First experience with real-time three-dimensional transoesophageal echocardiography-guided transseptal in patients undergoing atrial fibrillation ablation

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Aims Transseptal (TS) puncture during atrial fibrillation (AF) ablation is a relatively safe procedure in experienced hands. However, major and minor complications cannot be completely ruled out. Real-time three-dimensional transeosophageal echocardiography (RT 3D TEE) is a novel imaging technology that permits direct visualization of the fossa ovalis in a 3D perspective, thereby sensibly lowering the likelihood of potential adverse effects during TS. In our study, we describe the technique and assess the feasibility, advantages, and safety of this novel imaging method in guiding TS puncture in a series of consecutive patients undergoing AF ablation.

Methods and results We performed TS puncture guided by RT 3D TEE under general anaesthesia in 24 consecutive patients (16 male, 55.4 ± 8.1 years) undergoing ablation for drug refractory AF. The fossa ovalis could clearly be seen and easily be distinguished from surrounding anatomical structures in all 24 patients. All punctures required a single attempt to access left atrium. Mean orientation of the needle hub when puncturing was 4.30 o’clock (ranging from 3 o’clock to 6.30 o’clock), and mean distances from the needle tip to the aortic and to the posterior wall were, respectively, 13.5 ± 7 and 35 ± 7.3 mm. Total fluoroscopic time was 120.6 ± 34 s. No major or minor complications were experienced.

Conclusion Real-time three-dimensional transeosophageal is a very useful tool in guiding TS puncture in patients undergoing AF ablation with the invaluable advantage of the 3D direct visualization of the fossa ovalis. This permits fast and safe transatrial access with a single puncture attempt.

Keywords
Atrial fibrillation ablation; Real Time 3D echocardiography; Transseptal puncture

Introduction
Since pulmonary vein ectopic beats have been demonstrated to be the main source of atrial fibrillation (AF),1,2 many authors have concentrated on curing the arrhythmia by targeting particular areas of the left atrium with catheter ablation. Regardless of the energy source used (radiofrequency, cryothermic ablation) and of the choice of one of the many strategies previously described in the literature (anatomical approach, focal ostial segmentation, etc), one or even two transseptal (TS) punctures are needed to access the left atrium. Nowadays, TS puncture is a relatively safe procedure and globally carries a very low risk of major and minor complications. However, adverse effects of this procedure such as aortic perforation, atrial perforation, pericardial tamponade, thrombotic formation, or air embolism cannot be completely ruled out. Thus, to our opinion, it is mandatory to perform this technique with maximal safety. Recently, real-time three-dimensional transeosophageal echocardiography (RT 3D TEE) has become available for clinical practice offering clear and detailed imaging of the cardiac anatomy. This new technology permits direct visualization of the fossa ovalis in a 3D perspective, sensibly lowering the likelihood of potential complications if used during TS puncture. To our knowledge, experience with RT 3D TEE-guided TS puncture in a series of patients undergoing AF ablation has not yet been reported. The main aim of the present study was to assess feasibility, advantages, and safety of this novel imaging method in guiding left atrial access for AF ablation.

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Methods
Patient characteristics
We performed TS puncture guided by RT 3D TEE in 24 consecutive patients (16 male) undergoing ablation for drug refractory AF. Mean population age was 55.4 ± 8.1 years (range 38–75). All patients provided informed consent to the procedure. Seventeen patients (70.8%) were affected by paroxysmal and seven (29.2%) by persistent AF. Paroxysmal AF was defined as episodes terminating spontaneously within 7 days and persistent AF when episodes persisted longer than 7 days and needed cardioversion to restore sinus rhythm. All patients had been resistant to at least two antiarrhythmic drugs. AF started 3.3 ± 1.2 years prior to the enrolment in the study. Four individuals (16.6%) had previously undergone PV isolation ablation for AF. Thirteen patients had hypertension. Structural heart disease was present in three patients: two exhibited coronary artery disease, one dilated cardiomyopathy. All patients underwent 2D TEE the day before the procedure to exclude the presence of thrombi in the left atrial appendage. At the same time, TTE was performed and LA dimension and LVEF were measured. Average LA dimension and mean LVEF were, respectively, 47 ± 5.6 mm and 61 ± 6.2%. We excluded patients exhibiting left atrial thrombus on TEE, severe heart failure, or any contraindication to general anaesthesia.

Transseptal puncture
All procedures were performed under general anaesthesia. Before starting the catheterization, the TEE probe was introduced (Philips iE33, X7-2t TEE probe, Philips Ultrasound, Bothell, WA 98021-8431, USA). The first position of the TEE probe into the midoesophagus was guided by the x-plane view, with two perpendicular views on the interatrial septum (IAS), imaging optimally the fossa ovalis. We then proceeded to two consecutive TS punctures to insert both an ablation and a circular mapping catheter. We started by introducing via a 6 Fr sheath in a left-sided femoral arterial access a pigtail catheter which was positioned in the aortic root with the double purpose of arterial pressure monitoring and the assessment of position of aorta. Via the left subclavian or the right jugular vein, we inserted via a 6 Fr sheath a quadripolar catheter in the coronary sinus. These were used as fluoroscopic landmarks. We then placed two 8 Fr sheaths in the right femoral vein and advanced the first 8 Fr TS sheath (St Jude medical, St Paul, MN, USA) on a 0.32 mm guidewire in the right superior venous cava. The guidewire was then retracted and replaced by a Brockenbrough needle (BRK 1) after flushing of the system with saline. The whole system was withdrawn under biplane fluoroscopic guidance (antero-posterior and left lateral projections) and placed in the fossa ovalis keeping the needle hub arrow pointing between 3.00 o’ and 6.30 o’clock position. At that moment, the echocardiographic image was switched to the RT 3D mode, shifting with the scroll ball the fossa ovalis in a 3D perspective. We then applied slight pressure to obtain typical ‘tenting’ effect of the fossa ovalis (Figure 1A). We could thus perform puncture of the septum in total safety with the needle under low flow saline flushing (Figure 1B). A short injection of contrast was used for further confirmation. Right after this, we advanced the sheath-dilator assembly over the needle and then retracted needle and dilator once the sheath was far into the left atrium. A 4 mm cool tip ablation catheter (Navistar, Biosense Webster, Inc., Diamond Bar, CA, USA) was advanced through the sheath all the way into the left atrial cavity. Finally, via the second 8 Fr introducer, we performed the second puncture under RT 3D TEE guidance using the same technique described before. A circular mapping catheter (Lasso, Biosense Webster, Inc.) was inserted in the second TS sheath for sequential mapping of the pulmonary vein potentials. The ablation procedure was performed under continuous flush of the two TS sheaths. A 70 UI/kg heparin bolus was given after the first puncture, and during the whole procedure, activated clotting time was maintained between 250 and 350 min.

Real-time three-dimensional transeosophageal echocardiography
The multiplane TEE probe was inserted at the level of the midoesophagus. We started with a 0° degree rotation of the multiplane probe and adapted the level of the probe to obtain an ideal image of the fossa ovalis. Afterwards, we switched to the x-plane view permitting on the same screen, and during the same cardiac cycles, the visualization of two initially perpendicular planes visualizing the fossa ovalis. Small changes in the probe depth and angle correction were performed always with the same target to obtain an optimal fossa ovalis view. From that moment, the RT 3D button was pushed to obtain an RT 3D image of the fossa. For this procedure, we used live 3D image with a narrow segment and good temporal resolution. Gain settings were adapted so that enough gain was present (no anatomical detail of the fossa region was missed) but without too much gain since this leads to less 3D perspective. The final optimal RT 3D TEE image was obtained by slightly moving the scroll ball in order to obtain an optimal 3D perspective. Using an anatomical grid (the anatomical grid is a software incorporated in the Philips i33 3D system that can be activated by a touch on the left of the digital screen), semi-quantitative evaluation of the distances between the most important surrounding structures was possible in all patients. Tenting of the fossa by the needle was seen as a 3D cone shaping of the fossa when applying pressure. Successful puncture was seen as passing through of the needle with the appearance of microbubbles in the left atrium by the flush on the needle, while the fossa was still tented around the dilator. Using the anatomical grid, it was possible to exactly measure the distance from the needle tip to the posterior wall and to the aortic root. At the depth settings used in this protocol
to obtain the optimal visualization of both atria, the IAS, the aortic root just to the mitral and tricuspid annular plane, the distance between the lines of the grid equalled 5 or 10 mm, depending on which of the two gave clearer imaging of the anatomical structures. Although this was not the purpose of this first experience, we also checked the position of the ablation catheter in the different pulmonary veins.

Statistical analysis
Continuous variables are expressed as mean ± SD. Categorical variables are expressed as percentages.

Results

All 24 punctures were carried out successfully. All punctures required a single attempt to access the left atrium. Fluoroscopic time was 120.6 ± 34 s including coronary sinus and pigtail catheter positioning. The fossa ovalis’ average diameters were 13.1 ± 2.9 mm in TEE 0° projection and 18.9 ± 3.2 mm in TEE 90° projection. Mean needle hub orientation was 4.30 o’clock (ranging from 3.00 o’clock to 6.30 o’clock). Immediately after TS access, the angle (α) between the needle tip and fossa ovalis in the optimal RT 3D TEE projection considering the antero-superior portion of the septum as 0° (aortic root) and posterior part of the septum as 180° was 80.1° ± 19.2° (see Figure 2 and the diagram for explanation). Finally, using an anatomical grid in RT 3D TEE, it was possible to measure with precision the distance between the needle tip and the posterior wall and the aortic root (Figure 3). These measures were taken when maximal penetration of the needle was achieved (after initial TS puncture, the system was further advanced without retrieving the needle in order to facilitate dilator access in the left atrium). Average needle tip to aortic root distance was 13.5 ± 7 mm and mean distance from needle tip to posterior wall was 35 ± 7.3 mm. No major or minor complications related to the TS puncture were experienced in any patient.

Discussion

Nowadays, AF ablation is by far the most common ablation procedure performed in many electrophysiology laboratories worldwide. Pulmonary vein isolation, using different techniques, is a widely accepted strategy to cure AF. This procedure requires TS access. Most laboratories perform this procedure under fluoroscopic guidance using one or more adjunctive catheters as landmarks. Although currently TS puncture is relatively safe in experienced hands, potential life-threatening effects such as aortic or atrial perforation, cardiac tamponade, thrombotic formation, or air embolism cannot be completely ruled out. When occurring, complications are nearly all caused by incorrect puncture site. Moreover, patients with AF often exhibit subverted left atrial anatomy, with consequences on the usual fluoroscopic landmark positions that define the fossa ovalis localization. Recently, Rogers et al. described an incidence of 16 out of 255 patients with complex or...
abnormal cardiac anatomy in a population undergoing AF ablation. On the basis of these observations, the selection of exact puncture site is mandatory to avoid potential adverse effects particularly in a population which often presents cardiac anatomical alterations.

Real-time three-dimensional transeosophageal echocardiography offering detailed imaging of cardiac structures permits direct visualization of the IAS in a 3D perspective. In our experience, this structure could clearly be seen and easily be distinguished from the surrounding anatomical structures in all 24 patients. As mentioned before, each procedure required a single puncture attempt to gain left atrial access. According to our findings, mean orientation of the needle hub when puncturing was 4.30 o’clock. One patient exhibited uncommon position of the fossa ovalis (6.30 o’clock) documented by direct RT 3D TEE imaging. Puncturing with only fluoroscopic landmarks in this case would have been certainly more difficult. Interestingly, although the mean puncture angle (see Results for description) would suggest a fairly perpendicular puncture to the fossa ovalis’ surface (−80°), the distance from the needle tip to the aortic root (13.5 ± 7 mm) was significantly lower than the distance from the needle tip to the posterior wall (35 ± 7.3 mm). As mentioned before, this measure was taken when maximal penetration of the needle was achieved in the left atrium, suggesting the anteriorization of the TS access during the advancement of the system in the cavity to permit dilator entry. This finding might lead us to perform this manoeuvre more cautiously trying to avoid directing the needle too anteriorly.

Other techniques such as intracardiac echocardiography (ICE) and 2D TEE are the currently available imaging tools used to delineate cardiac anatomical structures during invasive procedures. Today, ICE is increasingly used to guide TS puncture. However this technique is relatively expensive and may require special expertise. Furthermore, one must also not underestimate the need of an adjunctive 10 Fr venous access to insert the ICE catheter. Currently, 2D TEE is also being used for TS puncture guidance. It was proved to be helpful in directly imaging the fossa ovalis especially in subverted cardiac anatomies. However, all these images are 2D. This leads to important difficulties to visualize precisely the correct puncture site and the distances from the needle tip to the posterior wall and the aortic root. Although tenting of the fossa will also be visible in 2D TEE or ICE, the precise location of the needle tip at the moment of the puncture is extremely difficult to find owing to the 2D limitation.

Moreover, fluoroscopic times in our study were relatively low considering that coronary sinus and pigtail catheter positioning times were included. With further experience, we will surely further lower X-ray exposure time and eliminate pigtail placement minimizing potential risks related to arterial catheterization.

Finally, RT 3D TEE, similar to ICE and 2D TEE, might also prove useful in guiding pulmonary vein isolation by offering important anatomical information, such as precise delineation of pulmonary vein ostia, avoidance of critical structures such as LAA during RF delivery, and direct visualization of optimal catheter tip–tissue contact which is crucial for the successful outcome of the procedure. Moreover, it could be very helpful in the early detection and management of procedure-related complications such as pericardial effusion, microbubble formation indicating tissue overheating, thrombus generation, or oesophageal injury.11,12

Conclusion
Our first experience demonstrates that TS puncture guided by RT 3D TEE is a fast, feasible, and safe procedure owing to direct visualization of the fossa ovalis. This novel imaging tool has the same advantages as ICE and 2D TEE with the added value of exhibiting 3D images. Furthermore, RT 3D TEE has proved to be extremely helpful in guiding TS access in case of abnormal localization of the IAS. Finally, further experience with this technique will lower fluoroscopic times.

Limitations
Our study has certain limitations. This is a first clinical experience on a restricted number of patients. Larger amounts of experience with TS punctures under RT 3D TEE guidance will be needed to assess more definite conclusions on safety and feasibility. Furthermore, an echocardiographer and anaesthesiology personnel are required owing to the fact that the procedure is performed under anaesthesia.

Conflict of interest: none declared.

References