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HOW TO

# Multimodality imaging for intraprocedural guidance of a transcatheter tricuspid valve replacement

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Transcatheter tricuspid valve replacement (TTVR) is poised to rapidly become a standard therapeutic strategy to treat severe-to-torrential symptomatic tricuspid regurgitation (TR). Several devices for orthotopic valve replacement are currently being used and investigated.[1,2] Procedural and, ultimately, clinical outcomes greatly depend on intraprocedural imaging guidance.[2,3] Transoesophageal echocardiography (TEE) is the 'gold standard' for tricuspid valve imaging but can be complicated because of the position of the probe relative to the tricuspid valve (TV), resulting in far-field tangential views with acoustic shadowing from other heart structures. This report illustrates how multimodal imaging, including cardiac computed tomography (CT)-fluoroscopy fusion imaging and intracardiac echocardiography (ICE), can contribute to a streamlined, safe, and successful TTVR.

The LuX-Valve Plus System (JensCare Scientific, China) is a TTVR device implanted through the jugular vein.[4] Before the procedure, all patients undergo a cardiac CT scan in order to measure the TV annulus size and dimensions of the right heart chambers and to determine the optimal fluoroscopic projections, which are co-planar to the TV annulus and perpendicular to the interventricular septum (IVS)—generally, a right anterior oblique (RAO) view with some degree of caudal or cranial inclination (see Supplementary data online, *Figure S1*).

During device implantation, we consider three critical steps, all heavily relying on intraprocedural imaging guidance (*Figure 1*). As a first step, after advancing the distal end of the delivery system into the right ventricle (RV), the delivery system must be sufficiently deep, and in the centre of and perpendicular to the TV annulus. The depth and co-axiality of the delivery system relative to the TV annulus is standard assessed on TEE using mid- and deep-oesophageal RV inflow–outflow X-plane views. The tip of the delivery system should be positioned ∼4 cm distal to the TV annulus (*Figure 2A*). An imaging modality that proved its value in this phase of the procedure is CT fusion imaging, relying on a CT-based overlay of the TV annulus onto fluoroscopy. At CT fusion imaging, the base of the leaflet grasping clips, still captured within the delivery system, should be positioned ∼1 cm distal to the TV annulus (*Figure 2B*; Supplementary data online, *Video S1*). When using CT-fluoroscopy fusion imaging, it is important to keep the overlay simple and not distracting or even disturbing. As shown in *Figure 2B*, the only anatomical structures marked on the CT overlay and exported as burned DICOM images onto fluoroscopy are the TV and aortic valve annuli; the latter is only used for intraprocedural calibration with a pigtail catheter on the aortic valve.

The LuX-Valve does not depend on radial forces for anchoring but on native leaflet grasping (lateral; step 2) and anchoring into the IVS (septal; step 3). The combination of TEE and ICE to guide these next two critical steps showed to be complementary and contributed to achieving a safe and well-controlled procedure. The leaflet grasping itself is, in fact, not visualized. Instead, verifying the correct position of the clips on imaging before further valve deployment is what is key for the leaflet grasping step. The mid-oesophageal RV inflow–outflow and transgastric X-plane views are used to confirm that both leaflet grasping clips are below the TV leaflets (*Figure 2C*). Typically, the clips (also called 'rabbit ears') grasp the anterior leaflet (lateral side) and over-ride the anterior papillary muscle that is located at the commissure between anterior and posterior leaflets. If in doubt whether the pair of clips are below the leaflets with TEE only, ICE from the right atrium can be highly valuable to confirm this (*Figure 2D*; Supplementary data online, *Video S2A and B*).

After expansion of the LuX-Valve, it is of utmost importance to assure contact of the septal tongue with the IVS, and this throughout the entire cardiac cycle (step 3). The angle of insertion of the delivery system already results in the septal tongue being deployed facing towards the IVS. Co-axiality of the septal tongue relative to the IVS is assessed on TEE using a deep transgastric view (*Figure 2E*). The correct anterior–posterior and co-axial position relative to the septum is acquired by flexing/unflexing the delivery system using the flex wheel and rotating the device's inner core using the rotation knob, respectively, guided by transgastric TEE imaging (see Supplementary data online, *Figure S2*). Before pushing the anchor out of the needle holder, it is of critical importance to verify that there is good apposition of the septal tongue with the IVS—and this throughout the entire cardiac cycle. In some cases, this may be challenging relying on TEE imaging

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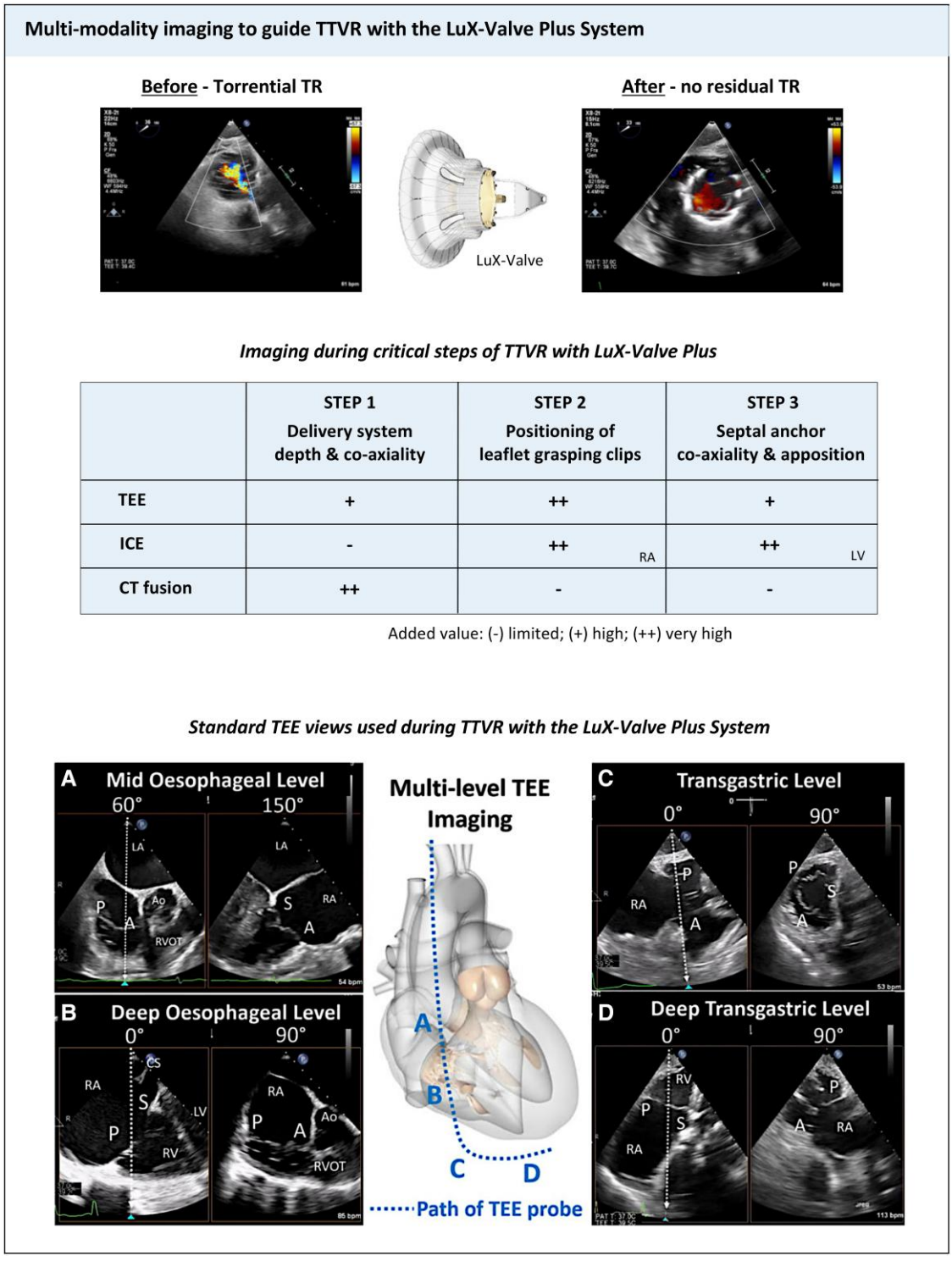


**Figure 1** The table indicates which imaging modalities can be used and are of added value during the three critical steps of TTVR with the LuX-Valve Plus System; the lower panel shows the standard TEE views used during TTVR with the LuX-Valve Plus System. A, anterior leaflet; Ao, aorta; CS, coronary sinus; CT, computed tomography; ICE, intracardiac echocardiography; LA, left atrium; LV, left ventricle; P, posterior leaflet; RA, right atrium; RV, right ventricle; RVOT, right ventricular outflow tract; S, septal leaflet; TR, tricuspid regurgitation; TEE, transoesophageal echocardiography; TTVR, transcatheter tricuspid valve replacement.

only. Following a transseptal puncture and keeping a stiff guidewire across to the left atrium (or introducing a 65 cm long 10 F arrow sheath into the left atrium), the ICE probe can be easily crossed over into the left atrium and ventricle. An alternative approach is retrogradely crossing the aortic arch and aortic valve. ICE from the left ventricle provides an excellent near-field view of the IVS

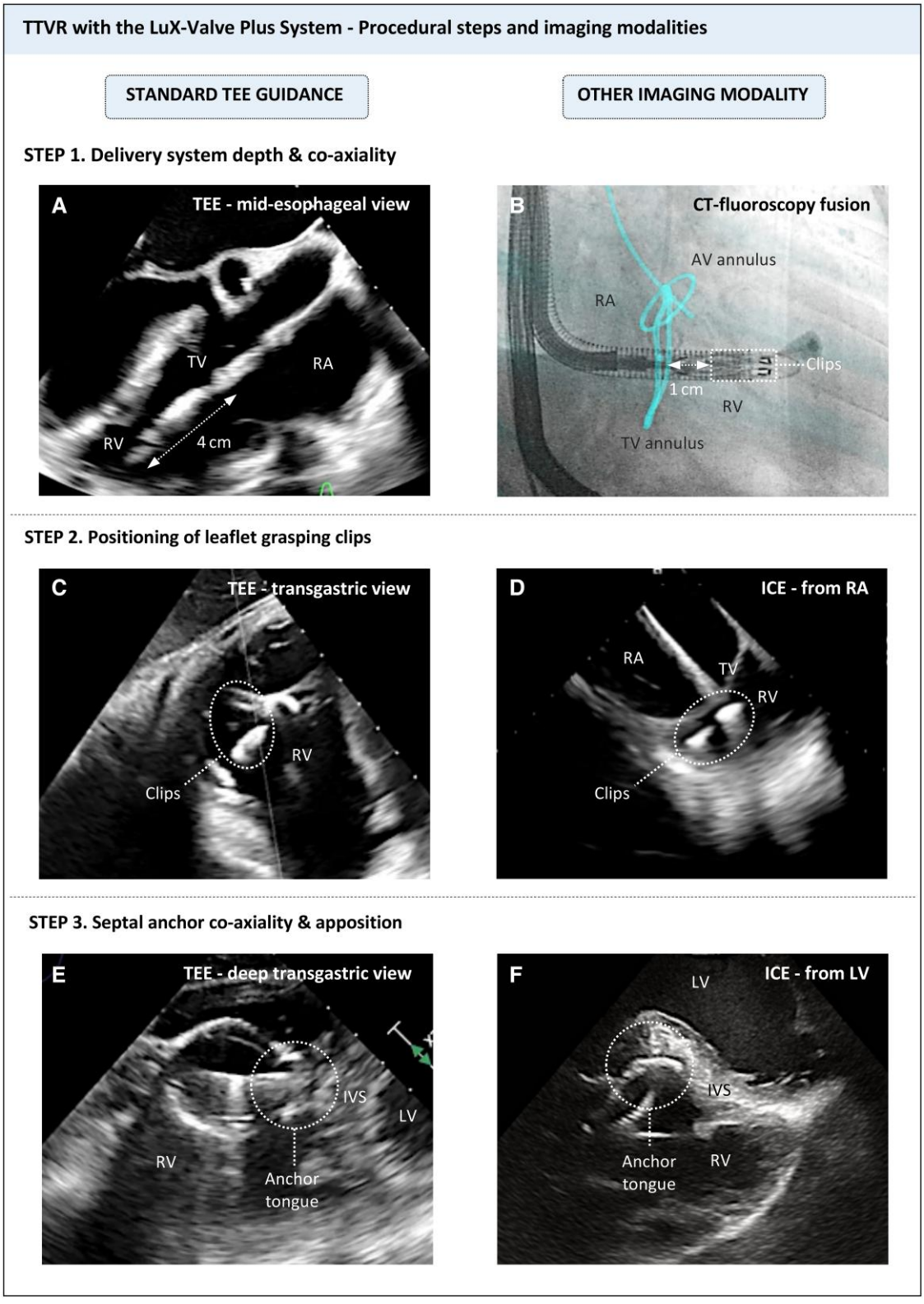


**Figure 2** The figure shows the standard TEE views and possible additional imaging modalities used for TTVR with the LuX-Valve Plus System; three-dimensional (3D) and multi-plane reconstruction (MPR) echocardiographic imaging is not required. AV, aortic valve; CT, computed tomography; ICE, intracardiac echocardiography; IVS, interventricular septum; LV, left ventricle; RA, right atrium; RV, right ventricle; TEE, transoesophageal echocardiography; TTVR, transcatheter tricuspid valve replacement; TV, tricuspid valve.

and septal tongue, which is superior compared with TEE (*Figure 2F*). Good apposition of the septal tongue with the IVS during the entire cardiac cycle can easily be verified by left ventricular ICE, and, if needed, improved by counterclock (posterior) rotation of the delivery system, pressing the septal tongue into the IVS (see Supplementary data online, *Video S3*).

In all eight cases performed so far in Copenhagen, follow-up transthoracic echocardiography 1 day after the procedure showed no or trace paravalvular or central leak and all patients were discharged in a good clinical condition within 3 days after the procedure.

In conclusion, intraprocedural multimodality imaging can promote safety and success of TTVR procedures by improved guidance during critical steps of device implantation.

# Supplementary data

Supplementary data are available at *European Heart Journal - Cardiovascular Imaging* online.

**Conflict of interest:** A.L. is a consultant for VDyne and Shifamed. T.M. received consulting fees from JensCare Scientific. The other authors have no relationships relevant to the contents of this paper to disclose.

## Data availability

The imaging source data underlying this article will be shared on reasonable request to the corresponding author.

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