

Chapter 23: Justification and Optimisation in Clinical Practice

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A Handbook for Teachers and Students*

Objective:

To familiarize the student with principles and practices associated to justification and optimization.



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23.1 INTRODUCTION

All **medical exposures** must be subject to the principles of justification and optimisation of **Radiological Protection** which are **common to all** practices dealing with potential exposures of humans to **Ionising Radiation**

Justification of medical exposures may be stated as follows:

All medical imaging exposures must show a sufficient net benefit when balanced against possible detriment that the examination might cause

23.1 INTRODUCTION

For patients undergoing medical diagnosis or treatment, there are **different levels** of justification

The practice involving exposure to radiation must be justified in principle

through the endorsement of relevant professional societies

as matters of effective medical practice will be central to this judgement



23.1 INTRODUCTION

Also, each procedure should be subject to a further, case-by-case, justification by both the

- **Referring Clinician** who is responsible for the management of the patient and the
- **Radiologist** who selects the most appropriate imaging examination to answer the referrer's question

23.1 INTRODUCTION

In addition to the requirements of **Optimisation of Radiological Protection**:

the concept of **Optimisation of Clinical Practice** in diagnostic radiology must also be considered

This is the process requiring **diagnostic outcome** for a patient from an imaging procedure while minimising factors that cause patient **detriment**

Along with radiation related considerations these factors include **adverse** patient contrast media **reactions** in CT and interventional radiology



23.1 INTRODUCTION

Optimisation is a multidisciplinary task involving the medical physicist, radiologist, radiographer, hospital or vendor engineer and department management

It is a **cyclical** process comprising:

- Evaluation of clinical **image quality** and **patient dose** to identify the need for action
- Identification of the possible alternatives to maintain necessary image quality and minimising patient absorbed doses
- Selection of the best imaging option under the given circumstances
- Implementation of the selected option
- Regular **review** of image quality and patient dose to evaluate if either requires further action

23.1 INTRODUCTION

One key element in managing quality in health care is **Clinical Audit**

Clinical audit is a **systematic review** of the medical procedures against agreed standards for good procedures

seeking to improve the quality and outcome of patient care

It is applicable to justification and optimisation and is reviewed later in this chapter



23.2 JUSTIFICATION

Justification of medical exposures is the responsibility of both the radiological medical practitioner and the referring medical practitioner

A medical exposure is justified if it provides:

- a **Benefit** to the patient in terms of relevant diagnostic information and
- a **Potential Therapeutic Result** that exceeds the detriment caused by the examination

23.2 JUSTIFICATION

Imaging methods with **less** patient effective dose should be considered if the same diagnostic information can be obtained

This is true for all patients but especially important for **younger** patients

No new imaging modality should be established unless the exposed individuals or society have a **net benefit** to offset the detriment

Justification of medical exposures should be made on **three** levels - see the following table



23.2 JUSTIFICATION

LEVELS OF JUSTIFICATION OF MEDICAL EXPOSURES

1	Use of radiation for diagnosis in medicine is generally accepted
2	Use of radiation in a specific procedure for a specific objective is justified
3	Use of radiation for an individual patient should be justified prior to the examination

23.2 JUSTIFICATION

LEVEL 2

Use of radiation in a **specific procedure** for a **specific objective**, for example mammography to follow-up after breast cancer, is justified

It is important to evaluate if the radiological examination will improve the accuracy of the diagnosis and treatment of patients

Justification may need to be **re-evaluated** if new information or new imaging techniques are made available

For **example** plain radiography of the lumbar spine for acute back pain or disk hernia except for osteoporotic collapse may not be justified but MRI or CT considered instead

Use of radiation for an **Individual Patient** should be justified prior to the examination

Here:

- the **Specific Reasons** of the exposure and
- the **Explicit Conditions** of the patient

should be considered

Referral Guidelines are an important tool in this evaluation

The **request** for a radiological examination should convey all relevant information in order for the radiologist to decide on the best radiological procedure

Communications between the referring clinician and the radiologist are very important

Pregnancy and allergy to contrast media should also be considered, as should any relevant previous examination or information in the patient's medical record

23.2 JUSTIFICATION

23.2.1 Referral Guidelines for Imaging

Referral Guidelines for imaging are precise statements to help the clinician in making correct decisions on which type of radiological examination is **most appropriate** given the clinical conditions

While such guidelines are not absolute rules, there must be good reasons for ignoring them, as they are examples of **Good Practice**

The objectives of the referral guidelines are to improve clinical practice, to reduce the number of unnecessary examinations and hence to reduce **Unnecessary Medical Exposure**



23.2 JUSTIFICATION

23.2.1 Referral Guidelines for Imaging

The main target group of the guidelines is **Referring Clinicians**

Medical Physicists can, however, also benefit from studying the general scheme of the guidelines in order to better co-operate with medical staff in using the guidelines

23.2 JUSTIFICATION

23.2.1 Referral Guidelines for Imaging

In Europe, referral guidelines for imaging have evolved from the United Kingdom **Royal College of Radiologist** publication ‘Making the best use of clinical radiology services’

European radiological societies in member states have contributed to an evidenced-based booklet adopted by the expert groups ‘Referral guidelines for imaging’

The **American College of Radiologists** have published ‘Appropriateness criteria’ that are evidence-based guidelines to assist referring clinicians in making the most appropriate imaging decision



23.2 JUSTIFICATION

23.2.1 Referral Guidelines for Imaging

Guidelines are important since not all medical imaging examinations give results that alter management of the patient or add confidence to the clinician's diagnosis and hence may **add unnecessary radiation dose**

There are **several causes** of unnecessary examinations:

- a repeated examination when relevant information was available but not obtained
- performing an irrelevant examination
- too frequent use of a particular examination
- inadequate clinical information so that important clinical questions could not be answered

23.2 JUSTIFICATION

23.2.1 Referral Guidelines for Imaging

The recommendations in the referral guidelines for imaging are classified as **indicated** when the examination is likely to contribute to clinical diagnosis and management of the patient

Other recommendations are **Specialised Examinations** that are complex, expensive and require individual discussion with an expert radiologist

Finally the recommendations can be **not indicated initially, routinely or not recommended** at all

23.2 JUSTIFICATION

23.2.1 Referral Guidelines for Imaging

The guidelines further classify the typical effective doses in five groups from 0 to IV, where:

- **Group 0** are examinations without ionising radiation (ultrasound and MRI)
- **Group I** examinations where the effective dose is less than 1 mSv (e.g. limb and plain chest radiography)

In **Groups II-IV** the effective doses are:

- 1-5 mSv (e.g. IVU)
- 5-10 mSv (e.g. CT chest) and
- >10 mSv (e.g. PET/abdominal-CT)

respectively

23.2 JUSTIFICATION

23.2.2 Sensitive Populations

It is recognised that the **Cancer Excess Mortality** by age of exposure is ~2-3 times higher for children than for the average population

It is therefore particularly important to optimise the imaging conditions for children

Typically, however, lower patient doses are used in **Paediatric Radiology** simply because the body or body part of the child is smaller than that of the adult

European guidelines with image criteria and criteria for radiation dose are available for common paediatric examinations but surveys show that the dose to the child can in some cases be **reduced further**



23.2 JUSTIFICATION

23.2.2 Sensitive Populations

Contrast media are sometimes necessary to visualise different soft tissues and vessels since the object contrast is inherently too low

The **ideal** contrast media will attenuate the X ray beam more than surrounding tissue but otherwise leave body organs unaffected

This is not always possible

23.2 JUSTIFICATION

23.2.2 Sensitive Populations

Some patients **react** negatively to injected iodine contrast media with acute (i.e. within two hours) or late (i.e. within two weeks) side-effects, which may be severe

Special caution needs to be taken with patients with **kidney** problems or with **diabetes**

The use of contrast media must be evaluated prior to imaging such patients

23.2 JUSTIFICATION

23.2.3 High Skin Dose Examinations

Some interventional radiological procedures may in addition to high equivalent doses to internal organs also result in such **high local skin or eye lens doses** that there is **Deterministic** (acute) radiation damage

