Role of Cardiac Imaging for Catheter-based Left Atrial Appendage Closure

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Abstract

Thromboembolic stroke is the most serious complication in patients suffering from Atrial Fibrillation. Atrial thrombi have a predilection to form in the left atrial appendage. Accordingly, oral anticoagulation is recommended for patients with high risk of stroke. However, it is widely underused and problems of compliance are associated with serious risk of bleeding or inefficacy. In these patients with non-valvular atrial fibrillation, percutaneous occlusion of the left atrial appendage might help to reduce the risk of thromboembolism.

Cardiac imaging plays a crucial role at all stages of this procedure and trans-esophageal echocardiography represents the current gold-standard for the assessment of the left atrial appendage. Cardiac imaging is mandatory to precisely determine the left atrial appendage anatomy and to select the appropriate size for the device. Finally, real time three-dimension echocardiography is a powerful additional tool that improves the safety profile of the procedure. 3D-transoesophageal echocardiography allows for the accurate assessment of left atrial appendage anatomy and helps determine if it’s suitable for device implantation. Finally, it also allows for continuous visualization of all intracardiac devices and catheters during the procedure, and the clear delineation of device positioning in the left atrial appendage.

Introduction

Stroke is the most serious complication of Atrial Fibrillation (AF). Irrespective of the rhythm management strategy, long-term Oral Anticoagulant (OAC) therapy is recommended according to the patient thromboembolic risk profile. In real life however, classic and new OAC are not totally reliable in preventing thromboembolic events. Moreover, OAC are often poorly tolerated and have a narrow therapeutic window. Percutaneous Left Atrial Appendage (LAA) occlusion was developed as an alternative therapeutic option to prevent stroke in high risk AF patients who are not candidates for a long term anticoagulant therapy. In this article, we discuss the LAA anatomy and the role of cardiac imaging for catheter-based LAA closure. According to recent studies, obliteration or amputation of the LAA might help to reduce the risk of thromboembolism in non-valvular AF. Surgical exclusion or excision of the LAA is safe and effective in patients with AF history undergoing an open heart surgery or a coronary artery bypass grafting surgery.

However, the long-term results of these procedures remain controversial. Percutaneous LAA closure has been developed with promising results, and is now a day indicated by the guidelines as a valuable alternative for patient with a high risk of stroke and contraindications for long-term oral anticoagulation. Currently, different devices are proposed for percutaneous LAA obliteration: the PLAATO system (Appriva Medical) is not available anymore, the WATCHMAN device (Boston Scientific, Natick, MA, USA) and the AMPLATZER® Cardiac Plug prosthesis (St. Jude Medical Inc., Saint Paul, USA). Preliminary results with those devices demonstrated the feasibility of percutaneous LAA obliteration.

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Cardiac imaging plays a key role at different stages of the procedure.

Patient Selection

According to their medical history, their thromboembolic profile (CHA₂DS₂-VASc) and bleeding risk (HAS-BLED), patients with non-valvular AF who are not candidates for a long term OAC can be eligible for a percutaneous LAA occlusion. Two-dimensional and Three-dimensional transthoracic echocardiography (2D- and 3D-TTE) allows for determining the left ventricular systolic function

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irregular, should be measured in several planes. MDCT appear to be a safe alternative to 2D-TEE. Its sensitivity for the detection of LAA thrombi is at least comparable with TEE and when associated with contrast injection, it yields to high quality 3-D images of the LAA anatomy. A few authors also proposed to use Cardiac MRI to assess the LAA anatomy and to detect LAA thrombi, however its role for percutaneous closure of the LAA needs to be better defined.

Procedure Planning and Assessment of LAA Anatomy

LAA is a tubular and muscular structure derived from the left wall of the primary atrium, which forms during the third week of gestation. LAA resembles a cone and communicates with the LA through an orifice located between the left superior pulmonary vein and for identifying potential procedural contraindications such as significant valvular disease or severe left atrium dilatation (>60mm). Therefore, the use of 2D- and 3D-transesophageal echocardiography (2D- and 3D-TEE), multi-detector computed tomography (MDCT) or Cardiac Magnetic Resonance Imaging (cMRI) is mandatory when planning the procedure.

As it plays a crucial role to guide the landing of the prosthesis in real time during the LAA occlusion, TEE has become the gold-standard technique for the assessment of the LAA. LAA anatomy is very complex, and careful evaluation by multiplane TEE is the first important step. The exact size of the LAA orifice, which is often
and left ventricle. There is an important inter-individual variability in the anatomy and size of LAA. In approximately 54% of cases, LAA had 2 or more lobes (range 1-4). In AF patients, the volume of the LAA increases. In those patients, atrial thrombi have a predilection to form in the LAA. The exact pathogenesis of clot formation in the LAA has not been fully elucidated; however, relative stasis which occurs in the appendage owing to its shape and the trabeculations within it is thought to play a major role.

