officer appointed; responsibilities defined; awareness of these roles in department; radiation safety committee; radiation safety policy
Licensing to conform to the national requirements e.g. licensing/authorisation/accreditation requirements fulfilled; for use of ionising radiation; for facilities; for storage, disposal, etc of radioactive material
Risk assessment and management e.g. risk and hazard evaluations undertaken; range of possible incidents, accidents considered; contingency planning in place for predictable events (actions, instructions, investigations, reporting) Patient dose incidents and accidents (actions, instructions, investigations, reporting) Radiation protection consideration in planning of facilities and procedures Procedures for pregnant workers, pregnant patients Procedures for visitors, comforters, carers, discharge of patients, etc. Procedures for transport of sources to/from the centre and within the centre
Classification and identification of areas e.g. criteria, signs, control
Local rules for radiation protection in different areas (cobalt units, linacs, brachytherapy, other); local supervision of this access control
Radiation protection equipment available / Acceptance, calibration and QC
Radiation surveys e.g. what is done; frequency, methods, records, actions
Practical procedures for personnel monitoring and investigation of significant doses; records
Radioactive source storage, security, inventory, handling, disposal, leak testing, records, etc.
Procedures for identification of authorized practitioners and operators; and for ensuring justification and optimisation

12.13 Therapy Radiographer (RTT) Checklist
Procedures, practices, protocols, roles and responsibilities, where appropriate, should be reviewed for all the RTT items.

RTT Quality Assurance Checklist

RTTs knowledge of treatment protocols
Orientation program for new RTTs / Radiation Safety / Familiarity with radiation safety protocol for patients, staff & public / Quality assurance departmental policies and procedures / RTT contribution to quality assurance procedure / Protocol for RTT role in the informed consent process / Patient identification protocol / Procedure for RTTs to question deviations / Quality control procedures on imaging units / Perform quality assurance procedures on film processing equipment / Policy for radiation safety in simulator: call out ‘screening’, checking lead aprons / Table top, laser light, field size, gantry, check - consistency on all units / Door interlocks checked / Check room monitors

Pre-treatment quality control procedures
(simulation/localization/planning)
Skin marking protocol / Simulation/portal film images: labels, date, field size, treatment parameters, Radiation Oncologist signature / Adequate time for simulation procedures Procedures Manual available / Process for RTTs to review Procedures Manual /
Quality control procedures on treatment records and setups. Exposition chart available/ Quality checks on treatment plans - protocols / Quality checks on dose calculations - protocols Policy on double check on treatment setups / Weekly quality control of charts/records / Set-up notes / Any field/dose parameter changes noted / Special instruction compliance (e.g. review films) / Blood-work compliance and results checked / Any gap/separation changes noted / Recalculations done / Port films/images done / Port films/images approved / Daily treatment entries complete and signed / Dose additions complete and correct / Oncologist’s new orders checked / Nurse teaching recorded / Patient care procedure / Condition and follow up documented

Documentation complete
Storage and retrieval of patient documents / On the treatment sheet what is recorded, how and by whom. / Signature protocol / Independent/double checks of the monitor units delivered / RTTs involvement in patient review - daily, weekly

Quality assurance procedures on clinical aspects of patient care and education
Protocol on patient care / Protocol on patient education (including psychosocial aspects) / Health and Safety protocol (including infection control)

Quality control of radiation oncology laboratory (mould room):
Procedure for checking construction of immobilization/positioning devices / Procedure for checking construction of shielding devices

Perform quality control procedures on:
Remote after-loading brachytherapy units / Manual after-loading intracavitary/interstitial sources, surface applicators

Quality control procedures on treatment units:
Table top, laser light, f/s, check - consistency on all units / Door interlocks checked / Check room monitors / Quality checks on
accessory equipment at point of use / Quality control of immobilization devices - storage, replacement

**Radiation oncology quality assurance committee**
RTT representative / Process to review errors and near misses / RTTs procedure for the reporting of error / “No-blame” policy / Feedback mechanism / Mechanism for corrective action and RTT involvement / Mechanism for the implementation and monitoring of change
CHAPER THIRTEEN

13.0 Radiation protection in diagnostic imaging and radiotherapy

13.1 Radiation protection in diagnostic radiology

The technical and physical factors in protection of the patient against ionizing radiation risk/hazard must be paramount and in the use of ALARA Principle.