Examples of deterministic radiation damages include skin erythema and temporary epilation or lens cataract with visual impairment

The **ICRP** gives guidance on how to identify and manage patients with potential high doses to their skin



23.2 JUSTIFICATION

23.2.3 High Skin Dose Examinations

In these situations it is important that the staff document

the measures of absorbed dose that the imaging equipment provides

after the procedure so that any subsequent radiation injury can be managed properly

23.2 JUSTIFICATION

23.2.4 Population Screening

Diagnostic procedures are examinations of individuals that have some signs or symptoms of disease

Population screening, on the other hand, is a systematic testing of **Asymptomatic Individuals** for a disease between its actual onset and display of its symptoms

The **Objective for Screening** is to detect the disease while treatment will have highest effect

Therefore **Specific Guidelines** and criteria for screening procedures and selecting individuals for screening are particularly important

23.2 JUSTIFICATION

23.2.4 Population Screening

The problem of selecting the **proper screening procedure** lies in the imaging procedure's ability to separate an early manifested disease in a healthy population

The adverse effects of, for example, **Cancer Screening** are:

- the radiation dose and the **potential cancer** it may induce later in life
- the risk of **False Positive Cases** with possible anxiety and unnecessary and potentially harmful subsequent examinations and of course
- potential harmful treatment

23.2 JUSTIFICATION

23.2.5 Informed Consent

Patients undergoing medical imaging procedures should **prior to the examination** be informed of the potential risk associated with the examination

This includes the risk of:

- **allergic reactions** to intravenous injected contrast media and
- potentially **high skin doses** following sometimes lengthy imaging sessions

for example percutaneous coronary intervention, PCI

23.2 JUSTIFICATION

23.2.5 Informed Consent

Healthy **volunteers** or patients undergoing alternative or experimental imaging procedures must also be properly informed of the risks

The scientist managing such research must seek and obtain approval by the **Ethics Committee** in advance in accordance with national legislation

23.3 OPTIMIZATION

Working as a medical physicist with responsibility for optimisation of radiographic procedures, it is necessary to use a **Strategy** to perform the optimisation work in an **efficient** way

Different Approaches for such strategies exist

For example, it could be argued that it is most important that the examinations that result in the highest patient doses – on an individual level or a population level – are optimised **first**

23.3 OPTIMIZATION

An **Alternative Strategy** is to focus on examinations that have questionable image quality as such examinations have the risk of

not providing the necessary diagnostic information

No matter what strategy is chosen, it is obvious that examinations that have questionable image quality, are of high importance for the patient **and** result in high radiation doses should be **optimised first**

23.3 OPTIMIZATION

Then it is important to carefully think about what **methods** to use for the actual optimisation

As optimisation involves both radiation dose and image quality, it is necessary to decide what relevant **measures** to use

Since for most radiographic procedures it is the **Stochastic Risk** of radiation that is of interest, a dose measure that can be used to estimate this risk should be used

Effective Dose

is therefore often the natural choice



23.3 OPTIMIZATION

Although the use of effective dose for individual patients is **not** appropriate, it is suitable for groups of patients and for the purpose of comparing:

- **Relative Risk** between different radiological examinations or
- Doses before and after a **change** in imaging conditions

The age and gender of the patients need to be considered for a proper risk evaluation

23.3 OPTIMIZATION

For **mammography**, the mean glandular dose to the breast tissues is generally used

It could be argued that for procedures for which there is a risk of deterministic injuries, such as interventional radiological procedures, other dose measures, such as **Skin Dose**, are also relevant

However, such injuries are **rare events** and can in most situations be avoided if the personnel are adequately trained and the imaging system is not malfunctioning

23.3 OPTIMIZATION

Regarding **Image Quality**, there is a large variety of methods intended for evaluation of this somewhat diffuse measure

No matter what method is chosen, it is important to bear in mind that the **validity of the results** is limited by the validity of the method

Thus, the method used should preferably incorporate the **entire imaging chain**

23.3 OPTIMIZATION

As the current gold standard for determining image quality is **ROC-based methods**, the use of such methods may be advocated for optimisation

However, conducting ROC studies may be a **cumbersome** task, and they may therefore not be best suited for the daily optimisation work

23.3 OPTIMIZATION

Visual Grading is a common and very practical methodology used for the determination of image quality in optimisation as an alternative to the ROC approach

It uses **Observers' Ratings** of the visibility of structures in the image

The ratings are then used to establish a **measure** of image quality

23.3 OPTIMIZATION

Visual Grading has the strengths that the entire imaging chain can be included in the evaluations

The task of the observer resembles that of the radiologist in everyday work:

deciding whether a given image can be used for the required task of detecting abnormality or not

A **successful** visual grading study is based on letting the observers judge the visibility of the structures that are important to be well visualised in the examination

23.3 OPTIMIZATION

Commonly reported **weaknesses** with visual grading are that it is somewhat subjective and that it is prone to bias

This is definitely true

However, **radiologists rely** on their subjective impression in their daily diagnostic work and it is difficult to remove this limitation without excluding the radiologist from the image quality assessment

23.3 OPTIMIZATION

There are many **differences** between analogue screen-film systems and digital systems for optimisation

The most important is the fact that while the **film** constitutes both detector, processing and display media with almost fixed properties, the **digital** system not only consists of independent detector, processing and display, but also many relevant properties of these components are adjustable

For a given screen-film system, optimisation is a **limited task** due to the fixed sensitivity and latitude of the system

23.3 OPTIMIZATION

Therefore, the **most important task** is to choose exposure settings for obtaining a correct exposure

The optimisation process consists of choosing the optimal **Beam Quality** (tube voltage and filtration) and **Tube Charge** ('mAs') to match the input signal to the latitude and sensitivity of the screen-film system

The sensitivity and latitude of the screen-film system can be altered by **changing** the screen and film, respectively

In this way, a noise level or spatial resolution **suitable** for a given examination can be obtained

23.3 OPTIMIZATION

For **Digital Systems**, the displayed image contrast can be adjusted without clinically relevant restrictions, which can be interpreted as if the system has adjustable sensitivity and latitude

The **two** most important tasks for optimisation of a screen-film system:

- correct **detector dose** to obtain optimal optical density
- correct **beam quality** to adapt the attenuation differences in the object to the latitude of the system

are therefore of **little relevance** for digital systems

23.3 OPTIMIZATION

Instead, optimisation of digital equipment can be more focused on actually finding the **parameter combination** (exposure parameters, image processing parameters, etc.) that results in the **best image quality** for a given **effective dose**

or other relevant dose measure

Finally you need to decide on the appropriate **Tube Charge** ('mAs') that provides sufficiently low noise given the clinical requirements

In this way, the necessary image quality is obtained at the **lowest possible exposure** of the patient

23.3 OPTIMIZATION

23.3.1 Equipment, Guidelines & Imaging Criteria

The **European Union** has, for some common radiographic examinations, published guidelines that give diagnostic requirements, criteria for radiation dose and examples of good radiographic technique

The **requirements** include both image criteria and important image details and apply to **standard sized** patients with the usual symptoms for that type of examination

The **Image Criteria** are important anatomical structures that should be visible in the images



23.3 OPTIMIZATION

23.3.1 Equipment, Guidelines & Imaging Criteria

Typically the **criteria** are expressed in several degrees of visibility

For example:

- **Visually Sharp Reproduction** means that the details are clearly defined

whereas

- **Visualisation** reflects a situation where the details are detected but not fully reproduced

23.3 OPTIMIZATION

23.3.1 Equipment, Guidelines & Imaging Criteria

The list of important **image details** gives the minimum dimensions in the image at which normal or abnormal anatomical details should be recognised

The criteria have been further developed over the years to be more specific to changes in the imaging condition for use in **Visual Grading** evaluations of clinical images

23.3 OPTIMIZATION

23.3.1 Equipment, Guidelines & Imaging Criteria

The criteria given in the EU document for radiation doses to the patient are expressed in terms of **Entrance Surface Dose**

However the IAEA code of practice recommends the use of **Air Kerma-Area Product**, P_{KA} , as the dosimetric quantity in fluoroscopy

The **advantage** of P_{KA} over entrance surface dose is that the radiation beam size is directly included in the measurement and that P_{KA} values for different projections can be added together with reasonable validity

Adding entrance surface dose from different projections is not meaningful



23.3 OPTIMIZATION

23.3.1 Equipment, Guidelines & Imaging Criteria

Internationally the concept of **Diagnostic Reference Levels** has been implemented in some countries and diagnostic standard doses are periodically measured locally in the hospitals and compared to the reference levels

If the reference level is **exceeded** in a particular X ray room, the hospital needs to:

- **Review** their imaging conditions
- **Consider** and possibly **implement** corrective actions to reduce the dose

if the clinical image quality requirements can still be met



23.3 OPTIMIZATION

23.3.1 Equipment, Guidelines & Imaging Criteria

The implementation of diagnostic reference levels has led to

reduction in patient absorbed doses

It must be considered as a

successful radiological protection action

and

a first step towards achieving optimal imaging conditions



23.3 OPTIMIZATION

23.3.1 Equipment, Guidelines & Imaging Criteria

As an **example**, European guidelines for an examination of the urinary tract:

TABLE 23.2. AN EXAMPLE OF GOOD RADIOGRAPHIC TECHNIQUE FOR A URINARY TRACT EXAMINATION USING A SCREEN-FILM IMAGE SYSTEM. OPTIMAL RADIOGRAPHIC TECHNIQUES FOR A DIGITAL IMAGE DETECTOR MAY DIFFER FROM THOSE LISTED HERE.

Technique variable	Technique value
Nominal focal spot size	≤ 1.3 mm
Total filtration	≥ 3.0 mm Al
Tube voltage	75-90 kV
Exposure time	< 200 ms
Imaging system sensitivity	400 (or air kerma $2.5 \mu\text{Gy}$ at detector)
Automatic exposure control	Central or lateral chamber
Anti-scatter grid	Grid ratio 10 and strip frequency 40 cm^{-1}
Focus image detector distance	115 cm (100-150 cm)
Protective shielding	Gonad shields for male patients where appropriate

23.3 OPTIMIZATION

23.3.1 Equipment, Guidelines & Imaging Criteria

The important details in urinary tract examination are **1 mm calcifications**

The image criteria require reproduction of the area of the **whole urinary tract** from the upper pole of the kidney to the base of the bladder as well as reproduction of the kidney outlines

The **psoas** outlines should be visualised and visually sharp reproduction of the **bones** is required

The criterion for entrance surface dose for a standard-sized patient is **10 mGy**



23.3 OPTIMIZATION

23.3.2 Good Practice

Listed below are some aspects associated with good radiological practice:

- Pregnant patient and foetus protection
- Adopting the exposure setting to patient size
- Managing high local skin doses
- Positioning of the patient
- Limiting the radiation field
- Protective shielding
- Compression
- Photon energy
- Low-attenuating materials
- Scatter rejection methods
- Automatic exposure control, AEC setting
- Appropriate film optical density or background quantum noise level
- Viewing conditions

Each will be considered in turn

23.3 OPTIMIZATION

23.3.2 Good Practice

Some are related to the **management of procedures** for examining pregnant patients and of handling patients receiving high absorbed doses

Others are related to **performing** the examination such as:

- **Positioning** of the patient and radiation field
- **Selecting** the most appropriate examination technique
- Circumstances for **Reading** the images

23.3 OPTIMIZATION

23.3.2 Good Practice

Pregnant Patient & Foetus Protection

Prior to an examination in the lower abdomen region women should be **asked** if they are pregnant

If the woman is pregnant or pregnancy cannot be ruled out and if the primary beam is located close to the foetus, the examination should be **postponed** until the baby is born provided this is acceptable from a clinical point of view

If postponing the examination is not possible, an examination **without** ionising radiation should be considered if sufficient diagnostic information could be expected



23.3 OPTIMIZATION

23.3.2 Good Practice

Pregnant Patient & Foetus Protection

If this also is not possible, the examination should be performed but **special measures** should be taken to minimise the dose to the foetus

The decision should be **noted** in the patient's medical records

This applies especially to an examination with relatively high dose (e.g. CT of the lower abdomen, urography, colon and interventional procedures in that region)

23.3 OPTIMIZATION

23.3.2 Good Practice

Pregnant Patient & Foetus Protection

Methods to **minimise** the dose to the foetus should be listed in the procedure documentation and may include limiting the number of projections, use of low-dose irradiation protocols and careful collimation of the primary radiation beam

If the foetus is exposed by either a planned or accidental medical exposure for example trauma CT of unconscious pregnant woman the **Medical Physicist** should be contacted to estimate the foetus dose in order for the clinician to inform the woman in due course of the risks involved

23.3 OPTIMIZATION

23.3.2 Good Practice

Adopting the Exposure Setting to Patient Size

As the relationship between the exposure setting used and the resulting image quality and patient dose is dependent on the **size** of the patient, it is important to adjust the exposure setting to the size of the patient

This is of particular importance for paediatric CT

Prior to the introduction of **tube current modulation** in CT, the radiation dose levels used in paediatric CT often were too high

If adult settings were employed, small children would obtain radiation doses several times higher than adults

23.3 OPTIMIZATION

23.3.2 Good Practice

Adopting the Exposure Setting to Patient Size

Tube current modulation has partially solved this problem, as the tube current used is **automatically** adjusted according to patient size and density

However, it is still necessary to find the optimal dose level as **different** tube current modulation techniques behave in **different** ways

23.3 OPTIMIZATION

23.3.2 Good Practice

Adopting the Exposure Setting to Patient Size

Also, the relationship between image quality and noise level is dependent on **patient size**

This is mainly due to the fact that the internal structures of children are **smaller**

But also that children typically have less intra-abdominal fat which requires the image noise to be **lower** (and dose higher) to delineate organs

23.3 OPTIMIZATION

23.3.2 Good Practice

Managing High Local Skin Doses

The patient should be placed close to the image detector, with the tube as far from patient as possible in order to:

- **Minimise** local entrance skin dose and
- **Reduce** the effect of geometrical unsharpness

In interventional radiological procedures, this is particularly important as long fluoroscopy times and multiple exposures can be anticipated

23.3 OPTIMIZATION

23.3.2 Good Practice

Managing High Local Skin Doses

Local skin dose can be high if the same projection is **maintained** throughout the whole or a large fraction of the procedure

Changing the projection slightly may reduce the local skin dose below that for deterministic skin injuries, but will not necessarily reduce the dose to internal organs or the stochastic radiation risk

To further reduce local skin dose, additional **copper filtration** can dynamically be inserted into the X ray beam provided the generator power is sufficient

23.3 OPTIMIZATION

23.3.2 Good Practice

Managing High Local Skin Doses

Additional copper filtration increases the mean energy of the primary X ray beam and increases the relative transmission through the part being imaged and hence for fixed image detector dose decreases the dose to the skin of the patient

The **documentation** of high skin dose is facilitated by use of the cumulative dose at the so-called **Interventional Reference Point**

For fluoroscopy units, this point is located 15 cm from the **isocentre** towards the XRT

23.3 OPTIMIZATION

23.3.2 Good Practice

Positioning of the Patient

The patient should be **accurately positioned** by the radiographer to allow the area of interest to be properly imaged

To minimise patient movement **immobilization** equipment should be readily available when needed

In paediatric radiology, the correct positioning of the child may be more difficult than for an adult patient

23.3 OPTIMIZATION

23.3.2 Good Practice

Positioning of the Patient

An accompanying person, for example a parent, should preferably **assist** in immobilizing the child to ensure that the radiographic projection is properly centred and collimated

The parent should be given appropriate **protective clothing** (i.e. protective apron, thyroid shield) and their hands should not be directly exposed to the primary beam

23.3 OPTIMIZATION

23.3.2 Good Practice

Positioning of the Patient

In CT it is particularly important to place the patient in the centre of the gantry to match the shape of the CT beam-shaping **bowtie-filters**

Otherwise the patient will be overexposed and image artefacts may appear

23.3 OPTIMIZATION

23.3.2 Good Practice

Limiting the Radiation Field

Limiting the radiation field to the area of interest will both:

- **Reduce** the radiation risk and
- **Improve** image quality

as, for a smaller irradiated volume, less scattered radiation will reach the image detector

For example, in fluoroscopy, reducing the radius of the primary beam from 12 cm to 9 cm will

almost half

the air kerma area product, P_{KA}

23.3 OPTIMIZATION

23.3.2 Good Practice

Limiting the Radiation Field

The primary radiation field should not extend beyond the active area of the image detector

This may not always be properly considered in:

- **Dental Radiology** (with rectangular image detectors and circular primary beam collimation) and
- **Computed Tomography** where the dose profile, in some cases, is much wider than the sensitivity profile

23.3 OPTIMIZATION

23.3.2 Good Practice

Protective Shielding

Protective shielding should not typically be used on patients with a few exceptions e.g.

