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Short communication

Quality criteria for cardiac images in diagnostic and interventional cardiology

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Abstract. The quality of cardiac imaging plays a pivotal role in clinical decision-making and depends mainly on the technical performance of the imaging system and on angiographic technique. The Italian Society of Invasive Cardiology and The Italian Society of Physics in Medicine have set quality criteria giving precise guidelines regarding how an angiogram should appear provided that good equipment and correct angiographic technique are used. The criteria have been reviewed by the European Concerted Action DIMOND Cardiology group and are reported here to provide a reference standard for images for the most common procedures in daily practice.

Cardiac cine-angiographic images should allow the cardiologist to evaluate the anatomic (and sometimes functional) details relevant for clinical decision-making. Scientific societies have implemented guidelines to guarantee an adequate level of quality and performance in invasive cardiology. These guidelines generally refer to training of operators, quantitative standards to maintain expertise in coronary angiography or angioplasty [1–3], and quality assurance programmes [4, 5]. The specific problem of achieving and maintaining high quality standards in angiographic imaging is the responsibility of cardiac catheterization laboratory directors. This process involves periodic cine-angiogram review and lesion quantification, but precise criteria have not yet been stated for coronary procedures.

The quality of cardiac imaging depends on the technical performance of the imaging system, as well as patient cooperation and angiographic technique. The technical performance of the system can be checked easily by means of test objects and phantoms. Nevertheless, correct angiographic technique remains of paramount importance and its impact on quality can be assessed only by evaluating the final images. This implies a variable degree of subjectivity depending on the method used [6]. In general there are two approaches: the first is applied when the task is to compare images produced in different conditions and implies the correct answer is known. The second is a relative measurement obtained by ranking a set of images in quality order: the strength of agreement between different observers will give an indication of quality. Whereas these methods, especially the first, may be very useful when applied to clinical studies, their use in routine practice is difficult. To achieve this, simpler techniques are required. Quality criteria for radiological images have been agreed for standard radiological examinations [7–9], and methods have been developed to compare clinical images with the specific requirements that these criteria demand. Such an approach has already proven to be effective in clinical practice for adult radiology [10, 11], paediatric radiology [12] and CT [13].

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Recently, the Italian Society of Invasive Cardiology and The Italian Society of Physics in Medicine [14] set quality criteria giving precise guidelines regarding the appearance of angiograms, based on the model of the European Guidelines on Quality Criteria for Diagnostic Radiographic Images [7] where the diagnostic requirements and image criteria have already been agreed.

These angiogram criteria have been reviewed by the European Concerted Action DIMOND 2 Cardiology group (Digital Imaging: Measures for Optimizing Radiological Information Content and Dose) and are reported here[1]. Beginning with these criteria, a method has been developed [15] to provide a tool to evaluate images produced in the daily practice of catheterization laboratories. A pilot study has been completed to test this method and the results are pending. A larger multicentre trial is planned as a part of the work of the DIMOND 3 group.

The following procedures were considered: left ventriculography, left coronary angiography, right coronary angiography, angiography of venous graft or arterial free graft, and angiography of left mammary artery *in situ*.

As in the original documents, two important points shoud be emphasized. First, it is not intended to repeat what has already been included in the manuals of coronary angiography, but to give some guidelines regarding how an angiogram should appear provided that good equipment and correct angiographic technique are used. Second, the quality criteria reported here cannot be applied in all cases, and in some situations a lower level of image quality may be acceptable, so that "under no circumstances should an image which fulfils all clinical requirements but does not meet all image criteria ever be rejected". However, reasons for a "suboptimal" procedure (*i.e.* renal failure, haemodynamic instability, etc.) should be recorded.

Quality criteria for cardiac images

Description of 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).

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Left ventriculography

Right anterior oblique (RAO) 25–35° projection

1. Performed at full inspiration to avoid diaphragm superimposition.
2. Reproduction of the left ventricle in the longitudinal axis (select the proper angulation to see the typical ovoid shape).
3. Visually sharp reproduction of ventricular walls in systole and diastole, without causing extrasystole, which interferes with ejection fraction evaluation.
4. Reproduction of mitral and aortic leaflets.
5. Visualization of mitral regurgitation when present.
6. Reproduction of the ascending aorta in the proximal portion.

