Commentary

Interventional Cardiology

Imaging in preparation for catheter interventions in congenital heart disease

"Knowing the limitations and also understanding potential pitfalls leads to better understanding and hence avoids overimaging."

Keywords: catheter intervention • congenital heart disease • imaging modalities • radiation dose

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The indication to intervene on congential heart disease can be dependent on clinical symptoms such as breathlessness, cyanosis and heart failure signs, but in many cases echocardiographical findings lead to further investigations and even interventional treatment (i.e., an atrial septal defect with right heart volume load is typically clinically asymptomatic for a long time, and transthoracic echocardiography (TTE) may be the only investigation carried out prior to treatment). The same appeals to purely valvar stenosis of the semilunatic valves; however, if there is doubt about outflow tract obstruction or sub-/supra-valvar stenosis, a transesophageal echocardigram (TOE) can delineate the anatomy in high detail. On the other hand, especially in children, this will have to be carried out under general anesthesia.

For the interventionalist dealing with congential heart disease, it is important to remember the advantages and disadvantages of the different imaging modalities that can be applied and should be applied depending on the question raised.

Planning of imaging is crucial for planning of the intervention, for choosing equipment and for good results. Hence the interventionalist needs to know the target zone of the intervention: is this intracardiac or extracardiac? Intrapericardial or extrapericardial? Intramediastinal or extramediastinal? Intrapulmonary or extrapulmonary? Depending on this, preinterventional imaging can be chosen.

Echocardiography

TTE is noninvasive and is universally available in cardiology. It provides a good overview on systolic and diastolic function, and allows to visualize almost all intracardiac and intraperitoneal structures in great detail, but is dependent on the cooperation of the patient and the 'windows', which can be limited by pulmonary pathology, and especially in adults by patient size and weight. Extrapulmonary, but intramediastinal vessels (i.e., the intrathoracic aorta or a persistent arterial duct) can typically be visualized from a suprasternal view. Frequently, indication for catheter interventions in young pediatric patients is based on TTE alone, especially for valvuloplasties and occlusion procedures of atrial or ventricular septal defects, or persistent arterial ducts.

TOE allows an even more detailed analysis of many intracardiac structures, especially the interatrial septum, the left ventricular outflow tract and the atrioventricular and semilunatic valves, although the aortic valve is typically better visualized than the pulmonary valve [1].

Intracardiac echocardiography is another addition to the armoury of the echocardiographer. The catheters used have a size of 8 or 9 Fr. It is an even more invasive procedure than TOE, and it is not applicable for small infants due to vessel size. In pediatric patients, this will be carried out under anesthesia and is rarely independent from the catheter intervention planned (mostly atrial septal defect closure).

Whilst echocardiographically obtainable information is mainly restricted to the intraperitoneal and intramediastinal structures, no such limits exist for MRI or computed tomography (CT). Both allow visualization of

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intracardiac, extracardiac, intra- and extra-peritoneal, and intra- and extra-pulmonary structures and vessels very well.

MRI

MRI can be seen as a 'one-stop' investigation, as in addition to the anatomical information functional assessment including flow measurements, ejection fraction, regurgitation fraction of incompetent valves, and the relation to extracardiac structures can be carried out [2]. It works radiation free. Although it is dependent on the cooperation of the patient and in children of (in my experience) less than 10 years, typically general anesthesia is required. This is especially important if ECG-gated dimensions are necessary for interventional planning – the interventionalist does not need the diastolic diameter of a vessel (i.e., the descending aorta or a pulmonary artery), but the maximum diameter during systole in order to choose the right size balloon or stent. For this, breathhold of a few seconds is necessary, which cannot be achieved without anesthesia in younger patients. Compared with angiography, the MRI can clearly show the location of any vessel stenosis, but it underestimates the minimum diameter of the stenosis. 3D reconstruction allows visualization of the heart and vessels from any angle, and can minimize the time of intervention based on the findings if used for planning angulations that are required to optimally visualize the target structures. The aquisition time is quite long (for a full scan including anatomical and functional information) and can mount up to more than 1 h. It requires offline analysis of the aquired data. The quality of the scan is dependent on the postprocessing and hence on the experience of the investigator. The interventionalist needs to know about the limitations (i.e., black-blood imaging may provide more adequate information regarding vessel size, but 3D gives a better overview of the anatomical structures).

Computed tomography

Compared to MRI, CT has much better spatial resolution. With modern equipment, scanning time is extremely short [3]. The great advantage is the delineation of all intrathoracic structures including the airways and the esophagus. Intrapulmonary pathology can be diagnosed too [4]. On the other hand, it does not allow functional analysis or flow measurements as obtainable by MRI. Although the radiation dose in modern CT is low compared with earlier generations of these, it still adds to the total cumulative dose a patient receives over time. Especially in children, apart from stochastic effects on the DNA, the dose-dependent effects of solid tumor induction (which may manifest as late as 40 years later) may play a greater role, as the risk is expressed over the longer life expectancy. The radiation used for the CT scan adds to the dose used during fluoroscopy and interventions. Reference values for common interventions in pediatric cardiac patients have been published [5].

> "The 'now we are here, let's see the other parts' approach needs to be avoided, especially if other imaging modalities have given the information already."

Many patients with congenital heart disease may require repeat interventions. Hence, previous angiography should always be reviewed prior to any subsequent intervention. With this, many angiographies can be avoided and radiation saved (i.e., children with pulmonary atresia or ventricular septal defect) and major aortopulmonary collateral arteries after unifocalization may undergo several catheterizations due to vessel stenosis within the first few years of life). In many centers they will undergo other imaging (MRI or CT) prior to each intervention to locate the stenosis. During intervention, multiple angiographies are then performed. These should be limited to the minimum and only the information necessary during the catheter intervention should be obtained. The 'now we are here, let's see the other parts' approach needs to be avoided, especially if other imaging modalities have given the information already.

Newer developments such as 3D roadmapping will allow to utilize previous imaging in the catheter laboratory and reduce the use of radiation furthermore.

Imaging modalities should be applied depending on the indication

Imaging modalities should be applied depending on the indication. To avoid unneccessary anesthesia and more so, radiation exposure to the patient and the staff, all investigations should only be performed if they have a direct impact on treatment decisions. Communication of the findings is crucial. Knowing the limitations and also understanding potential pitfalls leads to better understanding and hence avoids overimaging [6]. However, 'if you go to a barber shop, it is likely that you'll get a haircut', as John Gibbs used to point out. We will apply the imaging that is easily accessible in our department, but we should aim for the best imaging rather the easiest available. All previous imaging need to be reviewed, because many further investigations may be avoidable. If I know that I will perform angiography anyway, do I need a CT or MRI beforehand?

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