- **Thyroid Shield** in intra-oral radiography and
- **Male Gonad Shields** whenever the testicles are in or a few cms outside the primary radiation beam

In such situations their use is **recommended** when the protective shield does not obscure any important radiological structure or result in image artefacts

23.3 OPTIMIZATION

23.3.2 Good Practice

Compression

Examination of a small body or body part typically results in **lower** absorbed doses due to the shorter path length through tissue and decreased attenuation of the primary beam

Methods to reduce this path length by **Compressing** the body or body part can therefore result in significant dose reduction

For example, if the patient's abdomen can be made 3 cm thinner in the central beam direction, the tube charge ('mAs') can be reduced by **~50%** whilst maintaining dose at the image detector

23.3 OPTIMIZATION

23.3.2 Good Practice

Compression

Positioning a patient scheduled for a lumbar spine frontal view in PA position will allow the patient to **compress** themselves

By doing so the irradiated volume may be reduced and the degrading effect of scattered radiation on image quality will also be reduced

Furthermore, some tissue may be displaced out of the primary X ray beam and hence receive a reduced dose

Compression is generally used in **mammography** where, in addition to reducing the mean glandular dose, it has many other benefits

23.3 OPTIMIZATION

23.3.2 Good Practice

Photon Energy

The **energy** of the X ray beam should be adapted to the thickness of the part of the patient being imaged and the diagnostic tasks

Traditionally:

- **Lower** tube voltages (25-60 kV) are used for thin body sections such as extremities and female breast
- **Intermediate** tube voltages (60-120 kV) for imaging of the abdomen and when iodine contrast media are used, but
- **High** tube voltages (>120 kV) for chest radiography and computed tomography

23.3 OPTIMIZATION

23.3.2 Good Practice

Photon Energy

However, the selection of **tube voltage** is in many cases based on empirical data from screen-film radiography where:

- **Image Contrast** is not adjustable after exposure and
- **Total Exposure** (i.e. tube charge) is determined by properly exposing the film to achieve an appropriate optical density

These restrictions do not apply in DR

and

Tube voltage and tube charge should be selected based on other principles, for example **detection** of pathology

23.3 OPTIMIZATION

23.3.2 Good Practice

Photon Energy

When a fixed energy imparted per unit area to the image detector is required for properly exposing a screen-film system, the combination of higher tube voltages and lower tube charges typically results in **lower** effective dose to the patient

In DR, the opposite combination may be optimal

There are some indications that lower tube voltages than typically used in skeletal examinations and in examinations with iodine contrast media are more appropriate

23.3 OPTIMIZATION

23.3.2 Good Practice

Low-Attenuating Materials

Any **absorbing** material between the patient and the image detector will reduce the radiation fluence rate at the image detector and lead to a loss of image information

If an **AEC** system is used, the exposure time will automatically increase with increasing amounts of absorbing material between patient and image detector to compensate, leading to an **increase** in patient dose

Consequently efforts should be made to **reduce** this absorption

23.3 OPTIMIZATION

23.3.2 Good Practice

Low-Attenuating Materials

Such materials are the image detector protective coating, AEC-chambers, couch, cushion and anti-scatter grid

Today, most of these are made from low-atomic number, low density materials such as **plastic** or **carbon fibre** with the exception, of course, of the lead strips in the anti-scatter grid

Also without an AEC, the exposure setting may need to be altered but this will need to be made manually by the radiographer



23.3 OPTIMIZATION

23.3.2 Good Practice

Low-Attenuating Materials

It should be noted that if the XRT is situated below the patient

**as is common in fluoroscopy and
interventional radiology**

the couch and cushion add **extra** beam filtration but do not necessarily increase patient exposure

23.3 OPTIMIZATION

23.3.2 Good Practice

Scatter Rejection Methods

The majority of the photons exiting the patient are **scattered** in the patient and have changed direction before reaching the image detector plane

These photons will not convey information about the patient and will, if they are not removed before being absorbed in the image detector, **reduce** the contrast and **add** noise to the image

23.3 OPTIMIZATION

23.3.2 Good Practice

Scatter Rejection Methods

Three main methods are used to minimize the contribution of scattered photons to image formation

The most dose-efficient method is a **Scanning Fan-Beam Assembly**

Here only a small fraction of the patient is irradiated at a time, with one or several moving narrow **collimators** before and after the patient allowing all primary photons but only a small fraction of the scattered photons to reach the image detector

23.3 OPTIMIZATION

23.3.2 Good Practice

Scatter Rejection Methods

The **second** method is to increase the distance between the patient and image detector to 20-40 cm to allow the scattered photons to some extent miss the image detector

This method is often used when small volumes are irradiated such as limb radiography and small children

In these situations this **Air-Gap Technique** is also more dose-efficient than the third and most common method, the **Anti-Scatter Grid** technique

23.3 OPTIMIZATION

23.3.2 Good Practice

Scatter Rejection Methods

The grid consists of thin lead **strips** separated by a low-density material

to allow a large fraction of the primary photons to pass through but selectively absorb the scatter

With increasing **Grid Ratio** the solid angle that allows scattered photons to pass decreases and the efficiency of the grid increases

provided the interspace material between the lead strips is made of low atomic number and density such as **fibre material and not aluminium**

23.3 OPTIMIZATION

23.3.2 Good Practice

Scatter Rejection Methods

The optimal grid ratio and lead strip width **increase** with increasing scattering volume

The optimal grid ratio also **increases** with increasing lead strip frequency (lead strips/cm), although proper **alignment** of the grid becomes more critical

For this reason in **bed-side** chest radiography, grids with low strip frequency, grid ratio and large focusing distance are used

23.3 OPTIMIZATION

23.3.2 Good Practice

Automatic Exposure Control, AEC Setting

The setting of the **AEC** is important for both patient dose and image quality and should be evaluated for **each** type of examination

The AEC system usually consists of **Ionisation Chambers** located behind the grid but before the image detector

During the exposure the signal is read from the chamber and when the **required** air kerma is reached a signal is sent to the X ray generator to terminate the exposure

23.3 OPTIMIZATION

23.3.2 Good Practice

Automatic Exposure Control, AEC Setting

The AEC- system was initially designed for screen-film radiography to assist the radiographer in obtaining the correct exposure of the film

i.e. to **match** the patient structures of interest to the **linear** part of the film characteristic curve

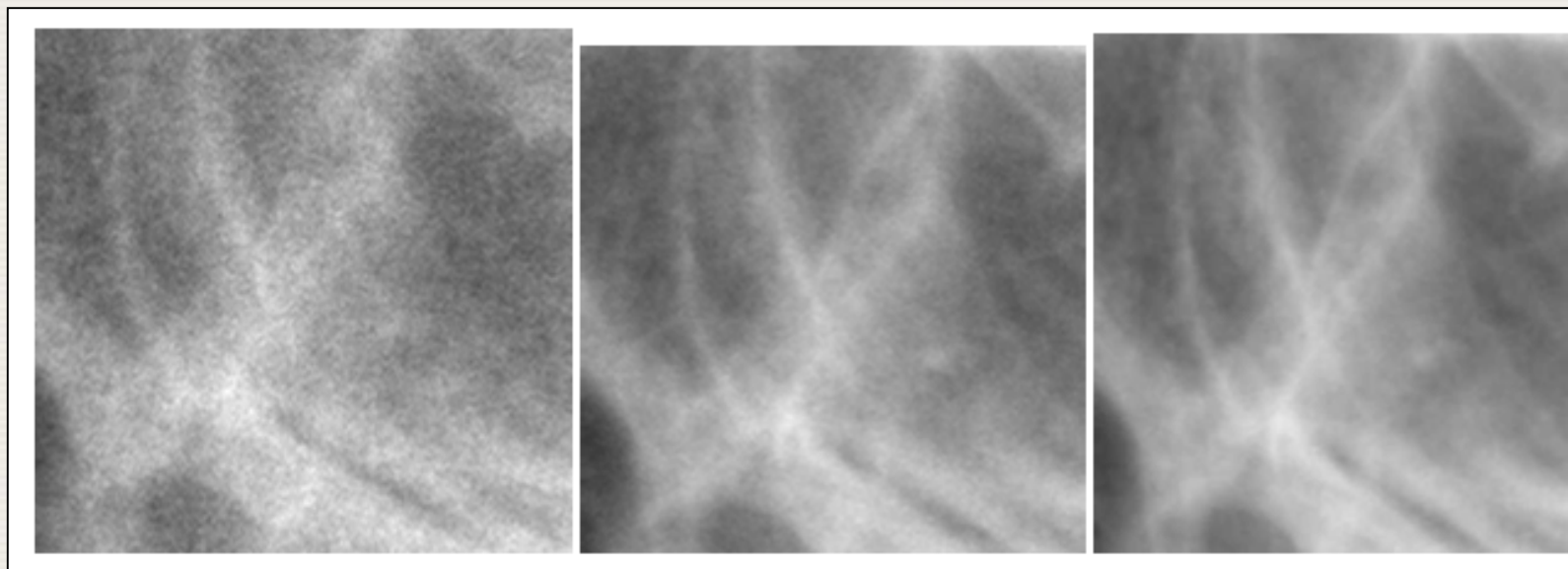
Digital image detectors have a wider useful **dynamic range** and can to some extent manage over- or under-exposure

23.3 OPTIMIZATION

23.3.2 Good Practice

Automatic Exposure Control, AEC Setting

Digital radiographs with different quantum noise levels, showing anatomical structures of the temporal bones in an anthropomorphic head phantom:



The dose and quantum noise level in the middle image are used **clinically** and the consequences of increasing and reducing the dose by a factor of **5** are shown to the right and to the left

23.3 OPTIMIZATION

23.3.2 Good Practice

Automatic Exposure Control, AEC Setting

The figure shows that a variation of exposure of a factor of **twenty-five** still results in a digital image with appropriate grey-scale image contrast

However, **quantum noise** is very visible in the image to the left with five times lower exposure than the one in the middle with the clinically used exposure level

23.3 OPTIMIZATION

23.3.2 Good Practice

Automatic Exposure Control, AEC Setting

Similar exposure correction systems exist in fluoroscopy units and are denoted **Automatic Brightness Control**

The **area** used to monitor the signal level from the image intensifier is outlined in the live-view monitor

It can to some extent be changed in size and location to adapt to different projection requirements and FOV

23.3 OPTIMIZATION

23.3.2 Good Practice

Appropriate Film Optical Density or Background Quantum Noise Level

In screen-film radiography, the **Optical Density** of the developed film influences image quality since the radiographic contrast depends on the optical density

i.e. the film characteristic curve

Regular control of the **film processing** is important for maintaining a consistent image quality and dose

23.3 OPTIMIZATION

23.3.2 Good Practice

Appropriate Film Optical Density or Background Quantum Noise Level

However, consistent film processing is not a sufficient requirement for good radiographic practice as the **processing temperature** may be set too low resulting in too low optical density and contrast

This may result in increasing the required **Tube Charge** to maintain sufficient image quality

23.3 OPTIMIZATION

23.3.2 Good Practice

Appropriate Film Optical Density or Background Quantum Noise Level

The **sensitivity** of a screen-film system depends on the sensitivity of both the fluorescent screen and the film and will influence the amount of quantum noise for a given optical density

The sensitivity of the screen can be altered by either increasing the thickness of the fluorescent screen material (absorb a larger fraction of the photons) or by increasing the light yield (emitting more light photons per X ray photon) or **both**

The latter, however, increases quantum noise

23.3 OPTIMIZATION

23.3.2 Good Practice

Viewing Conditions

Appropriate viewing conditions will aid in reading the diagnostic images

The **Maximum Luminance** of monitors ranges between **100-400 Cd/m²**

With **light boxes** the luminance ranges from **1500-6000 Cd/m²**

the higher values for mammography

The **ambient light** in the reading room should be kept low and reflections of other light sources in the monitor minimised

23.3 OPTIMIZATION

23.3.2 Good Practice

Viewing Conditions

The reader must be able to magnify the image **two to four times** to resolve sub-millimetre details, as the resolution of the image display typically is less than that of the image itself

Viewing stations of digital images should also be properly **calibrated** to match the sensitivity of the human eye

Today, common practice is to calibrate diagnostic monitors according to the **Gray-Scale Standard Display Function (GSDF)** described in DICOM part 14

23.3 OPTIMIZATION

23.3.2 Good Practice

Viewing Conditions

The GSDF aims at allowing the rendition of an image with similar appearance on all display systems that are both **GSDF-calibrated** and have the same **luminance ratio**

Furthermore, based on the assumption of **variable adaptation**, a calibration using the GSDF results in a **perceptually linearised system**

This means that a luminance change corresponding to a given number of pixel values has the same **probability** of being detected over the entire image

23.3 OPTIMIZATION

23.3.3 Two Practical Examples

Example 1: Optimal tube charge in lumbar spine radiography

The European image criteria can be used for simple optimisation studies together with anthropomorphic phantoms or with patients

In the example below an anthropomorphic pelvis phantom and **seven** image criteria in the lumbar spine AP projection were used to assess clinical image quality and to identify the required tube charge

Eight images of the pelvis phantom were obtained with different tube charge but the same tube voltage, filtration, field of view and post-processing etc



23.3 OPTIMIZATION

23.3.3 Two Practical Examples

Example 1: Optimal tube charge in lumbar spine radiography

TABLE 23.3. IMAGE CRITERIA FOR LUMBAR SPINE RADIOGRAPHY.

Criteria 1	Visually sharp reproduction ^b of the upper and lower plate surfaces, represented as lines in the central beam area
Criteria 2	Visually sharp reproduction ^b of the pedicles
Criteria 3	Reproduction ^a of the intervertebral joints
Criteria 4	Reproduction ^a of the spinous and transverse processes
Criteria 5	Visually sharp reproduction ^b of the cortex and trabecular structures
Criteria 6	Reproduction ^a of the adjacent soft tissues, particularly the psoas muscle
Criteria 7	Reproduction ^a of the sacro-iliac joints

^a Reproduction: Details of anatomical structures are visible but not necessary clearly defined; details emerging.

^b Visually sharp reproduction: Anatomical details are clearly defined; details clear.

