2 Quality Assurance In A Diagnostic Radiology Department

1.1 Aim

Aim is to implement an effective quality assurance programme in the Hospitals to ensure production of consistently high quality images with a minimum exposure of the patient & the staff working in the Hospitals wherever radiological imaging facilities are available.

1.2 Introduction

Quality assurance means that planned & systematic actions that provide adequate confidence that a Diagnostic X-ray facility will produce consistently high quality images
With minimum exposure of the patient & the staff working in the Department
Components of the "X-ray system"

i. An X-ray high voltage generator
ii. An X-ray control
iii. A tube housing assembly
iv. A beam limiting device
v. Supporting structures

Other components that functions with the system are Image receptors, Image processors, & dark rooms

Quality assurance includes "quality control" techniques & "quality administration" procedures

Quality administration procedures are management actions intended to guarantee that monitoring techniques are properly performed & evaluated & that necessary corrective measures are taken.

Quality control techniques are techniques used in the monitoring (or testing) & maintenance of the components of a X-ray system. Quality control techniques are concerned directly with the equipment.

1.3 Key Elements of Quality assurance

i. Responsibility
ii. Purchase specifications
iii. Standards for image quality
iv. Monitoring & maintenance
v. Evaluation
vi. Records
vii. Manual

Implementation of Quality Assurance program should be based on IAEA/AEA regulations

1.3.1 Responsibility

Duties of the committee

Assign the duties to the Radiation safety committee in Teaching Hospitals & Provincial General Hospitals if established

When there are no established committee following duties should be done by the Radiation protection officer.

Assigning quality assurance responsibilities
Maintaining acceptable standards of quality.
Reviewing

- Program effectiveness & Quality assurance program.
- Reports quarterly.
- Monitoring & maintenance **techniques Standards** for image quality.
- Results of evaluation of **effectiveness** preparation of Quality Assurance **manual** annually**.**

Quality control officer

Physicist or Radiologist
When only plain radiography is available Superintendent Radiographer or a Radiographer with special training

Duties of the quality control officer

- In-charge of the QA programme & is a member of the QA committee.
- When there is no radiation safety committee duties of the committee should be done by the Radiation safety officer.
- Maintain lines of communication among all groups involved with quality assurance & image production. e.g. conducting regular departmental meetings.
- Assign responsibilities. Responsibility of day-to-day administration related to QA to the staff working in the Department
- Preventive maintenance & Corrective maintenance
- Assignment of BME service staff for corrective maintenance or preventive actions.
- Monitoring duties beyond the level of training of the staff technologists.
- Establishment & maintenance of standards for image quality.
- Training of staff technologists.

Duties of quality control supervisors

Quality control supervisors are responsible for quality control monitoring of the following machines & other responsibilities assigned by the Quality control officer. Plain Radiography, CT, Mammography, Angiography & Digital fluoroscopy & nuclear imaging.

Grade Y

1.3.2 Purchase specifications

Should be done according to the AEA/IAEA regulations

Before purchasing should determine the desired performance specifications according to the type of imaging & number of images required for a given period of time.

Should be approved by the Radiation safety committee if an established committee is available & when there is no established committee by the Quality control officer.

Written final purchase specification should include performance specifications.

The availability of experienced service personnel should also be taken into consideration if not available training of such personnel should be incorporated into the purchase specifications.

At the time of installation vendor should conduct equipment performance evaluations to ensure that the purchase regulations meet the Equipment should be formally accepted after the vender has made any necessary corrections.

After installation purchase specifications & records of acceptance testing should be retained through out the life of the equipment for comparison of monitoring results in order to assess continued acceptability of performance

1.3.3 Standards for image quality

Standards for acceptable image quality should be established.
These should be objective. When objective standards cannot be defined the opinion of the Radiologist should be consulted for assessment of image quality. Standards depend on the needs & the resources. Should be routinely reviewed & redefined at least annually. **Grade Y**

1.3.4 Monitoring & maintenance

A. Monitoring

Purpose of monitoring is to evaluate the performance of the machines in terms of the standards for the image quality established by the facility in compliance with the IAEA /AEA standards.

Five key points for monitoring

- Film processing
- Basic performance characteristics of the X-ray unit
- Cassettes & grids
- View boxes
- Dark room

(i) **Film processing**

QC equipment (QC kit)	Standards	How frequently
Digital thermometer	Solution (developer) temperature 35˚C ±0.3	Should be done daily
Digital densitometer	Contrast- Standard (1.75 ±0.15)	Should be done daily
Digital sensitometer (Dual color)	Base + fog 0.20 ± .02 OD	Should be done daily
QC film box Films of same batch number as those in current use	Speed index– Standard (1.2±0.15)	Should be done daily
QC chart		Should be plotted daily
Film/screen artifact identification	Should be free of artifacts	

Grade Y

(i) Basic performance characteristics of the X-ray unit

Following measurements should be done at least annually with the assistance of Atomic Energy Authority & Bio Medical Engineering Department.

