Editorial

# Intraprocedural guidance: which imaging technique ranks highest and which one is complementary for closing paravalvular leaks?

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**Abstract:** Echocardiographic guidance is critical for procedural success of paravalvular leak closure. Transesophageal echocardiography (TEE) and particularly three-dimensional echocardiography represent the gold standards. Fusion imaging provides real-time integration of three-dimensional echocardiography and X-ray fluoroscopy and can further facilitate spatial orientation, wire placement and device deployment. Intracardiac echocardiography (ICE) is a secondary approach possibly beneficial in selected cases.

**Keywords:** Three-dimensional transesophageal echocardiography (3D-TEE); intracardiac echo; fusion imaging

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In addition to accurate pre-interventional diagnostics and post-implantation follow-up, adequate intra-procedural guidance of percutaneous paravalvular leak closure is critical for procedural success and for minimizing radiation exposure. It also keeps the burden to the patient as low as possible. Transesophageal echocardiography (TEE) and especially real-time three-dimensional (RT-3D) imaging play a prominent role as procedural guiding tools. Both methods are also important for assessing the results after device deployment (1). RT-3D TEE of the sewing ring has made this assessment even easier and more accurate (2). It can depict not only the relevant cardiac landmarks adjacent to the sites of paravalvular leaks, but also wires, delivery catheters and closure devices (3). Visualization, however, is impaired by significant echo artifacts concealing cardiac structures behind these instruments and beneath mechanical valve prostheses. In contrast, on fluoroscopy, native cardiac structures do not show up unless they are significantly calcified. Therefore, both imaging techniques complement each other perfectly. This is particularly true for hybrid viewing systems, also known as fusion imaging systems, which are capable of delineating structures in the fluoroscopic image previously identified in the echocardiographic image. Hybrid viewing is accomplished by overlaying fluoroscopic images with RT-3D volume images. In these aggregate views, the echo volume is displayed in a coordinate system that can be easily related to the heart and the patient's body. Hybrid echo/fluoroscopy imaging permits much more precise catheter and guide wire positioning—a clear advantage of this method. Visualization of catheter direction in relation to the anatomical structures facilitates faster and more targeted and accurate advancement to the intended anatomical site.

RT-3D imaging provides a 90°×90° field of view and can thereby also facilitate transseptal puncture, which is required for the antegrade approach to closing paravalvular mitral leaks (4). Especially the 'clock face' view of the mitral valve obtained from the left atrium and the corresponding view of the aortic valve from the ascending aorta, both also known as 'surgical views', facilitate communication between interventional cardiologist and imaging specialist. In addition, improved spatial and temporal image resolution result in better spatial orientation for the interventional cardiologist and facilitate adequate manipulation and placement of wires and devices (5).

TEE, however, requires general anesthesia during those prolonged interventions, and is therefore not ideal for procedural guidance. Lázaro *et al*. point out correctly that this may present an additional burden to seriously ill cardiac patients (6). Intracardiac echocardiography (ICE), another echocardiographic guiding tool increasingly used to enable visualization of cardiac structures and interventional devices in order to facilitate precise guidance (7), can be employed in fully conscious patients. It therefore represents an alternative to TEE. RT-3D ICE may be of particular benefit in specific clinical settings, e.g., if paravalvular leaks of aortic prostheses are located anteriorly. In these cases, the aortic prosthesis will often lead to acoustic shadowing of the anterior sewing ring during TEE imaging. Alternatively, this region can be imaged with ICE from the right ventricular outflow tract or with the transatrial short axis views (5). Paravalvular leaks after mitral valve replacement located along the medial section of the circumference can also be interrogated by transventricular long axis ICE views with the ICE-catheter located in the right ventricle close to the interventricular septum. Unfortunately, many of mitral paravalvular leaks occur along the lateral circumference (4) and are therefore invisible on ICE due to acoustic shadowing by the posterior/medial sewing ring of the mitral prosthesis.

In contrast to RT-3D TEE, RT-3D ICE does not provide en face views of the mitral valve prosthesis and can therefore not provide 'clock face' based orientation. For aortic valve prostheses, 'clock face' orientation could be obtained from transatrial or transventricular short axis views. However, the 'clock face' is then rotated by approximately 4 hours compared to TEE images. This requires a specific mental reorientation by examiners used to TEE views. RT-3D imaging of the sewing ring has made guidance by ICE easier and more accurate, although the field of view provided by the current version of the RT-3D ICE catheter comprises just 22°×90° and is therefore much smaller than the field of view obtained with RT-3D TEE. Fusion imaging integrating RT-3D ICE and fluoroscopy in hybrid images is not available yet. Nevertheless, guidance of paravalvular leak closure by RT-3D ICE has been reported to be a feasible and advantageous technique (8). It may be particularly beneficial in patients in whom endotracheal intubation should be avoided by all means, e.g., patients with chronic obstructive pulmonary disease. In these individuals the benefits of obviating general anesthesia must be weighed against the costs of ICE and the need for an additional venipuncture.

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