ADEQUATE PARAMETERS FOR QUALITY ASSURANCE IN RADIODIAGNOSTICS

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ABSTRACT - - Criteria are discussed, which a set of parameters must have, to be suitable in practical use for quality assurance in radiodiagnostics. The choosen parameters are described by

1.: definition (if necessary)

2.: a method for measurement

3.: absolute values and tolerances.

Only film-processing and radiological standard-methods are described, that means direct radiography and fluoroscopy with image - intensifier. Digital methods (DSA or CT), special techniques (tomography) and applications in dentistry (panorama) are not regarded. Some first experiences concerning the most common faults of radiographic equipment are mentioned.

1. Introduction

In the field of quality - assurance for radiodiagnostics there are activities since many years, which are documented in many papers (see references).Obligatory measurements for all physicians who practice radiodiagnostics are performed in Germany since about 1 year and first experiences have been made.The proceeding has two steps: first the equipment is tested by the manufacturer and eventual faults are eliminated (" acceptance - test ") , then the physician measures in regular time intervals. The acceptance - test must describe the machine completely and a set of parameters for this purpose is described. The measurements done by the physician must be much simpler but it is necessary to recognize any deviations surely and methods for this task are described also. All measurements should match three conditions, that means there should be 1.: low cost, 2.: easy handling and 3.: low time consume.

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2. Acceptance - test

2.1 Film processing

The common procedure is to expose a film to the light-source of a sensitometer that creates a 21 step grayscale on the film. The film is processed and the optical densities (OD) of all 21 steps are measured .From these measurements the characteristic curve is drawn which delivers the actual values of

a.) fog, b.) speed, c.) gradient and d.) maximal OD

Furthermore the type of chemicals used, processingtime and the temperatur e of the develloper are marked.

For direct radiography the following values are obligatory: fog < 0.2 OD
gradient: 2 - 3
maximal density : > 3 OD

2.2 Direct radiography and fluoroscopy

The state of an Xray-installation can be described completely by measuring the following 10 parameters. For each quantity a method of measurement and tolerable deviations are given.

1. Voltage kV

The difference between the measured voltage and the indicated one must be smaller than + or - 10%. Suitable instruments, that work by analysing the Xray-beam by the socalled double-filter-method are commercially available (see references nr. 2 and 4).

2. Dose yield Y

This quantity is defined as the dose measured at 80 kV behind an absorber of 25 mm Al at a distance from focus of 1m per 1 mAs. For a 12 or a multipuls-generator there must be

$$Y = 2 \ \mu Gy \ m^2 / mAs \qquad (1)$$

with a tolerable deviation up to + or - 35 %. The dose yield gives a hint on the condition of the anode.

3. Time

The measured time of a radiograph should be equal to the indicated one within + or - 10%. Depending on the construction of the generator (mechanic or electronic time switching) the shortest time available , when automatic exposure is used must be 60 ms or 5 ms. Measuring instruments use the principle of double - filter (see kV - measuring)

4. Dose D

The dose that is necessary to produce an OD of 1 depends on the used film - screen-combination . There has been defined a "sensitivity - class " S which is normalized to 100 for a socalled "universal"-film-screen-combination and the corresponding dose is calculated by

$$D = 1000 / S \quad (\mu Gy) \qquad (2)$$

According to this formula a high resolution film-screen combination with S = 25 needs a dose of 40 μGy, a fast combination with S = 400 needs 2.5 μGy only.

5.Resolution

The required resolution naturally depends on the class S of the film-screen combination. For S = 100 there must be visible > 3.4 Lp/mm, for S = 800 the value is > 2 Lp/mm. The minimum resolution in fluoroscopy are 0.8 Lp/mm on the monitor.

6.Filter

In general the minimal filtration in radiography and fluoroscopy mut be equivalent to 2.5 mm Al. Deviations for special techniques are possible. The filtration can be measured indirectly by measuring the half value layer of the radiation.

7.Attenuation factor

This quantity describes the attenuation of the X-ray beam caused by all layers between the patient and the image receiver (cassette or image intensifier). It is measured at 80 kV behind an absorber of 25 mm Al and may not be > 3.5. The attenuation factor gives an advice on the quality of the patient table.