The level for radiation exposure of a patient depends on technical and physical factors. The factors leading to the reduction of exposure to patients are in line with the principles of radiation protection, Justification and dose optimization. Whereas all medical exposure must be justified, dose optimization through the cardinal principles of time, distance and shielding is also paramount. Basing on this, the following should be done;

- Strict limitation of the size of the beam to the region of interest to achieve effective patient protection without compromising diagnostic information
- Optimization of radiation beam/protection
- Divergence of x-ray beam
- Radiation quality
- Voltage wave form
- Tube voltage
- Filtration - 2mm Al equivalent
- Carbon fiber materials
- Size of field and the alignment of the beam
- Provide Shielding for:
  - Patient
  - Gonad protection
  - Eye shielding in radiotherapy
  - Care for Critical organs and normal structures in the treatment field in radiotherapy.
  - Use of beam modifiers like shielding blocks, missing tissue compensators, wedges and bolus in
radiotherapy
  o Proper treatment planning for every treatment field in radiotherapy.

- Control of scatter to recording system.
  o Gridded cassettes
  o Air gap

- Films and screens combination.

- Fluoroscopy
- Images, intensifier
- Computed tomography
- Film processing techniques
  o Manual processing.
  o Automatic processing.
  o Control of radiation exposure
- Exposure charts
- Reduction of repeat and giving proper instructions to the patient.
- Quality assurance programme - is a must for every unit
- Special types of radiological procedures
  o Chest examination - High Kvp technique
  o Examination of women of reproductive age - use ultrasound
  o Obstetric radiology - use of ultrasound
  o Other radiological examination during pregnancy - is discouraged unless there is strong clinical indication
  o Mammography - use of suitable cones
  o Dental Radiography
  o X-ray examination in wards and operating theatres - restriction of beam to the area of interest.
  o Paediatric Radiology - short exposure time and immobilization
- Digitized Diagnostic Radiography
  o Digital Radiography. (DR)
  o Computed Radiography CR)
  o Digital Mammography (DM)
  o Digital Subtraction Imaging (DSI)

All the above minimize radiation to patients
Principles for optimizing radiation dose

Radiation dose optimization should involve safety of the radiation workers, patients and members of the public. To achieve this, the following should be implemented:

- Correct site for facility construction should be made. Consultation should be made from AEC with help of the facility radiation Safety officer.
- The bunker to house the machines using noising radiation should be designed and constructed according to national and international guidelines. Consultation should b made from AEC with help of the facility radiation Safety officer.
- Machine installation should be made by the vendor using qualified biomedical engineers. Machine acceptance testing and commissioning should be made by the medical physicists. Independent checks are relevant for compliance.
- Throughout the life time of the machine, several operational procedures should be implemented by all the workers in their respective duties, to include:
  - All radiographic films or images shall be permanently labeled with patient identification, date of the examination, and anatomic marker.
  - All facilities performing radiographic investigations and procedures shall have protocols for standard views of each anatomic area that will be radiographed. These should be designed to optimize diagnostic information while minimizing radiation exposure.
  - Appropriate collimation should be used to limit exposure to the anatomic area of interest.
  - All facilities performing radiographs should have technique charts listing exposure factors that will reliably produce diagnostic radiographs of anatomic parts of patients of different sizes to minimize the need for repeat exposures.
  - All radiographs shall be reviewed for positioning and diagnostic quality at the facility before the patient is released. Repeat radiographs shall be performed
when necessary. Repeat rates should be part of the routine quality control process.

- All facilities providing radiology and imaging services shall have policies and procedures for appropriate shielding of patients and radiation workers.
- Immobilization and assistance procedures appropriate for the age and size range of patients to be imaged should be available to ensure that images of diagnostic quality can be obtained in patients who are unable to cooperate, or unable to be positioned in the usual manner due to age or physical limitations, and without unnecessary irradiation of Radiation workers.

Develop protocols / guidelines for designing radiology units.

- Needs assessment
- Stake holders identified
- Resource persons identified.
- Consultation meetings held
- Draft guidelines developed
- Final guidelines approved
- Monitoring and evaluation done.

Design dose-monitoring protocols for radiology units in the country.

- Dose monitoring needs assessed.
- Contact persons identified.
- Dose monitoring budgets drawn up.
- Funds secured
- Monitoring equipment procured
- Dose monitoring manuals drawn up.
- Reporting sequence / mechanism established
- Evaluation and follow up done.

Design procedures / protocols that promote the ALARA principle in the Radiology units in the country.

- Needs assessed.
• Processes procedures identified.
• Bottlenecks in the processes identified
• Monitoring and evaluation done.

Establish a licensure scheme for radiology units in the country
• Needs assessed
• Radiology units identified
• Radiation secretariat establish
• Requirements for setting up radiology units established and disseminated countrywide.

Standards to improve the quality of radiology and imaging services.
• Provision of regular / periodic reports and radiation safety due dates when these reports have to be handed in.
• Setting of acceptable dose levels for the workers basing them on the international standards.
• Establish maximum duration of stay in radiation areas and establishment of an exclusion scheme for the vulnerable e.g. pregnant ladies.
• Establish dose reference levels

13.2 Radiation protection in nuclear medicine
An appropriate standard of radiation protection against ionizing radiation without limiting the benefits. Availability of comprehensive quality care and safety for medical users in ionizing radiation with emphasis on medical application

Government shall provide essential services for radiation protection and safety that exceeds or complement the capabilities of the legal persons authorized to conduct the practice.

The standards are based on presumption that a national infrastructure is in place enabling Government to discharge its responsibilities for radiation protection and safety.
National infrastructures requirements:

- Legislation and regulations
- Regulatory Authority empowerment to authorize and inspect regulated activities, to enforce the legislation and Regulation.
- Government need sufficient resources, trained personnel for detecting build up radioactive in the environment.
- Disposal of radioactive waste
- Emergency preparedness
- Arrangement for training specialist in Radiation protection and safety
- Provide facilities and services
- Provide dosimetry for environmental monitoring.
- Provide calibrations for radiation measuring equipment
- Provide central registries in occupational exposure records.

Protection and safety

- Distant quadrant law to stay as far away from the radioactive source.
- Near contact to patient administered radioactive substance to be avoided.
- Regular measurement of personal by TLD every month
- Pregnant women should not work in nuclear medicine

Technical requirements for radiation protection

- Generators that produce short lived radionuclide from long-lived radionuclide. Example; 99m Technetium from 99m Mo
- Radiation dose to patients must be as low as possible.
- Radiation emitted must be sufficient energy to penetrate the surface of the body for good response to the detecting equipment.
- Ideal nuclide that emit gamma radiation
- Detectors scintillation counters with NaI crystals with Lead collimation.
- Optimum energy between 0.12 to 0.16 Mega Volts for
gamma camera

**SPECT-Gamma Camera**
- Using Scintillation Camera therefore excellent linearity and uniformity
- Be evaluated regularly
- Regular measurement of axis of rotation
- The centre of the field of view should correspond to the computer
- Evaluation of errors in the centre of rotation weekly

**Computer connected to Camera**
- Testing Camera computer systems to verify the validity of images and numerical data
- Data Acquisition must be evaluated regularly
- Analysis of software by processing a standard set of data to verify reproducibility of results
- Cardiac phantom to produce both data acquisition and processing data

**Maintenance of Equipment**
- Instrument Maintenance and service must be regular
- A service log book for repair must be kept
- Useful for documentary equipment reliability
- Providing information to service personnel

**Imaging principles**
- Proper Selection of collimator
- Routine use of common Collimator
- Low energy, All purpose and Parallel-hole Collimator
- Radiopharmaceutical distribution imaging at appropriate time
- Collect enough counts
- Imaging anterior, posterior and lateral or modified oblique views
- Anatomical markers hot or cold be used
- Reporting results after careful analysis
Radiopharmaceuticals

Definition
Radioactive product administered to persons usually for purpose of medicinal or investigational where radioactivity is essential part of the product.

- Pharmaceutical purity for intravenous injections with sterile solution, free from pyogenic, foreign particle and acceptable pH
- Chemical purity from 99m eluate should be checked for presence of alumina.
- All record must be kept of all radionuclide that come into the department and all radioactive waste.
- Record of activities obtained at each elution.
- All radioactive solutions including patients dose
- Check for toxicity of the eluate.

Preparation of radiopharmaceutical

- The environment where radioactive pharmaceutical is being prepared must be free of microbial contamination.
- Clean room without dust particles environment.
- The area must be far from the staffs’ room.
- Adequate lead glass shielding.

Protection safety of generator

Radioactive sources in two main areas

- In the hot area storeroom of low activity.
  a) Activities of few mCi radionuclides for tracer investigations.
  b) Therapeutic iodine 131 dose.
- In the hot area radiochemical laboratory sources are
  - Molybdenum-technetium99m generator, indium 113 generator
  - Very low activities of radiopharmaceuticals are stored at low temperature in the refrigerator or deep freezer.
Disposal of Radioactive Waste

Liquid waste
- Hospitals are allowed to dispose up to 500 mCi of all radionuclide
- Disposal of over 100 mCi must be recorded in book
- Radioactive of up to 100 uCi may be disposed in designated sink.

Solid Waste
- Regulation shall be stringent.
- Disposal shall be not more than 3 mCi per week
- All solid waste must be sent direct to the incinerator for disposal

Quality Assurance in Nuclear Medicine
Quality assurance is extremely important in routine performance of diagnostic imaging in nuclear medicine involves many aspect.

- Routine quality assurance.
- Preparation of radiopharmaceutical
- Evaluation of the instruments.
- Record must be maintained
- Constant monitoring of procedures

Instrument for quality control
- Dose calibrator, regularly calibrated.
- Routine use of dose calibrator to ensure correct doses.
- Accuracy and linearity be checked after every six-month.
- Proper choice of collimators

Patient screening
- Removal of necklace, earrings, button belts.
- Prevent movement of patient during examination during imaging
- Use means of immobilization when necessary.
• Detector as close as possible.
• Use hot mark for anatomical references.

13.3 Radiation protection in radiotherapy:

Protection for Radiotherapy services.

- All radiotherapy units shall be manned by a certified Registered and licensed Radiation workers.
- The minimum team of radiation worker in Radiotherapy shall include:
  - 1 Radiation Oncologist / Radiotherapist
  - 2 Therapy radiographers
  - 1 Medical physicist,
  - 4 Oncology Nurses
  - 1 Mould room technician.
- Buildings and Radiation emitting equipment shall meet the recommendations of National Standards, IAEA and International Commission on Radiological Protection (ICRP).
- The buildings and radiation sources shall be licensed and periodically monitored for any radiation leakage by the National Radiation Protection service.
- The following shall be required:
  - Protection barriers specified by a medical physicist
  - Radiation warning signs
  - Radiation safety interlocks
  - Closed circuit monitor
  - Provision for in- patients on long- term treatment.
- The supplier of Radioactive source shall carry the contractual obligation to take back (dispose) the depleted source at the decommissioning of the radioactive source.

13.4 Managing radioactive wastes

The Atomic Energy Council should put in place all the range of requirements needed for the establishment of the nuclear waste disposal facility and control all the disposed wastes in
Standards on diagnostic imaging and therapeutic radiology for Uganda

accordance with the national and international laws. Invite experts to review the document in compliance with any site selected by Council to safeguard the interests of other occupants and the environment. All producers of radioactive wastes shall follow the protocol designed by the AEC for disposition.

These should be in line with
1. Waste Characteristics; different sources of low and intermediate level radioactive wastes differ considerably in their characteristics in terms of half-lives and toxicity, radioactive components degradable and non-degradable properties and can vary in physical and chemical forms. A clearly safety procedure between the Council/ disposal facility and the waste producers should be documented indicated storage and transportation to the facility. This should state the radionuclide waste and their related activity levels, waste origin and nature, waste quantity, physical dimension and weight, content and property of the waste packages.

2. Site Characteristics; This is vital to evaluate the design process to ensure that the disposal system design is compatible with the site characteristics and that the construction, operation and closure of the disposal facility can be accomplished in a safe manner. Site selection takes a number of actors;
   - Logistics example; proximity of the waste source, transport links and existing other disposal sites.
   - Existing infrastructure and services
   - Space available
   - Proximity to waste produces
   - Topography
   - Climatology

3. Engineering works; the construction works should be done by qualified personnel to cater for proper drainage, safety
barriers and technical issues not to contaminate environment and expose the members in the proximity of the facility.

