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QUALITY CRITERIA FOR CARDIAC IMAGES: AN UPDATE

G. Bernardi[1,*], O. Bar[2], T. Jezewski[3], E. Vano[4], C. Maccia[5], A. Trianni[6] and R. Padovani[6]
[1]Cardiology Department, Az. Ospedaliero-Universitaria Udine, Italy
[2]Clinique Saint Gatien, Tours, France
[3]II Chair and Department of Cardiology, Medical University of Lodz, Poland
[4]Medical Physics Department, San Carlos Hospital, Complutense University, Madrid, Spain
[5]Centre d'Assurance de qualité des Applications Technologiques dans le domaine de la Santé (CAATS), Paris, France
[6]Medical Physics Department, Az. Ospedaliero-Universitaria Udine, Italy

The DIMOND II and III Cardiology Groups have agreed on quality criteria for cardiac images and developed a scoring system, to provide a tool to test quality of coronary angiograms, which was demonstrated to be of value in clinical practice. In the last years, digital flat panel technology has been introduced in cardiac angiographic systems and the radiological technique may have been influenced by the better performance of these new detectors. This advance in digital imaging, together with the lesson learned from previous studies, warranted the revision of the quality criteria for cardiac angiographic images as formerly defined. DIMOND criteria were reassessed to allow a simpler evaluation of angiograms. Clinical criteria were simplified and separated from technical criteria. Furthermore, the characteristics of an optimised angiographic technique have been outlined.

Quality of cardiac angiographic images should be as high as to allow the cardiologist to evaluate the anatomic (and sometimes functional) details relevant for patients' care. This topic is quite neglected in literature and guidelines of Scientific Societies[1–4] address in a limited manner the way of achieving and maintaining high-quality standards in angiographic imaging, which is not granted: in a study performed in 29 New York State hospitals, major defects have been demonstrated in more than half of angiograms[5].

Moreover, the European surveys on cardiac interventional procedures performed by DIMOND and SENTINEL cardiac groups[6,7] have demonstrated a wide variation of exposure parameters in common practice and very different behaviour among cardiologists in terms of fluoroscopy time, number of series and frames: quality evaluation plays a pivotal role in the process of optimisation, as the radiation dose delivered to patients should follow the as low as reasonably achievable (ALARA) principle.

Several methods to evaluate image quality in clinical radiology have been proposed. In particular, the method of image quality criteria has proven to be effective and relevant in clinical practice and for training purposes in radiographic studies and computered tomography scan[8–12]. In this approach, quality of images is assessed in comparison to prespecified criteria to comply with. The DIMOND II and III Cardiology Groups have set quality criteria for cardiac images[13,14] and developed a scoring system to provide a tool to test the quality of coronary angiographies in daily practice. The results of the two trials performed on coronary angiograms collected in some cardiac European centres demonstrated that the method of quality criteria can be applied to cardiac images and yields reproducible data in most instances[15,16].

Cardiac angiographic systems adopting digital flat panels have been introduced in the practice in the last years. Consequently, the radiological technique may have been influenced by the better imaging performance of the new digital detectors: the wider dynamic range may prevent or reduce the use of wedge filters and X ray beam collimation and the smaller detector size allows more angulated projections.

This advance in digital imaging technology, together with the lesson learned from previous studies, warranted the revision of the quality criteria for cardiac angiographic images as formerly defined. This task was carried out by the SENTINEL Study Group; DIMOND criteria were reassessed and the necessity to restrict the number in order to allow a faster and handy evaluation of angiograms was recognized.

Clinical criteria were simplified and separated completely by the criteria named 'technical

*Corresponding author: bernardi.guglielmo@aoud.sanita.fvg.it

criteria', which had been the major source of disagreement[15].

Further to this, 15 items characterising an optimised angiographic technique have been identified. This list partially parallels the set of technical criteria and consists of technical factors that mostly influence image quality, patient and staff doses. In Table 1, together with these factors, the justification

Table 1. Aspects of an optimised angiographic technique.

Item number	Elements for an optimised procedure	Suggestions	Why	Priority (High–Medium)
1	Apnoea		To improve image quality	H
2	Arms raised clear of the angiographic field		To avoid high skin dose to arms To improve image quality	H
3	Avoid spine in the field (when possible)	Particularly for right More difficult for left anterior descending or circumflex	To reduce organ dose to bone marrow To improve image quality	M
4	Full inspiration (if necessary to avoid diaphragm superimposition or to change anatomic relationship)		To improve image quality To reduce dose/frame	M
5	Selectivity, coaxiality of the catheter	Consider appropriate catheter shape	To improve fulfillment of coronaries	H
6	Simultaneous and full opacification of the vessel lumen (at least until the first flow-limiting lesion; in general $\sim$ 90–95% by visual estimation)	Consistently adjust the amount and the flow rate of contrast and/or use a different catheter type	To improve image contrast of the arteries	M
7	Consider the advantages of remote controlled injector for cine and rotational angiography		To obtain better opacification of vessels To reduce staff dose (increasing the distance of staff from patient)	M
8	Avoid use of panning to select the area of interest during cine runs. Panning for visualisation of collateral should be limited	Use sufficient field of view (FOV). Consider the benefit of another run with larger FOV without panning.	To reduce the length of cine runs To avoid degradation of image quality due to motion	H
9	Use X-ray beam collimators		To reduce patient dose To reduce scatter dose to operator To improve image quality	H
10	Use wedge filter on bright peripheral areas		To improve image quality in bright areas To reduce patient dose	H
11	Typical no. of series for left coronary angiography 3–5 (except for difficult anatomic details); for right coronary angiography 2–3 (except for difficult anatomic details)	Avoid run when fluoroscopy control suggests poor opacification	To reduce patient dose To reduce staff dose	H
12	Normal practice frame-rate: 12.5–15 Possible use of the 7.5 fr s^{-1} for some of the cine runs	Use 25–30 only if heart rate exceeds 90–100 bpm or in paediatric patients	To reduce patient dose To reduce staff dose	H