For fluoroscopic X-ray units

Tabletop exposure rates
Centering alignment
Collimation
kVp accuracy
mA accuracy
Exposure time accuracy & reproducibility
Reproducibility of X-ray output
Focal spot size consistency
Half-value layer
Representative entrance skin exposures
-Flat ionization chamber

Grade Y

For radiographic X-ray units

Reproducibility of X-ray output
Linearity& reproducibility of mA stations
Reproducibility & accuracy of timer stations
Reproducibility &accuracy of kVp stations
Accuracy of source -to -film distance indicators
Light/X-ray film congruence
Half -value layer
Focal spot size consistency
Representative skin exposures
-Flat ionization chamber

Grade Y

For automatic exposure control devices

Reproducibility
kVp compensation
Field sensitivity matching
Minimum response time
Backup timer verification

Grade Y

Following should be checked at least monthly

For cassettes
Film /screen contact
Screen condition
Light leaks
Artifact identification

For grids
Alignment & focal distance
Artifact identification

For view boxes
Consistency of light output with time
Consistency of light output from one box to another
View box surface conditions

Dark room
Dark room integrity – Check for light leaks
Safe light conditions depends on the type & sensitivity of films for standard films <15W

Grade Y

Monitoring of specialized equipment

For Computerized Tomography

- Precision (noise)
- Contrast scale
    - High & low contrast resolution
    - Alignment
    - Representative entrance skin exposures

Should be regularly checked by using quality control phantoms

Grade Y

For Angiography
Objective methods

Are based on measurement of some physical parameters
These are rather complex and rarely applied to daily practice

Subjective methods

Test objects or phantoms
These are able to simulate the same radiation conditions as the part of the body
These describe behavior of radiology equipment in specific operating condition

Evaluation of clinical images
Allow evaluation of the overall performance including patient's collaboration and technique

Progressive judgement in terms of quality

Variable level of quality (clarity of thoracic calcification, arrange images in order of preference) strength of agreement by different observers gives indications on superiority.
Should be done regularly at least monthly.

Grade X

For mammography

High quality mammography requires film-by-film assessment of film quality & immediate & on-site corrective measures.

Grade Y

Image quality assessment.

.Comparison images should be available
.Adequate visualization of all the areas of radiographic & clinical concern
.Optimal amounts of tissue should be included
.Should have adequate & proper compression.
.Should be free of artifacts
.Should be properly labeled
.should be adequately exposed
.Images should be sharp (high contrast & high resolution)
. Should be viewed under optimal viewing conditions

Factors affecting image quality

1. **Choice of films & screens**

   Film with single emulsion (most sensitive in the green region of the visible spectrum) coated on one side with an anti -halation backing on the reverse.
   Films should match the single fluorescent screen in the mammography cassette.
   High contrast, high sensitivity films should be selected. Should be processed in a machine where the parameters are closely controlled & monitored.
   Equipments required for testing are phantoms for quality control 4c.m & 2c.m thick, designated cassette, film from the current batch & image quality phantom

2. **Processing conditions**

   Should have a dedicated processor for mammography.
   Extended processing should be used with a development time of 35-40 seconds at a temperature of 32-35˚C.
   Take measures to prevent heating of the developer (regular adding of replenisher & or starter specific for mammography).
   Should carefully & regularly monitor & control.

Following equipments are necessary for testing film processing in Mammography

21 step light sensitometer
Densitometer of proven accuracy
Thermometer
Processor control charts
Measuring jug
A dedicated box of mammography film with the same batch number as those in current use.

Standard baseline must be established

- Base+ fog should be less than 0.2OD depending on choice of film 0.17 density can be easily achievable.
- Limits of acceptability on this are +or-0.03OD.
- For the speed index the limit should be=or-0.10OD For contrast the limit should be =or-0.10OD
- For D max the minimum acceptable level is 3.6 OD

Processor monitoring should be done daily & information should be recorded on a processor monitoring chart.

Processor servicing & cleaning
Should be monitored before & after cleaning
Regular replenishment should be done according to the rates specified by the service engineer at the time of service

Processor cycle time
The time should not be changed for more than 5 seconds from the time set.