23.3 OPTIMIZATION

23.3.3 Two Practical Examples

Example 1: Optimal tube charge in lumbar spine radiography

The images were assessed by a group of **four** radiologists and the **seven** criteria were scored as either fulfilled or not fulfilled

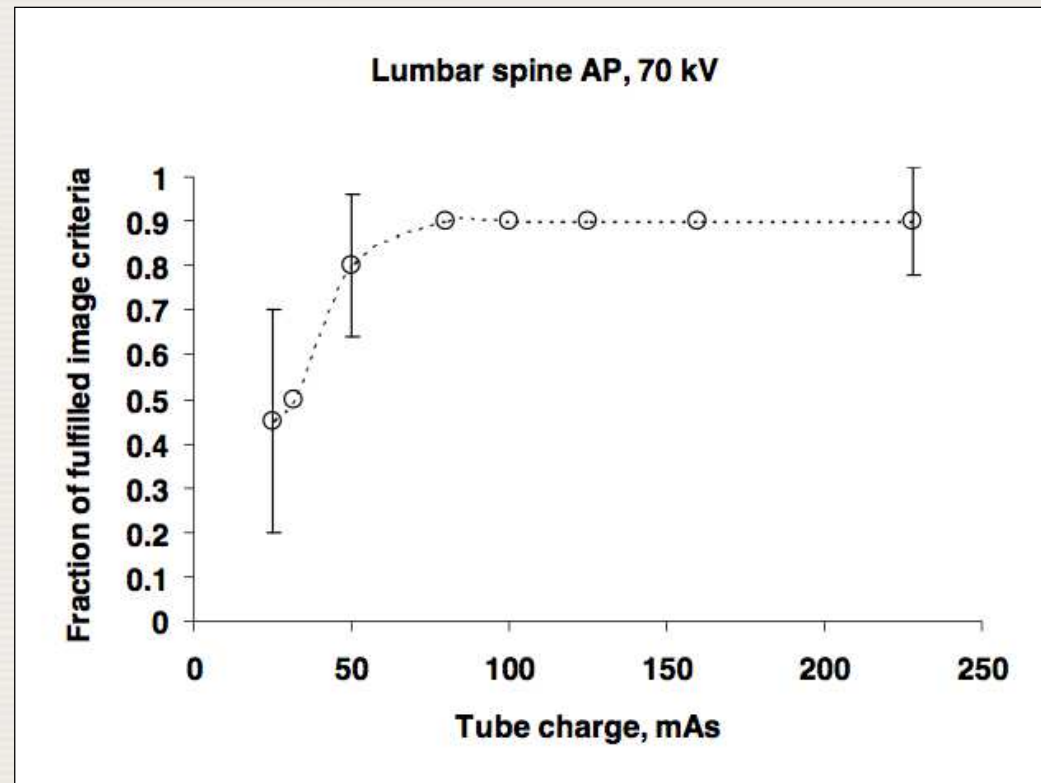
The **average fraction** of fulfilled criteria was then plotted as function of the tube charge that in this case is directly proportional to the effective dose

23.3 OPTIMIZATION

23.3.3 Two Practical Examples

Example 1: Optimal tube charge in lumbar spine radiography

The figure shows the average fraction of fulfilled image criteria assessed by radiologists for images of an anthropomorphic pelvis phantom as function of the tube charge



The error bars represent

± 1 standard deviation of the mean

23.3 OPTIMIZATION

23.3.3 Two Practical Examples

Example 1: Optimal tube charge in lumbar spine radiography

The figure shows that the average fraction of fulfilled criteria is **independent** of the tube charge down to ~ 100 mAs, but that this fraction then rapidly **decreases** to 0.5 with decreasing tube charge

It was **primarily** the 5th image criterion and **secondly** the 1st and 2nd image criteria that were rated not fulfilled when the dose was reduced and quantum noise increased

23.3 OPTIMIZATION

23.3.3 Two Practical Examples

Example 1: Optimal tube charge in lumbar spine radiography

These **three** criteria are evaluated on a higher level of image quality **visually sharp reproduction** than the others

Limitations of the phantom did not allow the 6th example criterion to be properly evaluated by the radiologists

In this simple example, a tube charge of ~ 100 mAs minimises the absorbed dose but maintains clinical image quality in terms of fulfilment of the criteria

23.3 OPTIMIZATION

23.3.3 Two Practical Examples

Example 2: Optimal tube voltage for conventional urography

In the **second** example, it was identified that with the increasing use of CT for urography examinations, the indications for conventional urography, when still performed, had changed and were more focused on high-contrast details

It therefore could not be assumed that the existing tube voltage setting (73 kV) remained optimal for the $\text{Gd}_2\text{O}_2\text{S}$ -based flat panel image detector used, although the image quality was acceptable

23.3 OPTIMIZATION

23.3.3 Two Practical Examples

Example 2: Optimal tube voltage for conventional urography

The purpose of the work was therefore to optimise the tube voltage for urography examinations for the new conditions of the examination so that the necessary image quality possibly could be obtained at a **lower** effective dose

As a **first step**, a phantom study was performed to investigate a wide range of tube voltages

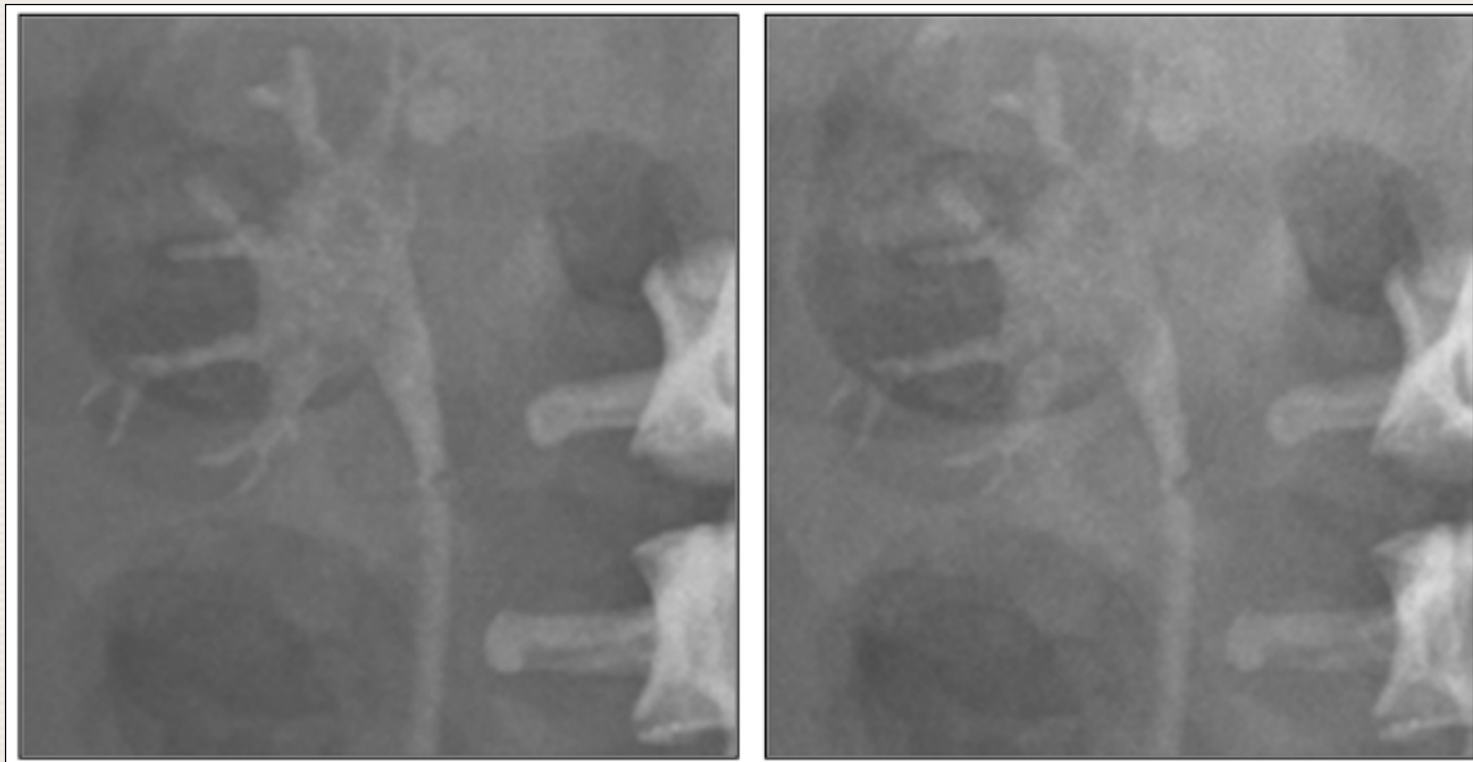
Images of an anthropomorphic pelvis phantom, containing simulated contrast-filled kidneys and ureters, were collected with the system at tube voltages from 50 kV to 90 kV at constant effective dose

23.3 OPTIMIZATION

23.3.3 Two Practical Examples

Example 2: Optimal tube voltage for conventional urography

Two X ray images of a pelvis phantom with an added contrast-filled kidney collected at 50 kV (left) and 90 kV (right) that were post-processed to achieve similar image contrast



23.3 OPTIMIZATION

23.3.3 Two Practical Examples

Example 2: Optimal tube voltage for conventional urography

As the image display stage is separated from the image collection stage for a DR system (contrary to a screen-film system), the dependence of the displayed image contrast on tube voltage can be much smaller

Hence the selection of optimal tube voltage in DR can be different from screen-film radiography

23.3 OPTIMIZATION

23.3.3 Two Practical Examples

Example 2: Optimal tube voltage for conventional urography

The images were analysed by radiologists in a visual grading study, where the **reproduction** of the simulated renal pelvises, calyces and ureters was rated

The tube voltage resulting in the best image quality was 55 kV, which therefore was selected as the clinical setting

23.3 OPTIMIZATION

23.3.3 Two Practical Examples

Example 2: Optimal tube voltage for conventional urography

After using the new setting for some time, images from a number of patients collected with the new setting were selected for comparison with images previously collected with the old setting of 73 kV

The 55 kV images underwent simulated dose reduction to represent images collected at 80, 64, 50, 40 and 32% of the original dose level

All images were included in a visual grading study where radiologists once again rated the **visibility** of the renal pelvises, calyces and ureters



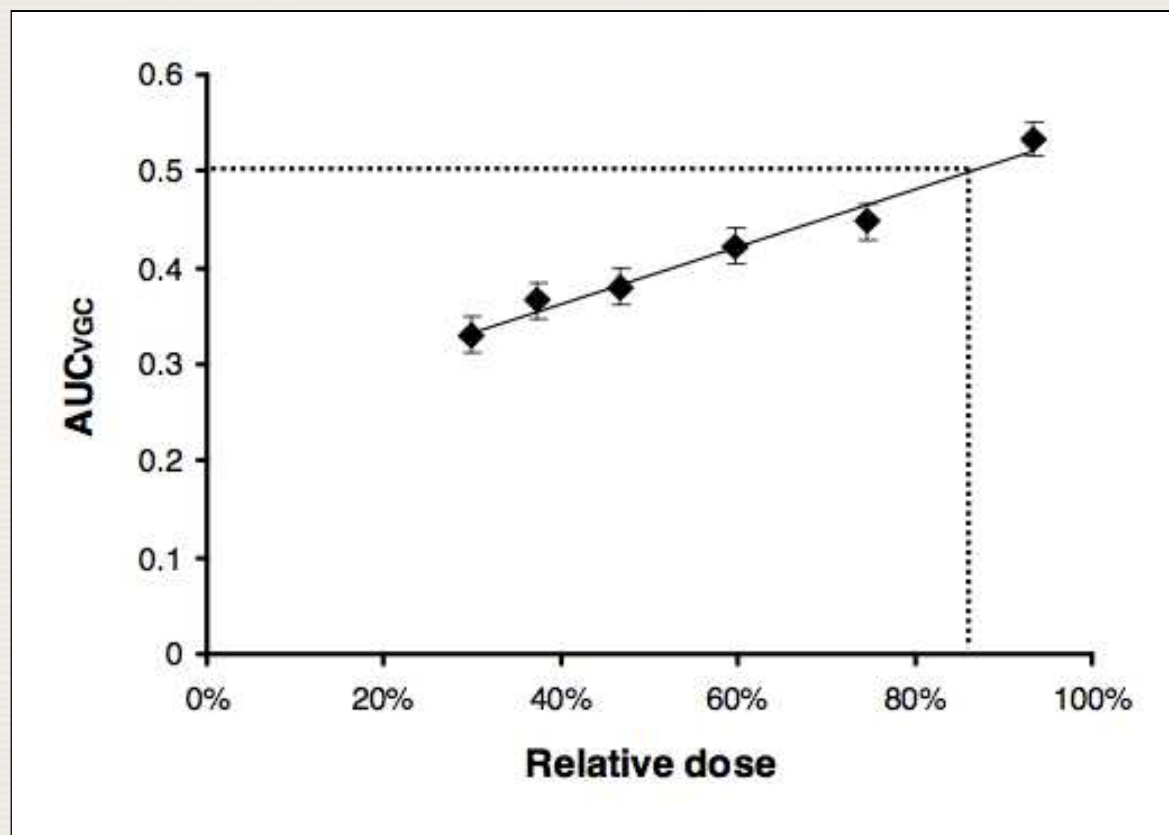
23.3 OPTIMIZATION

23.3.3 Two Practical Examples

Example 2: Optimal tube voltage for conventional urography

Analysis of the given ratings:

The image quality measure AUC_{VGC} for each simulated dose level at 55 kV in the patient study with 73 kV and 100% dose as reference



23.3 OPTIMIZATION

23.3.3 Two Practical Examples

Example 2: Optimal tube voltage for conventional urography

The analysis shows that for images collected at 55 kV, an effective dose of ~85 % resulted in the same image quality as for images collected at 73 kV at 100 % dose

It was therefore **concluded** that:

- **Low tube voltage** should be used for conventional urography focused on high-contrast details and
- Using a tube voltage of **55 kV** instead of 73 kV, the effective dose could be reduced by **~10-20 %** without negatively affecting the image quality

23.3 OPTIMIZATION

23.3.3 Two Practical Examples

Example 2: Optimal tube voltage for conventional urography

Interestingly, the **European Guidelines** suggest a tube voltage between 75 and 90 kV for urography

This shows both that the:

- **Recommended** technique settings for screen/film systems are not automatically valid for digital radiography and
- **Exposure** parameters need revision after the diagnostic requirements have changed

23.3 OPTIMIZATION

23.3.3 Two Practical Examples

Example 2: Optimal tube voltage for conventional urography

The AUC_{VGC} data can be interpreted as the proportion of comparisons for which the image quality for the evaluated system (here the 55 kV images at different dose levels) is rated **higher** than the reference (the only alternatives for each comparison are higher or lower image quality)

An AUC_{VGC} of **0.5** thus corresponds to **equal** image quality between the evaluated system and the reference

The figure indicates that with 55 kV, only 85% of the dose is needed to obtain the **same** image quality as with 73 kV

23.4 CLINICAL AUDIT

23.4.1 Objectives

In the European Commission **Medical Exposures Directive**, clinical audit is **defined** as:

a systematic examination or review of medical radiological
procedures

which seeks to improve the quality and outcome of patient care
through structural review

whereby radiological practices, procedures and results are
examined against **agreed standards** for good medical
radiological procedures

with **modification** of practices where indicated and
the **application** of new standards if necessary



23.4 CLINICAL AUDIT

23.4.1 Objectives

In general, the **objectives** of clinical audit can be distinguished as follows:

1. **Improvement** in the quality of patient care
2. **Promotion** of the effective use of resources
3. **Enhancement** of the provision and organisation of clinical services
4. **Further** professional education and training

With these objectives, clinical audit is an integral part of the overall quality improvement process and should be considered as an **integral part** of quality management and Clinical Governance



23.4 CLINICAL AUDIT

23.4.1 Objectives

Clinical audit is a truly multi-disciplinary, multi-professional activity

It must be carried out by **auditors** with extensive knowledge and experience of the radiological practices to be audited, i.e. they must generally be professionals involved in clinical work within these practices

Further, the general understanding of the concept **Audit** implies that the review or assessment is carried out by auditors independent of the organizational unit or practice to be audited



23.4 CLINICAL AUDIT

23.4.1 Objectives

Clinical audit aims at **continuous improvement** of the medical practices

Therefore, it should be carried out regularly and it should be ensured that the audit cycle is completed

The general **audit cycle** consists of:

- **Selecting** a standard of good practice,
- **Assessing** and comparing local practice with accepted standards
- **Implementing** change when necessary, and
- **Re-auditing** after a certain time

Regular re-audits will improve the quality or give **reassurance** that a good quality is maintained



23.4 CLINICAL AUDIT

23.4.1 Objectives

Clinical audit should comprise both **internal** and **external** assessments and these should supplement each other

Internal audits are undertaken within a given health care setting by staff from the same institution, while the audit findings can be **externally reviewed**

In small health care units, internal audits would rather be self-assessments

23.4 CLINICAL AUDIT

23.4.1 Objectives

External audits involve the use of auditors who are independent of the radiology department/institution

External audits bring added perspectives to the audit process, because internal auditors might not be able to see all weaknesses in their own institution

External auditors should also possess better **benchmarking** skills in relation to the assessment



23.4 CLINICAL AUDIT

23.4.1 Objectives

Clinical audit should yield **multiple benefits** to the health care system, such as:

- **Provision** of a tool for quality improvement
- **Recognition** of quality,
- **Good** practices and outdated practices
- **Motivation** of staff to increase quality improvement of practice and local standards
- **Adherence** to national standards
- **Avoidance** of litigation
- **Improvement** of communication within the institution
- **Revealing** weak points
- **Promoting** development of quality systems



23.4 CLINICAL AUDIT

23.4.1 Objectives

Clinical audit should thus be able to identify the **strengths** of a radiology department, as well as areas requiring improvement, while the main beneficiary will eventually be the **patient**

Comprehensive **guidance** for clinical audits has been published by the European Commission and the IAEA

The **former** provides a general framework for establishing sustainable national systems of audit, while the **latter** supplements this framework for diagnostic radiology by introducing very practical advice for implementing external clinical audits



23.4 CLINICAL AUDIT

23.4.2 Coverage of Radiological Practices

Clinical audit should cover the whole clinical pathway, and address the **three main elements** of the radiological practices:

- **Structure:** the attributes of the setting in which care occurs, including material resources (e.g. facilities, equipment), human resources (e.g. number, grade and qualification of staff) and organisational structure
- **Process:** the delivery of patient care
- **Outcome:** the impact of the department on the health status of patients

23.4 CLINICAL AUDIT

23.4.2 Coverage of Radiological Practices

A single clinical audit can:

- assess either the whole clinical pathway of the radiological process, from referral to follow up (**Comprehensive Audit**), or
- can be limited to specific critical parts of it (**Partial Audit**)

It can assess the parts of the practices which are **generic** either

- to **all** radiological procedures or
- to a **given** speciality (e.g. for CT), or

can go deeper to a **selected individual examination**



23.4 CLINICAL AUDIT

23.4.2 Coverage of Radiological Practices

Clinical audits should address both the

- **critical issues** of the radiation protection for the patient
and
- **key components** of the overall quality system

These include:

- Justification and
- Optimisation

as essential parts of the process

23.4 CLINICAL AUDIT

23.4.2 Coverage of Radiological Practices

Auditing the examination specific practices can **usually** means only a few selected examination types per audit

Full details of the procedures should be assessed at least for the parts where a **reasonable consensus** on a good practice can be achieved, such as:

- Indications
- Image criteria, reproduction of anatomical structures
- Patient position and imaging parameters
- Protective shielding

23.4 CLINICAL AUDIT

23.4.2 Coverage of Radiological Practices

Before starting the clinical audit the critical areas should be identified and the objectives agreed

For **internal** audits, the objectives are set by the management of the health care unit to be audited

For **external** audits, the detailed objectives should be agreed between the auditing organization and the unit to be audited, and should be based on:

- any legal requirements on audit programmes
- any recommendations by national coordinating organizations or by health professional and/or scientific societies when available



23.4 CLINICAL AUDIT

23.4.2 Coverage of Radiological Practices

In **practice**, the process may be subdivided into four sections:

- Quality Management Procedures and Infrastructure
- Patient Related Procedures
- Technical Procedures
- Teaching, Training and Research

23.4 CLINICAL AUDIT

23.4.2 Coverage of Radiological Practices

The audit of **Quality Management Procedures and Infrastructure** includes:

- the mission and vision of the radiology unit
- its business plan
- long-term objectives and
- the departmental workload/patient demographics
- the department's organisational structure
- staff management processes such as programmes for continuing professional development, working practice instructions and protocols/procedures
- departmental premises and equipment

23.4 CLINICAL AUDIT

23.4.2 Coverage of Radiological Practices

The audit of **Patient Related Procedures** includes:

- the processes to ensure the appropriateness of examination (referral guidelines used, risk benefit considerations, contraindications etc)
- processes for ensuring relevant clinical conditions are taken into account prior to undertaking an examination (asking about allergies, anti-coagulant therapy, pregnancy etc)
- patient identification procedures and fail safes
- the policies to respect patient confidentiality, and
- the protocols and procedures for imaging techniques, clinical care, image quality reporting, accidents/incidents, image and record retention etc



23.4 CLINICAL AUDIT

23.4.2 Coverage of Radiological Practices

The audit of **Technical Procedures** includes the:

- Quality assurance infrastructure and
- Equipment quality assurance procedures

Particular attention is paid to personnel, instrumentation, management support and documentation

If the centre undertakes **Research and /or Teaching**, the programmes for these activities should also be assessed

23.4 CLINICAL AUDIT

23.4.3 Standards of Good Practice

Good Practice is the practice which can be recommended based on the most recent considerations of evidence based data, long term experience and knowledge gained on the necessary structure, process and outcome

These can be based on:

- Legal requirements
- Ethical principles
- Results of research
- Consensus statements
- Recommendations by learned societies
- Local agreement (if there is no more universal reference)



23.4 CLINICAL AUDIT

23.4.3 Standards of Good Practice

The definition of clinical audit presumes that suitable written **criteria** for good practice are available for the assessments

The guidelines published by the **IAEA** include basic criteria, and also reference other publications which can be used as a basis for the establishment of extended criteria

International medical/scientific/professional societies could play an important role in developing such standards



23.4 CLINICAL AUDIT

23.4.4 Relationship with Other Quality Assessments & Regulatory Control

For **external** clinical audit, it is important to recognize that this is a different concept to other activities of external quality assessment such as quality audits for certification of a quality system, audits for accreditation or regulatory inspections

Therefore, when defining the aims and objectives of external clinical audits, it is important to ensure that these will **supplement** rather than duplicate those of other activities

The relationship of clinical audit with other quality assessments and regulatory control is discussed in detail in the **EC Guidelines**



23.4 CLINICAL AUDIT

23.4.5 Methods and Practical Organization

Partial Audits can be carried out externally by the collection of recordable or measurable data via mail or internet, with central assessment of the data

For **Comprehensive Audits**, a site visit is needed and should comprise:

- A series of interviews
- Observations
- Document and data reviews
- Measurements
- Collection of data samples
- Analysis

23.4 CLINICAL AUDIT

23.4.5 Methods and Practical Organization

Due to the **multidisciplinary** nature of the audit, a team of auditors is usually needed, comprising different professionals - radiologist, medical physicist, radiographer etc. - depending on the scope of the audit

Besides the basic clinical competence, the auditors should receive specific training on:

- General audit procedure and techniques
- Agreed audit programme
- Criteria of good practices to be applied

23.4 CLINICAL AUDIT

23.4.5 Methods and Practical Organization

Once the clinical audit has been **completed** and the auditor's report with recommendations is available to all staff, the unit should **respond** to the recommendations with an agreed timeline for improvement

This is important not only to achieve maximum benefit from the audit but also to retain the **respect** and **motivation** of the staff for subsequent re-audits

23.4 CLINICAL AUDIT

23.4.6 Role of the Medical Physicist

In collaboration with the other professionals, the **Medical Physicist** has an important role in the

- Planning
- Preparation
- Conduct

of clinical audits of radiological practices

Medical physics expertise is inevitably required for:

- **Judging** the adequacy and quality of equipment
- **Assessing** patient dose and physical image quality
- **Establishing** and **running** the QA/QC programmes for equipment



23.4 CLINICAL AUDIT

23.4.6 Role of the Medical Physicist

Medical physicists often play a key role in the arrangements and provisions for **radiation safety** of patients and staff, which are among the major areas for clinical audits of radiological practices

When the audit involves specific **measurements** or **tests**, usually the physicist member takes care of these tests

Further, physicists are usually well practiced in making use of different mathematical or statistical tools which can be of great value in organizing and analysing the audit data

For all these reasons, the audit team should include a Medical Physicist

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