8.Beam alignment

The differences between light-field and radiation-field and between central beam and center of the image receiver may not exceed 2 % of the distance from the focus. Measurements by taking radiographs from a phantom with suitable grid.

9. Doserate at the entrance of the image intensifier

This quantity mainly influences the dose of the patient during fluoroscopy and must be measured with a well calibrated ionisation-chamber at the entrance screen of the image intensifier. According to the type of the automatic doserate regulation a homogenius or an inhomogenius absorber must be placed into the beam. The maximal allowed value is 0.6 μGy/s.

10.Minimal contrast

With an Al - absorber a radiation contrast of 4 % is realized which must be visible at the monitor (voltage 80 kV).

After having described the condition of the equipment by these 10 quantities,a more simplified procedure is necessary to check the constancy, done by the physician.

3.Constancy test

3.1 Film processing

The evaluation of the 21 steps of the gray scale is reduced on measuring 3 optical densities:

1.: fog with OD <0.2 and a tolerance of + 10 %

2.: OD of the step nearest OD = 1 + fog

3.: OD of the step 4 numbers higher than point 2 (index of contrast)

This method is called "3 - point - method" and the tolerated deviations of point 2 and 3 are + or - 0.2 OD. The temperature of the develloper is noted, automatic processing needs dayly control, hand processing once a week.

3.2 Direct radiography

Monthly a radiograph is taken from a test plate behind an absorber of 25 mm Al at 70 kV and 100 kV and the dose for both images is measured. This measurement must not be absolutely and a rather simple instrument can be used which has a diode as detector. The test plate image delivers information on

1.: achieved OD, measured on a dedicated area of the image (tolerance + or - 0.2 OD)

2.: area of the radiation field (tolerance + or - 2 % from focus distance)

3.: achieved contrast (visual evaluation, no tolerance defined)

The measured dose may vary between + or - 20 % of the aiming value.

3.3 Fluoroscopy

An image of a test plate is regarded on the monitor and the following quantities are evaluated:

1.: resolution with a required minimum of 0.8 Lp/mm and a tolerance up to -40%

2.: contrast (all steps of a 6 - step copper wedge must be visible)

3.: alignment (central beam at the center of the monitor), tolerance + or - 1cm.

Using the same instrument like in radiography the accumulated dose within 60 s is measured, accepted tolerance is + or - 30%.

The procedure must be repeated monthly.

4. First experiences

Acceptance tests on 35 radiographic units, 20 fluoroscopic units and 58 darkrooms have been carried out and constance tests have been started. The described reduced set of measured quantities allowed to recognize faults and gave advices to find the reasons.

4.1 Film processing

In 30% of all cases automatic processors showed to high deviations from allowed values and the main reason was a low number of dayly processed films which led to an unstable regeneration of the develloper. Hand tanks had problems in 50 % of the cases, resulting from the habit to devellop a film not a constant time at constant temperature but according to progress.

4.2 Radiography

About 1/3 of all units were without objections, the most common fault was a wrong voltage (50 %), followed by a to high dose of the automatic exposure chamber (40 %).

4.3 Fluoroscopy

Only 20 % of the tested units were without objections , 75 % had problems with beam alignment , mostly when automatic formating was used.

5. References

1.: DIN 6868: Image quality assurance in x-ray diagnostics (May be obtained from Beuth Verlag GmbH, Burggrafenstrasse 6, D 1000 Berlin 41)

2.: Quality Assurance Handbook (May be obtained from RMI, P.O.Box 44, 7617 Donna Drive, WI 53562 USA)

3.: Bildqualität und Strahlenschutz in der Röntgendiagnostik, F.E. Stieve und H. St. Stender, 1990, ISBN 3-7691-0200-2

4.: Kompaktkurs zur praktischen Durchführung der Konstanz prüfung , 1990 (May be obtained from Storbecksche Buchhandlung GmbH, Hauptstr.84, D 1000 Berlin 41).

5.: Quality Assurance in Diagnostic Radiology, WHO, Geneva 1982, ISBN 92-4-154164-4