4. Operational consideration; Well trained personnel to transport the wastes, operate the facility and provide safety and security should be in place

5. Transportation of sources; acceptable packaging, transport accidents, radiation protection, environment protection and transport regulation should be a key issue addressed by the Council.
CHAPTER FOURTEEN

14.0 MONITORING AND EVALUATION

- There shall be continuous monitoring and evaluation of the performance of imaging and radiotherapy services.
- There shall be continuous training and updating of information by the professionals working in radiation areas.
- Support supervision shall be provided to the districts at regular intervals. In this regard radiologists, medical physicists, imaging technologists and senior radiographers shall assist the Quality Assurance Department in providing outreach services.
- There shall be dissemination of the standards to all units dealing with imaging and therapy.
- There shall be mechanism of feedback to ensure that the standards are adhered to.

14.1 Training

Ministry of Education and Ministry of Health will be responsible for training of the necessary human resources in order to meet the high demand of various cadres of professionals.

14.2 Supervision

- Shall be carried out in all areas of Radiological investigations and radiotherapy.
- The In-charge of the imaging unit shall ensure that the right examination is performed to the right patient.
- Consumables of the right quality and quantity shall be delivered at the right time. The Equipment shall be safe and fully functional.
- The personnel shall have the right qualifications and shall undergo continuous professional development.
- Proper radiation monitoring shall be done regularly.
- Premises shall meet the specified standards.
- Periodic reports on performance shall be written and submitted.
• Premises shall be kept clean and tidy.
• Correct Disposal of medical wastes shall be done.
• Regular checks on performance of the equipment shall be done
• Ethical code of conduct shall be enforced
• Issues of radiation leakage or injuries shall be reported promptly.

14.3 Client Satisfaction
• Patients shall be received with a smile
• Provide proper waiting area with adequate seats
• Provide necessary Information required about the investigation to be carried out.
• Provide privacy to the patient
• Provide changing gowns
• Provide security for patient’s property
• Carry out the examination in the minimum required time
• Provide necessary support
• Ensure informed consent
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## ANNEXES

### Annex I: List of contributors

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GLOSSARY (Key terms)

Practice
Any human activity that introduces additional sources of exposure or exposure pathways or extends exposure to additional people or modifies the network of exposure pathways from existing sources, so as to increase the exposure or the likelihood of exposure of people or the number of people exposed.

Controlled area
A controlled area is any area in which specific protection measures and safety provisions are or could be required for:

- Controlling normal exposures or preventing the spread of contamination during normal working conditions; and
- Prevent or limit the extent of potential exposure.

Employer
A legal person with recognized responsibility, commitment and duties towards the worker in his/ her employment by virtue of a mutually agreed relationship. (A self - employed person is regarded as being both an employer and a worker)

Legal person
Any organization, corporation, partnership, firm, association, trust, estate, public or private institution, group, political or administrative entity or other persons designated in accordance with national legislation, who or which has the responsibility and authority for any action taken under these standards.

License
An authorization granted by the AEC on the basis of a safety assessment and accompanied by specific requirements and conditions to be complied with by the licensee.

Licensee
The holder of a current license granted for a practice or source who has recognized rights and duties for the practice or source, particularly in...
relation to protection and safety.

**Registrant**
An applicant who is granted registration of a practice or a source and has recognized rights and duties for such a practice or source, particularly in relation to protection and safety.

**Radiation Protection Officer (RPO)**
An individual who is appointed under section 19 of the Act. He is a competent person with knowledge and skills in radiation protection and part of the secretariat to carry out duties of the council in compliance with the law by the users.

**Radiation Safety Officer (RSO)**
An individual who is competent in radiation protection matters as provided for by section 36 of the ACT, to oversee the implementation of the requirements of the Atomic Energy law of 2008 and Atomic Energy Regulations of 2012 at any facility using ionizing radiation.

**E-health** is a communication process providing healthcare via electronic means, in particular over the Internet. The term has been used to describe the various activities related to the electronic exchange of health related data, voice, or video.