Continued

Table 1. *Continued*

Item number	Elements for an optimised procedure	Suggestions	Why	Priority (High–Medium)
13	Typical number of images/sequence is 60 on average (@ 12.5–15 fr s^{-1}) except if collaterals have to be imaged or in case of slow flow	Consider lower number of frames for some selected projections	To reduce patient dose To reduce staff dose	H
14	Fluoroscopy modes (and image quality) should be selected according to the diagnostic or therapeutic procedure	Typically low image quality for diagnostic and higher quality for therapeutic		M
15	Cranio-caudal angulated projections	Dose reduction technique should be particularly adopted	To improve image quality To reduce patient dose To reduce staff dose	M

for requirements and the level of priority are indicated. Suggestions to improve practice are also added, when appropriate.

Compared with the clinical criteria of the previous version, left main, left anterior descending and circumflex branches were considered separately.

As previously stated[13,14], quality criteria cannot be applied in all cases, and in some situations, a lower level of image quality may be acceptable so that under no circumstances an image, which fulfils all clinical requirements but does not meet all image criteria should be rejected. However, any reasons for a 'suboptimal' procedure (such as renal failure or haemodynamic instability) should be recorded.

QUALITY CRITERIA FOR CARDIAC IMAGES

The quality criteria for coronary angiography images are reported. The clinical criteria define the clinical information content of optimal images. Besides these criteria, technical criteria are introduced to define the quality of the radiological technique. Technical criteria can also help to improve the practice when clinical or dose criteria are not met.

Description of terms

Clinical criteria: defined as level of visualisation of important anatomical features; the level of visualisation is expressed by the use of the following terms:

- *Visualization*: characteristic features are detectable, but details are not fully reproduced (features just visible).
- *Reproduction:* details of anatomical structures are visible, but not necessarily clearly defined (details emerging).
- *Visually sharp reproduction*: anatomical details are clearly defined (details clear).

Technical criteria: these take into account the frequency of image acquisition, the number of sequences per procedure, the number of images per sequence (except for difficult cases or special settings), the use of wedge filters and other aspects like acquisition in apnoea condition, use of panning, arms position, etc.

Clinical criteria

(1) Visually sharp reproduction of the origin, proximal, mid and distal portion of the right coronary artery, left main, left anterior descending and circumflex arteries, in at least two orthogonal views, with minimal foreshortening and overlap.
(2) Visually sharp reproduction of side branches $\geq$1.5 mm of the right coronary artery, left main, left anterior descending and circumflex arteries, in at least two orthogonal views, with minimal foreshortening and overlap. The origin should be seen in at least one projection.
(3) Visually sharp reproduction of lesions in vessels $\geq$1.5 mm in at least two orthogonal views, with minimal foreshortening and overlap.
(4) Visualization of collateral circulation when present.

Technical criteria

(1) Performed at full inspiration, if necessary to avoid diaphragm superimposition or to change anatomic relationship (in apnoea in any case).
(2) Arms should be raised clear of the angiographic field.
(3) When possible, avoid lumbar spine in the X-ray field.
(4) Selectivity, coaxiality of the catheter.

(5) Simultaneous and full opacification of the vessel lumen at least until the first flow-limiting lesion (in general ~90–95% by visual estimation).
(6) Panning should be limited. If necessary, pan in steps rather than continuously, or make subsequent cine runs to record remote structures.
(7) Use of X-ray collimators.
(8) Use of the wedge filter on bright peripheral areas.
(9) When clinical criteria 1–4 are fulfilled, avoid extra projections (mainly left anterior oblique semi-axial).
(10) Three to five sequences (except for difficult anatomic details) for left coronary angiography.
(11) Two to three sequences (except for difficult anatomic details) for right coronary angiography.
(12) 12.5–15 frames/s (fr s^{-1}); (25–30 only if heart rate exceeds 90–100 bpm or in paediatric patients).
(13) Sixty images per sequence at average (12.5–15 fr s^{-1}) except if collaterals have to be imaged or in case of slow flow.

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