Left anterior oblique (LAO) 40–60° projection

(If indicated after performing RAO view and, preferably, after coronary angiography.)

1. Performed at full inspiration to avoid diaphragm superimposition.
2. Arms should be raised clear of the angiographic field.
3. Reproduction of the left ventricle in the cross-sectional axis (grossly circular shape), avoiding superimposition of the spine.
4. Visually sharp reproduction of ventricular walls in systole and diastole.
5. Reproduction of mitral and aortic leaflets.
6. Visualization of mitral regurgitation when present.
7. Reproduction of the ascending aorta in the proximal portion.

Left coronary angiography

(Projection based on operator's choice.)

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. Visually sharp reproduction of vessel walls.
4. Simultaneous and full opacification of the vessel lumen at least until the first critical lesion ($\geqslant 70\%$ by visual estimation).
5. Panning should be limited. If necessary, pan in steps rather than continuously, or make subsequent cine runs to record remote structures.
6. Visually sharp reproduction of the origin,

proximal, mid and distal portion of the left anterior descending and circumflex arteries, in at least two orthogonal views.
7. Visually sharp reproduction of side branches $\geqslant$1.5 mm of the left anterior descending and circumflex arteries in at least two orthogonal views; the origin should be seen in at least one projection.
8. Visually sharp reproduction of lesions in vessels $\geqslant$1.5 mm in at least two orthogonal views.
9. Visualization of collateral circulation when present.
10. When criteria 6–9 have been fulfilled, avoid extra projections (mainly LAO semi-axial).

Right coronary angiography

(Projection based on operator's choice.)

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 and the spine should appear as little as possible.
3. Visually sharp reproduction of vessel walls.
4. Simultaneous and full opacification of the vessel lumen at least until the first critical lesion ($\geqslant$70% by visual estimation).
5. Panning should be limited. If necessary, pan in steps rather than continuously, or make subsequent cine runs to record remote structures.
6. Visually sharp reproduction of the origin, proximal, mid (especially the crux region) and distal portion in at least two orthogonal views.
7. Visually sharp reproduction of side branches $\geqslant$1.5 mm in at least two orthogonal views; the origin should be seen in at least one projection.
8. Visually sharp reproduction of lesions in vessels $\geqslant$1.5 mm in at least two orthogonal views.
9. Visualization of collateral circulation when present.
10. When criteria 6–9 have been fulfilled, avoid extra projections (mainly LAO semi-axial).

Angiography of venous graft or arterial free graft

(Projection based on operator's choice.)

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 and the spine should appear as little as possible.
3. Visually sharp reproduction of graft walls.
4. Simultaneous and full opacification of graft lumen at least until the first critical lesion ($\geqslant$70% by visual estimation).
5. Panning should be limited. If necessary, pan in steps rather than continuously, or make subsequent cine runs to record remote structures.
6. Visually sharp reproduction of proximal and distal anastomoses, possibly in two orthogonal views.
7. Visually sharp reproduction of the origin, proximal, mid and distal portion in at least two orthogonal views.
8. Visually sharp reproduction of the lesions in at least two orthogonal views.
9. Visualization of collateral circulation when present.
10. When criteria 6–9 have been fulfilled, avoid extra projections (mainly LAO semi-axial).

Angiography of left mammary artery *in situ*

(Projection based on operator's choice.)

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 and the spine should appear as little as possible.
3. Visually sharp reproduction of graft walls.
4. Simultaneous and full opacification of graft lumen at least until the first critical lesion ($\geqslant$70% by visual estimation).
5. Panning should be limited. If necessary, pan in steps rather than continuously, or make subsequent cine runs to record remote structures.
6. Visually sharp reproduction of the origin, proximal and mid portion in at least two orthogonal views.
7. Visually sharp reproduction of the distal portion and distal anastomoses in at least two orthogonal views.
8. Visually sharp reproduction of the lesions in at least two orthogonal views.
9. Visualization of collateral circulation when present.
10. When criteria 6–9 have been fulfilled, avoid extra projections (mainly LAO semi-axial).

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