When planning an LAA occlusion procedure, non-invasive imaging is needed to precisely determine the LAA anatomy (thrombus, accessory lobes, orifice diameter and depth) (Figures 2,3). The accurate measurement of the LAA orifice diameters and landing zone is of paramount importance to avoid either prosthesis oversizing, which carry a risk of perforation and cardiac tamponade, or prosthesis undersizing, which is associated with a risk of device embolization or residual leak. Therefore, it is recommended to measure the LAA orifice diameter by using several imaging techniques. In our experience, gross anatomical information is commonly provided by 2D-TEE. However, 2D-TEE does not adequately allow a complete visualization of the LAA. Moreover, it tends to underestimate the LAA ostium diameter. Three-dimensional imaging modalities (3D-TEE, MDCT or cMRI) are more reliable and accurate than 2D-TEE for the assessment of LAA orifice size. Real time 3D-TEE currently represents our first-line approach as it can be used during the procedure itself and provides a full view of the LAA without any radiation exposure or contrast administration (Figure 4).
Procedure Guidance

During the procedure itself, both TEE and contrast angiography play a major role to guide the procedure. TEE or Intracardiac Echocardiography (ICE) can be used to guide the transseptal puncture. TEE, ICE and LAA contrast angiography in several projections (usually 4 for TEE and 2 for contrast angiography) confirm the LAA orifice dimensions. Based on these measurements and according to the different manufacturers charts and recommendations, the size of the device is chosen. The positioning of the device in the LAA cavity is monitored by TEE and fluoroscopy (Figure 5). At all stages of the procedure, full visualization of the intracardiac catheters and devices is important in order to avoid complications. Catheters can be seen on the 2D images. However, their exact location is difficult to determine as it is impossible to align all of them in only one imaging plane. Using real time 3D-TEE allows for imaging the entire intracardiac region with all the catheters in live. Real time 3D-TEE contributes largely to increase the safety of the procedure and the confidence of the cardiologist who manipulates the catheters. In particular, it allows for the direct visualization of the anatomical relationships between the mitral valve, the pulmonary veins and LAA. Once the device is positioned in the LAA, its position is re-assessed prior to final deployment. The real time 3D zoom mode with a “en face” visualization of the device evaluates the anatomical fit of the prosthesis (Figure 6B and 6C). If the placement appears suboptimal, the device can be re-positioned until satisfactory result has been achieved.

Evaluation of Procedural Efficacy

Once the position of the device appears anatomically satisfactory, the device is released. TEE and contrast angiography are used to evaluate immediate procedural efficacy. Colour Doppler 2D-TEE is used to assess potential residual communication between the LAA and the left atrium (Figure 6). If the placement appears suboptimal, the device can be re-positioned until satisfactory result has been achieved.

Detection of Procedural Complications and Evaluation of Long Term Results

At the end of the procedure, echocardiography is used to assess the absence of any possible early complications, which might
include pericardial effusion and cardiac tamponade, device dislodgement or embolization and abnormal mitral valve movement.

During follow-up, TEE, MDCT or cMRI are performed at predetermined intervals to assess the long-term results and to exclude any late complications. The final device position is appreciated by using the 2D-TEE and 3D-TEE zoom mode with “en face” visualization of the LAA orifice (especially for the AMPLATZER® Cardiac Plug prosthesis). Colour Doppler is used to exclude any residual communication between the LAA and the left atrium. Both 2D- and 3D-imaging techniques are used to exclude the presence of any intra-cardiac clots or thrombus covering the device. Some reports showed that MDCT has a superior image resolution and might be helpful to non-invasively evaluate the device position and assess the LAA after obliteration.28,29 Cardiac MRI also seems to be an interesting non-invasive alternative to confirm the correct positioning of the occluder and to detect residual LAA leaks.30

Conclusions:

Percutaneous LAA occlusion procedure is a safe and effective alternative for patients with non-valvular AF at high risk for thromboembolism who are not candidates for long term anticoagulant therapy. Cardiac imaging play a crucial role at all stages of the procedure. Conventional 2D-TEE is the current gold-standard for the assessment of the LAA. However, real time 3D TEE imaging is a powerful additional tool that helps to improve the safety of the procedure. Real time 3D TEE allows for the evaluation of the LAA anatomy and for determining its suitability for device implantation. It also allows for continuous visualization of all intracardiac devices and catheters during the procedure and the clear delineation of device position in the LAA.

References:


