Invasive coronary angiography – do we need to know about it?

by Dr Sarah Hamilton, Dr Tinu Purayil
Peninsula Radiology Academy, Plymouth

Dr Gareth Morgan-Hughes
Consultant cardiologist, Plymouth Hospitals NHS Trust

Coronary artery disease is one of the leading causes of mortality in the developed world. With the increasing prevalence of coronary arterial disease the demand for accurate cardiac imaging is on the rise. Imaging of the heart has traditionally been the remit of cardiologists with invasive coronary angiography (ICA) and echocardiography being performed and interpreted within the cardiology department. While radiographers play an important role in the acquisition of angiographic images, radiologists have little experience of these procedures or their interpretation.

With the increasing accuracy of non-invasive imaging such as CT coronary angiography (CCTA) and cardiac magnetic resonance imaging (CMR) there is a shift in the focus of cardiac imaging towards radiology but ICA is currently still considered the gold standard for diagnosing coronary disease. The versatility of the technique allows for diagnosis and subsequent guided percutaneous coronary intervention, which means invasive angiography will continue to play a significant role in cardiology.

An understanding of invasive coronary angiography is therefore important for radiologists as well as radiographers, in order to appreciate all the clinical information available and guide further imaging appropriately to ultimately optimise patient outcomes.

Principles
ICA is essentially a contrast enhanced cine x-ray of the coronary vasculature. Contrast is directly injected into the coronary artery using shaped catheters placed within the coronary ostia. Two dimensional imaging of vessels running on the surface of an irregular oblong shaped structure demands multiple views with varying angulations.

Indications
• Chest pain of recent onset – patients with a high pretest probability of coronary artery disease (61-91%) or positive exercise tolerance test or other non-invasive test for myocardial ischaemia
• Acute coronary syndrome
• Suspected or known coronary artery disease
• Myocardial infarction
• Valvular heart disease
• Preoperative congenital heart disease

Procedure
Vascular access
Arterial access for left heart catheterisation is obtained through an arterial sheath sited in either the femoral or radial artery. The trans-radial route is now more commonly used than the femoral and is the access site of choice in the UK. Although marginally more technically demanding, there are less access site complications with this route and it allows early mobilisation, thus potentially shortening patient stays and decreasing immobility related complications. The main disadvantage is that spasm is more common, which is painful for the patient and makes the procedure more difficult.

Catheters
A selection of preformed catheters is available, designed to fit smoothly into the respective coronary ostia, choice depending on the access site used and the artery to be catheterised. The Judkins is the most commonly used for diagnostic procedures. There is a variety of sizes and there are additional options for bypass and anomalous vessels. Some centres use multipurpose catheters that can catheterise both left and right coronary ostia.

Contrast agents
Contrast injection is predominantly carried out manually for coronary artery opacification. Usually 6-9ml is injected into the left coronary artery per coronary ‘run’ and 3-6ml for the right coronary artery per ‘run’. The cine run begins with the injection and continues for a few seconds after the injection is completed to give an indication of dye clearance, as a surrogate for coronary flow. Left ventriculogram will add another 25-30ml of contrast, using an automated syringe injector capable of adjusting the volume, rate of flow and the pressure.

Imaging
As the branching of the coronary arteries forms a complex three dimensional pattern, the coronary arteries have to be visualised in a number of different views to obtain a complete picture of coronary anatomy.

The aim is to image each artery in two orthogonal planes. Selective coronary angiography is usually performed by taking five or six views of the left coronary system followed by three views of the right coronary artery and branches. Most operators start with a caudally angulated projection to delineate the left main anatomy, sometimes termed the prize money shot. These views are named after the position of the x-ray image intensifier (II) in relation to the supine patient and not as in normal radiological nomenclature to the position of the passage of the beam through the patient.
Common angiographic views
There is no universally accepted sequence of specified images and each centre, and indeed operator, may vary in their preferred routine.

The views used are abbreviated as follows: left (L), right (R), anterior (A), oblique (O). The number indicates the degree of angulation used.

<table>
<thead>
<tr>
<th>Vessel</th>
<th>View to image proximal aspect</th>
<th>View to image main and distal aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left main stem artery (LMS)</td>
<td>AP, LAO, LAO caudal</td>
<td>AP, LAO, LAO caudal</td>
</tr>
<tr>
<td>Left anterior descending (LAD)</td>
<td>LAO cranial, RAO caudal</td>
<td>RAO cranial, lateral</td>
</tr>
<tr>
<td>Left circumflex artery (LCX)</td>
<td>RAO cranial, LAO caudal</td>
<td>LAO caudal</td>
</tr>
<tr>
<td>Right coronary artery (RCA)</td>
<td>LAO 45, RAO 30</td>
<td>LAO cranial, lateral</td>
</tr>
<tr>
<td>Left ventricle</td>
<td>RAO 30, LAO 45</td>
<td></td>
</tr>
</tbody>
</table>

All views are not used in every patient. Additional views or altered magnification may be used.
- Cranial views are good for the LAD, and caudal for the circumflex. Caudal projections image proximal vessel segments well.

Tips for interpretation
- In all views of the left coronary artery, the circumflex is the vessel closest to the spine.
- LAD branches running towards the circumflex are diagonals.
- LAD branches running towards the right ventricle (and interventricular septum) are septals.
- If the spine is on the left then the view is RAO.
- If spine is on the right, the view is LAO.
- If there is a diaphragm shadow there is cranial angulation, good for distal vessel views and the LAD.

Report interpretation
In many trusts ICA reports are held on cardiology IT systems, rather than the imaging system, although the images may be stored within a PACS system, and therefore in general reports are not readily accessible within the imaging department, and therefore unfamiliar to those within the department.

A standard ICA report will include:
- A summary of the procedure +/- some patient history.
- Location of any stenosis, usually including a diagram illustrating the site. This may describe the location in terms of the American Heart Association classification (figure 7).

**FIGURE 2**
The LAD may be identified most readily by the fact that it almost universally supplies the apex of the heart as shown in this image.

**FIGURE 3**
LAO caudal or ‘spider’ view. Good for the left main stem (LMS) and the ostium of the main branches of the LCA. A normal variant – an ‘intermediate’ artery arising from the bifurcation point of the LMS is also shown here.

**FIGURE 4**
The LAO cranial is useful for the LAD and particularly the LAD/diagonal bifurcation. RAO cranial is also useful for the LAD and its branches.
• Assessment of the % stenosis (visually or semi automated using quantitative coronary analysis software – QCA).
• Assessment of LV function.

The coronary arteries can be described using the AHA model illustrated (figure 7) and cardiologists will often refer to segments within their reports according to this.

Radiation exposure
Coronary angiography can result in significant radiation doses to the operator and potentially the rest of the staff within the catheter laboratory. Different views alter the radiation dose to the operator; for example the left anterior oblique view results in a six-fold increase in radiation dose compared to the right anterior oblique view. Although the radiation dose is higher during cine exposure, fluoroscopy accounts for a higher operator dose because of its prolonged use in interventional procedures. As a consequence of this there is increased incidence of corneal opacities seen in interventional cardiologists when compared to non-interventional cardiologists.

Summary
Despite the recent advances in cross-sectional cardiac imaging, the versatility offered by invasive coronary angiography means that it will continue to form an integral part of cardiac imaging, so a basic understanding of the procedure as well as an ability to interpret the resulting images will be useful for anyone involved in any aspect of cardiac imaging.

Further reading
For anyone interested in further reading there are many handbooks aimed at cardiology trainees offering guidance to ICA, and the first three listed below are all good. For any radiology registrars with access to the RCR Radiology integrated training initiative (R-ITI), e-learning module 1a-007 (normal heart by angiography) covers similar ground.


References