Developer temperature
Developer tank temperature should vary by less than 0.5 seconds

Changes in the PH or specific gravity
Should be 10 -11 for developer & 4-5 for fixer

Residual spent agents
Cleaning should be performed according to the manufacturer's instructions

3. Equipment capability & settings
KVp output
There should be facility for automatic selection.
Tube current should be as high as possible
Focal spot size should be as small as possible
Automatic exposure control device is essential
A moving grid is essential

Equipment should be monitored daily for its performance

Following are also essential components.
Proper positioning & adequate compression
Optimal viewing conditions.
Training of staff

Grade Y

B. Maintenance

Procedure for maintenance should be established at the time of installation of the machine & conducted on a regular schedule.

Preventive maintenance helps to prevent unexpected breakdowns & Disruption of the Departmental routine.

Should be performed on a regular schedule determined at the time of installation to prevent break downs due to equipment failing without warning signs detectable by monitoring. Preventive maintenance is cost effective.

Responsibility is assigned to the Radiographer using the machine.

Visual inspection of the mechanical & electrical characteristics of the X-ray system covering such things as Checking conditions of cables

Assuring cleanliness with respect to spilling of contaminants in the examination room or dark room

Listening of unusual noises in the moving parts of the system. Follow recommended procedures for cleaning & maintenance of the equipment

Regular inspection & replacement of switches & parts that wear out or routinely fail.

Corrective maintenance is to eliminate potential or actual problems revealed by monitoring or other means as regular inspection, cleaning & regular replacement of switches. Corrective maintenance should be carried out to eliminate the problems to prevent deleterious impact on patient care. **Grade X**

1.3.5 Evaluation

A. First level of evaluation

The results of the monitoring procedures should be used to evaluate performance of the X-ray systems to determine

i. Whether corrective actions are needed to adjust the equipment
ii. And to keep the image quality consistently with in the standards.

This evaluation should include

- Analysis of the trends in evaluation data e.g. Reject analysis

- Use of the data on a day-to-day basis to determine the need for corrective measures
- Comparison of the monitoring data with purchase specifications & acceptance testing results for the equipment **Grade Y**

B. Second level of evaluation

Is for evaluating the effectiveness of the program

On going studies of

retake rate & causes of the repeated radiographs (reject analysis) is the most useful. The number of rejects should be recorded daily or weekly. The reasons should be determined & recorded.

Analysis should be done

- after a 2 weeks period after major changes have occurred in diagnostic procedures or the X-ray systems.
- and at least by annually
- examination of equipment repair & replacement costs
- subjective evaluation of the radiographs being produced
- occurrence & reasons for complaints by the Radiologists
- analysis of trends in the results of monitoring procedures

Grade X

Studies should be used to

- evaluate potential for improvement
- to make corrections
- determine whether the corrective actions were effective

Reject analysis will provide useful information in the first level evaluation **Grade Y**

1.3.6 Records

Results of the monitoring & data should be the basis for evaluation.

Any difficulties detected, corrective measures applied & effectiveness of these measures.

The extent & forms of these records should be according to the Atomic Energy Authority.

Grade Y

1.3.7 Manual

QA manual should be written in a format permitting convenient revision of as needed & should be made readily available to all personnel.

Items

i. List of individuals responsible for monitoring.

ii. List of the parameters to be monitored & the frequency of monitoring.

iii. Description of the standards, criteria of quality, or limits of acceptability, which have been established for each of the parameters monitored.

iv. Brief description of the procedures used for monitoring each parameter.

v. Description of procedures to be followed when difficulties are detected to call these difficulties to the attention of those responsible for correcting them

vi. List of the publications in which detailed instructions for monitoring & maintenance procedures can be found.

vii. List of records that should be kept & sample forms.

viii. Copy of each set of purchase specifications & the results of acceptance testing for that equipment

ix. List of persons to call for answers to quality control questions.

Grade Y

1.3.8 Training

Training should include both training provided before the quality assurance responsibilities are assumed & continuing education to keep the staff up-to –date.

Grade Y

1.3.9 Review

Should review at least annually.

Radiation protection committee or Radiation protection officer should review the program to determine if the effectiveness could be improved.

Grade Y

1.4 References

1. Manual on quality assurance in diagnostic radiology - Part1 Radiographic equipment July 2001

2. Manual on specifications for medical diagnostic X-ray installations Feb 2002

3. Fundamentals of mammography
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   A. Robin M. Willson Mb ChB FRCR, FRCP (E)
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4. AEA regulations 1999

5. ICRP work shop 2006 Radiation protection for interventional cardiology