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CASE SERIES
Cardiovascular imaging

Intracardiac echocardiography probe via oesophageal to guide percutaneous left atrial appendage closure procedure: a case series

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Background Left atrial appendage closure (LAAC) can be an alternative to oral anticoagulant therapy in patients with non-valvular atrial fibrillation, characterized by high risk of stroke (CHA2D2VASC ≥ two for men and CHA2D2VA2SC ≥ three for women) and high risk of bleeding (HASBLED = 3).

Case summary We describe three case reports in which an intracardiac echocardiography probe was used via the oesophageal route as an alternative to traditional transoesophageal echocardiography (TEE) or ICE methods to guide LAAC. Guiding the procedure via conventional TEE, even if feasible, could be difficult in these patients due to different causes: one patient was affected by Brugada syndrome while the other two patients reported oropharyngeal abnormalities. For these reasons, we performed an alternative use of the ICE probe to guide the entire LAAC procedure.

Discussion Currently, LAAC is performed using intracardiac or transoesophageal echocardiography. This alternative use of ICE probe via oesophageal (ICE-TEE) is reported in previous studies that describe the feasibility of this technique both in excluding the presence of thrombus in left atrial appendage before cardioversion and in guiding percutaneous foramen ovale closure. Therefore, the ICE probe has been used as an intraoperative transoesophageal echocardiographic probe to repair congenital heart disease in infants or children with oropharyngeal abnormalities.

This case series reports the first use of ICE-TEE to guide the entire LAAC procedure, guaranteeing the visualization of all echocardiographic views needed to perform it. The present case series highlights the potential of ICE-TEE to safely perform both preprocedural and intraoperative evaluations in LAAC procedure.

Keywords Left atrial appendage • Left atrial appendage closure • Trans-oesophageal • Echocardiography • Intracardiac echocardiography • Case series • Atrial fibrillation • Procedural imaging

ESC Curriculum 5.3 Atrial fibrillation • 7.4 Percutaneous cardiovascular post-procedure • 2.2 Echocardiography

Learning points

To report the use of ICE via oesophageal route as an alternative to traditional TEE or ICE methods to guide LAAC procedure.

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Introduction

Atrial fibrillation (AF) is the most common sustained cardiac arrhythmia in adults.[1] Moreover, the increasing life expectancy will lead to a further increase in prevalence. Patients with AF report an increased risk for thromboembolic complications and ischaemic stroke.[2] Different studies have demonstrated that over 90% of stroke-causing thrombus that come from the heart are localized in the left atrial appendage (LAA)[3]. For this reason, in 1996 LAA obliteration was first suggested as stroke prophylaxis in non-rheumatic AF.[4]

In 2001, the first left atrial appendage closure (LAAC) procedure was performed, implanting an occlusion system into the LAA. Since then, several studies have been conducted on LAAC in patients with non-valvular atrial fibrillation characterized by both a high risk of stroke and risk of bleeding. Results report that LAAC should be considered a valid alternative to oral anticoagulant (OAC) therapy in such patients demonstrating its non-inferiority.[5–7]

Currently, although general anaesthesia-facilitated TEE remains the gold standard imaging modality to guide LAAC, ICE appears to be a feasible alternative. Both techniques have similar outcomes and hospital charges.[8,9]

Instead, the use of the ICE probe via the oesophageal route (ICE-TEE) has not currently been used and validated to monitor LAAC procedure, although it is safe compared to standard TEE in excluding the presence of thrombus in LAA,[10] in guiding percutaneous foramen ovale (PFO) percutaneous closure[11] and in guiding the repair of congenital heart disease.[12,13]

Timeline

Case	Time Point	Event
1	2020	Diagnosis of AF start of treatment with OAC
	12 September 2021	Gastrointestinal bleeding
	12 September 2021	Blood transfusion
	13 September 2021	Ineffective gastric cauterization
	15 September 2021	LAAC (WATCHMAN device) was performed
	17 September 2021	Routinely transthoracic echocardiographic examination was performed
	20 September 2021	Discharged in stable condition
	16 October 2021	Follow-up at 1 month with TEE. No clinical and echocardiographic complications
2	April 2019	Diagnosis of AF start of treatment with Dabigatran 110 mg
	3 November 2021	intracranial haemorrhage
	28 November 2021	LAAC (WATCHMAN device) was performed
	4 December 2021	Routinely transthoracic echocardiographic and discharged in stable condition
	6 December 2021	Follow-up at 1 month with ICE-TEE. No clinical and echocardiographic complications
3	July 2017	Acute myocardial infarction and percutaneous coronary interventions in left anterior descending
	August 2019	Diagnosis of AF start of treatment with DOAC
	January 2022	Diagnosis of oesophageal cancer and the start of chemotherapy
	15 February 2022	Ischaemic stroke
	28 February 2022	LAAC (WATCHMAN device) was performed
	25 March 2022	Follow-up at 1 month with ICE-TEE. No clinical and echocardiographic complications

OAC, oral anticoagulant.

Patient 1

A 78-year-old woman with permanent AF, severe chronic kidney disease (CKD) [creatinine 2.5 mg/dL, (<1.2 mg/dL) creatinine clearance 15 mL/min (>85 mL/min and <125 mL/min)], hypertension and diabetes. No myocardial injury was reported [NT-ProBNP was 40 pg/mL and creatinine kinase-myoglobin binding (CK-MB) was 14 UI/L]. In September 2021 had gastrointestinal bleeding due to a gastric ulcer. During OAC therapy she was treated with a blood transfusion and ineffective endoscopic procedure. Her cardiovascular and respiratory examinations reported normal results. The patient was affected by Brugada syndrome (BrS). Due to both high stroke risk (CHA2DS2-VASc score of 5: hypertension, age > 75, diabetes mellitus, female) and high bleeding risk (HAS-BLED score of 5: hypertension, renal insufficiency, prior bleeding, age > 65), she was referred for percutaneous LAAC.

Our heart team, made up of anaesthesiologists and cardiologists, evaluated the option to perform a standard ICE-guided LAAC or TEE-guided LAAC with general anaesthesia administering propofol. The administration of propofol in patients who suffered from BrS is quite controversial. In fact, the BrugadaDrugs.org Advisory Board recommends avoiding propofol administration in these patients (recommendation is class IIa).[14] Nevertheless, some recent studies have shown that propofol in bolus is safe for anaesthesia induction in this class of patients.[15,16] Flamee *et al.* suggest that current recommendations to avoid the administration of propofol in this cohort of patients should be reconsidered.[16] Despite the recent evidence and conflicting data about administration of propofol in BrS patients, we have proposed ICE-TEE as an alternative to traditional TEE or ICE methods to guide LAAC in order to improve patient compliance and reduce the use of both general and local anaesthetic drugs in the patient. Then, we informed the patient of the three options, who then gave her consent to perform the procedure using this experimental technique. We carried out a brief pre-procedural TEE to check the LAA and choose the device size. Generally, we used to perform a pre-procedural TEE in patients referred for LAAC because computed tomography, which is the alternative used for pre-procedural workup, is not available in our hospital.

We used an ACUNAV probe, distributed by Johnson and Johnson, a phased-array system with a penetration power of 16 cm that provides an image section of 90°. The catheter can be steered in four directions (anterior, posterior, left, and right). The transducer frequency ranges from 5.5 to 10 MHz, and it consists of a 64-element phased-array transducer with Doppler capabilities. In the handpiece, there is a locking

system that allows the catheter tip to be fixed in a desired position. The ACUNAV catheter has an 8 F diameter (around 2.66 mm, compared to the TEE probe which has a diameter of 1.5 cm around). This system is compatible with GE and Siemens echocardiographic consoles, we have used a GE Vivid iq.

To perform procedural imaging, we descended the ACUNAV probe into the mid-oesophagus (about 30–35 cm) as a traditional TEE. Oesophageal intubation for ICE-TEE was successfully performed and well tolerated by the patient. The probe was introduced in the oesophagus without administration of any anaesthetic drugs. In fact, the patient tolerated the ICE probe during the entire procedure. The first echocardiographic view visualized was the 2-chamber (2C) apical view and the LAA. Once we visualized the view, we locked the catheter tip thanks to the locking system. Then, we visualized the interatrial septa (IAS) with a clockwise rotation of the control wheel. Furthermore, we used the anterior-posterior control wheel to obtain both bicaval and aortic short-axis views (*Figure 1A* and *B*). Thanks to these views, we were able to perfectly visualize the transseptal system position and tenting on the fossa ovalis, and thus to perform transseptal puncture as traditional TEE-guided LAAC. Subsequently, we performed a counterclockwise rotation, obtaining the LAA view (*Figure 1C*) that we used for the final device size selection (diameter, depth) and device deployment (*Figure 1D*). We found LAA measures correspondence between the TEE and ICE-TEE. A Watchman FLX device was successfully deployed at the ostium with no residual leaks. No periprocedural complications occurred, so the patient was discharged on dual antiplatelet therapy (DAPT) consisting of aspirin 100 mg once a day and clopidogrel 75 mg once a day for six months from the day of the procedure. The follow-up was performed at 45 days consisting of a cardiological exam and TEE: no bleeding or stroke events were reported and we ruled out device complications.

Patient 2

An 85-year-old man was admitted to our hospital with an intracranial haemorrhage during regular intake of DOAC therapy. He reported persistent AF, hypertension, and CKD [creatinine 1.2 mg/dL (<1.2 mg/dL), glomerular filtration rate (GFR) 50 mL/min (>85 mL/min and

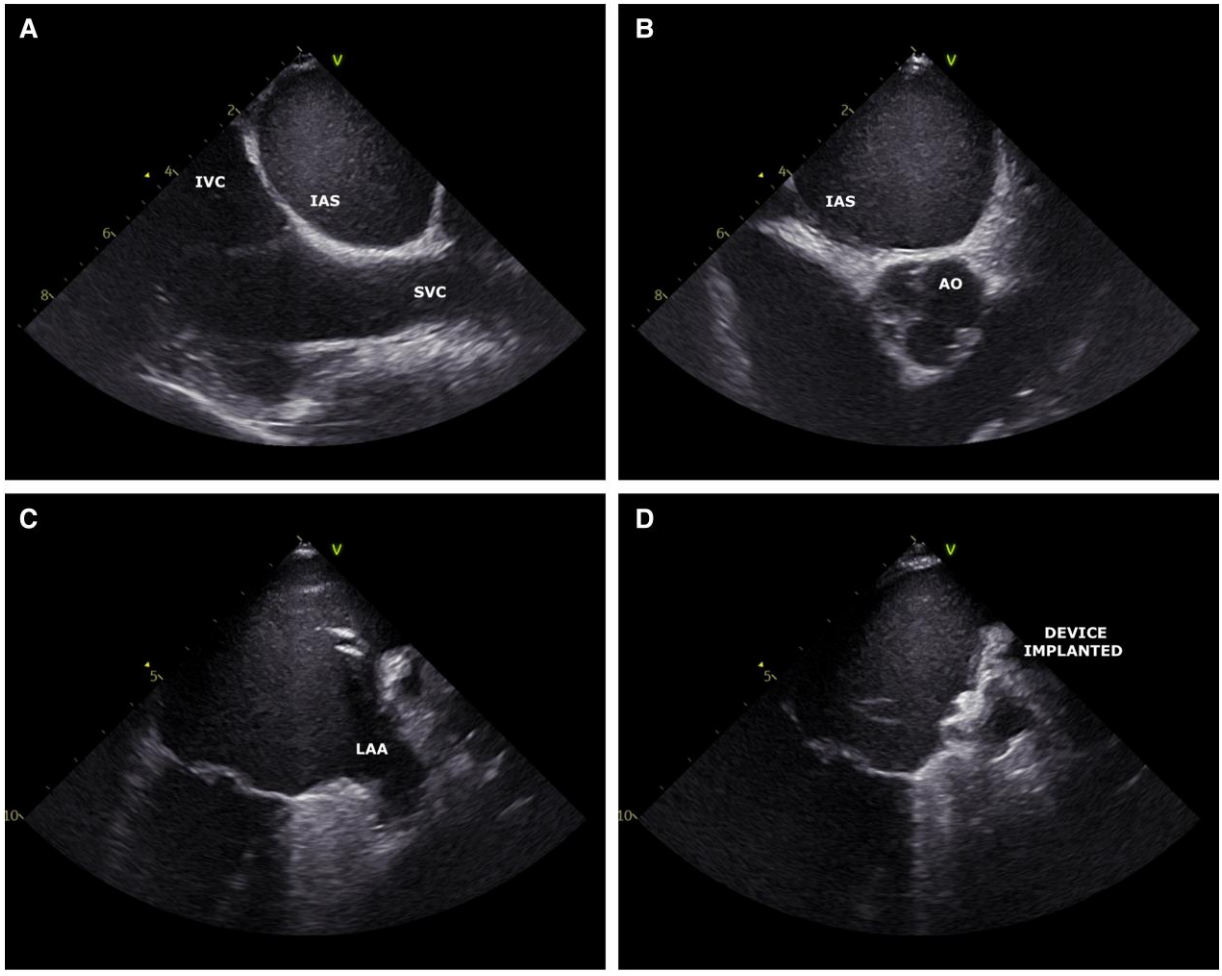

Figure 1 Echocardiographic images. (*A*) Bicaval view; (*B*) aortic short-axis planes. These are the two images used for the transseptal puncture, in these views, we can evaluate tenting and next transseptal passage. (*C*) LAA view that is used to choose device size selection (diameter and depth), initial device size is chosen to be at least 10% to 20% greater than the maximal diameter. The decision on device size is also based on fluoroscopic landmarks as we use TEE; also in this projection, you can see the pulmonary vein. (*D*) A WATCHMAN device successfully deployed at the ostium of LAA. IAS, interatrial septa; IVC, inferior vena cava; SVC, superior vena cava; Ao, aortic valve; LAA, left atrial appendage.

<125 mL/min)]. No myocardial injury was reported (NT-ProBNP was 66 pg/mL and CK-MB was 21 UI/L). His cardiovascular and respiratory examinations were normal. Due to the high stroke risk for this patient (CHA2DS2-VASc score of 5: congestive heart failure, hypertension, age > 75, vascular disease) and major bleeding risk (HAS-BLED score of 4: hypertension, prior bleeding, age > 65), he was referred for percutaneous LAAC. He suffered from known oesophageal narrowing caused by gastroesophageal reflux disease, so traditional TEE was not viable. We decided to propose a percutaneous LAAC using ICE-TEE. We acquired the patient's consent to perform this new technique. Even in this case, the probe was introduced into the oesophagus without the administration of any anaesthetic drugs and the patient tolerated the ICE probe during the entire procedure. Similar to Case 1, we performed the whole procedure by ICE-TEE properly visualizing all the views needed (*Figure 2*). The measures reported by ICE-TEE were comparable to those obtained by fluoroscopy (*Figure 3*). A Watchman FLX device was successfully deployed. No residual leak and no periprocedural complications were reported. The patient was discharged on DAPT (aspirin 100 mg once a day and clopidogrel 75 mg once a day) At 45-days after the procedure, a follow-up by ICE-TEE was performed, reporting no complications related to the procedure, neither bleeding nor stroke events.

Patient 3

An 82-year-old man was admitted to our hospital with an ischaemic stroke despite regular intake of direct oral anticoagulation (DOAC) therapy. He reported permanent AF, hypertension, chronic coronary syndrome with reduced ejection fraction (left ventricular ejection fraction 40%) but without acute heart failure (NT-ProBNP was 80 pg/mL), CKD [creatinine 1.4 mg/dL (<1.2 mg/dL), GFR 44.4 mL/min (>85 mL/min and <125 mL/min)]. Cardiovascular and respiratory examinations were normal in this patient. The CHA2DS2-VASc score was five points and the HAS-BLED score of 4. He was referred for percutaneous LAAC. He suffered from oesophageal cancer, so traditional TEE was not recommended. We decided to suggest this experimental technique as an alternative to the traditional ICE-guided LAAC. We obtained patient consent to perform the LAAC guided by ICE-TEE. As in previous cases, the probe was introduced into the oesophagus without administration of any anaesthetic drugs and the patient tolerated the ICE probe during the entire procedure. Therefore, the technique allowed us to obtain all the views needed to perform the entire procedure. Similar to CASE 2, we compared measures obtained by ICE-TEE to those reported by fluoroscopic views (*Figure 4*). A Watchman FLX device was successfully deployed at the LAA ostium with no residual leak.

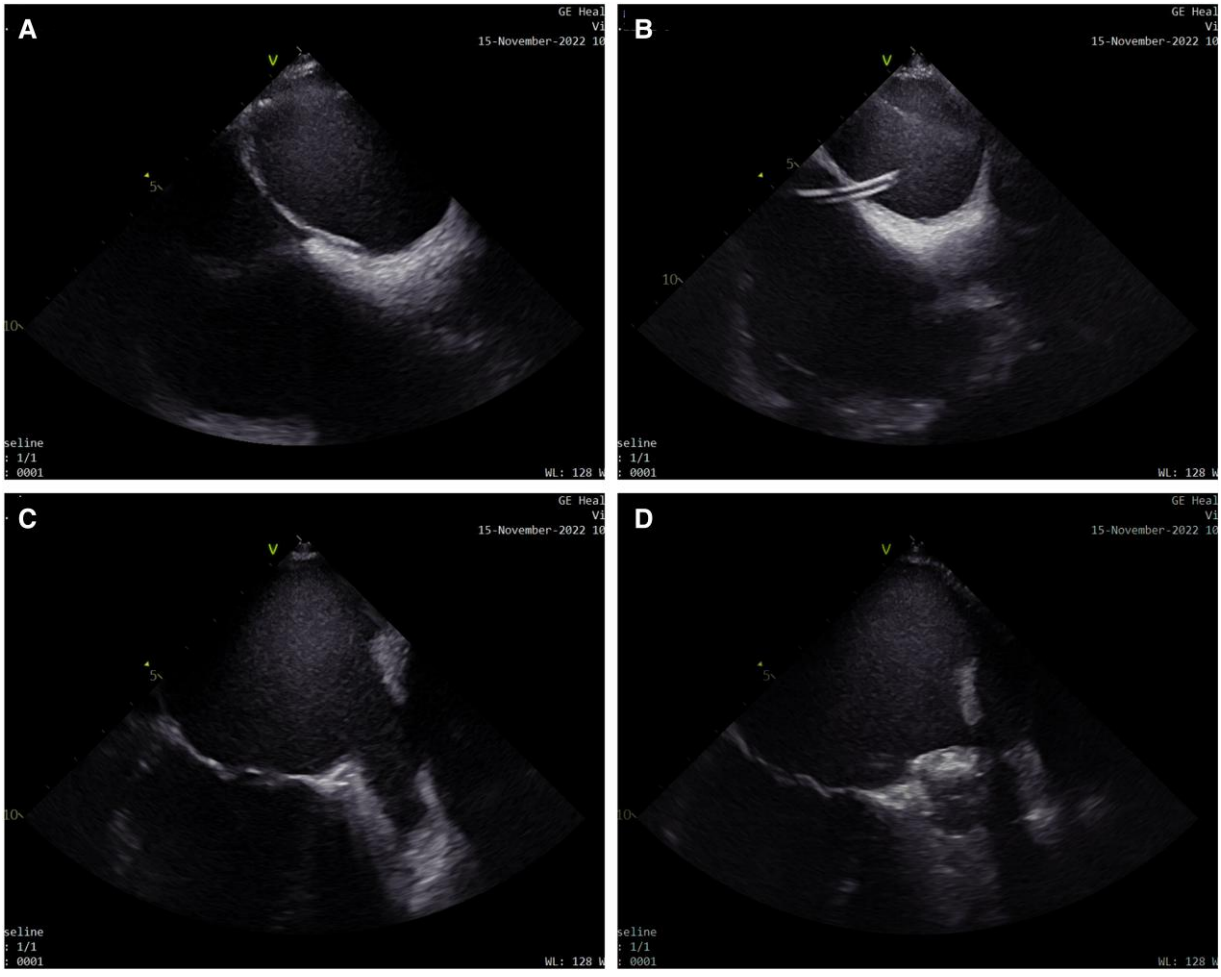

Figure 2 Echocardiographic images: (*A*) septal view, (*B*) transseptal passage view, (*C*) LAA view, and *D*) device successfully deployed.

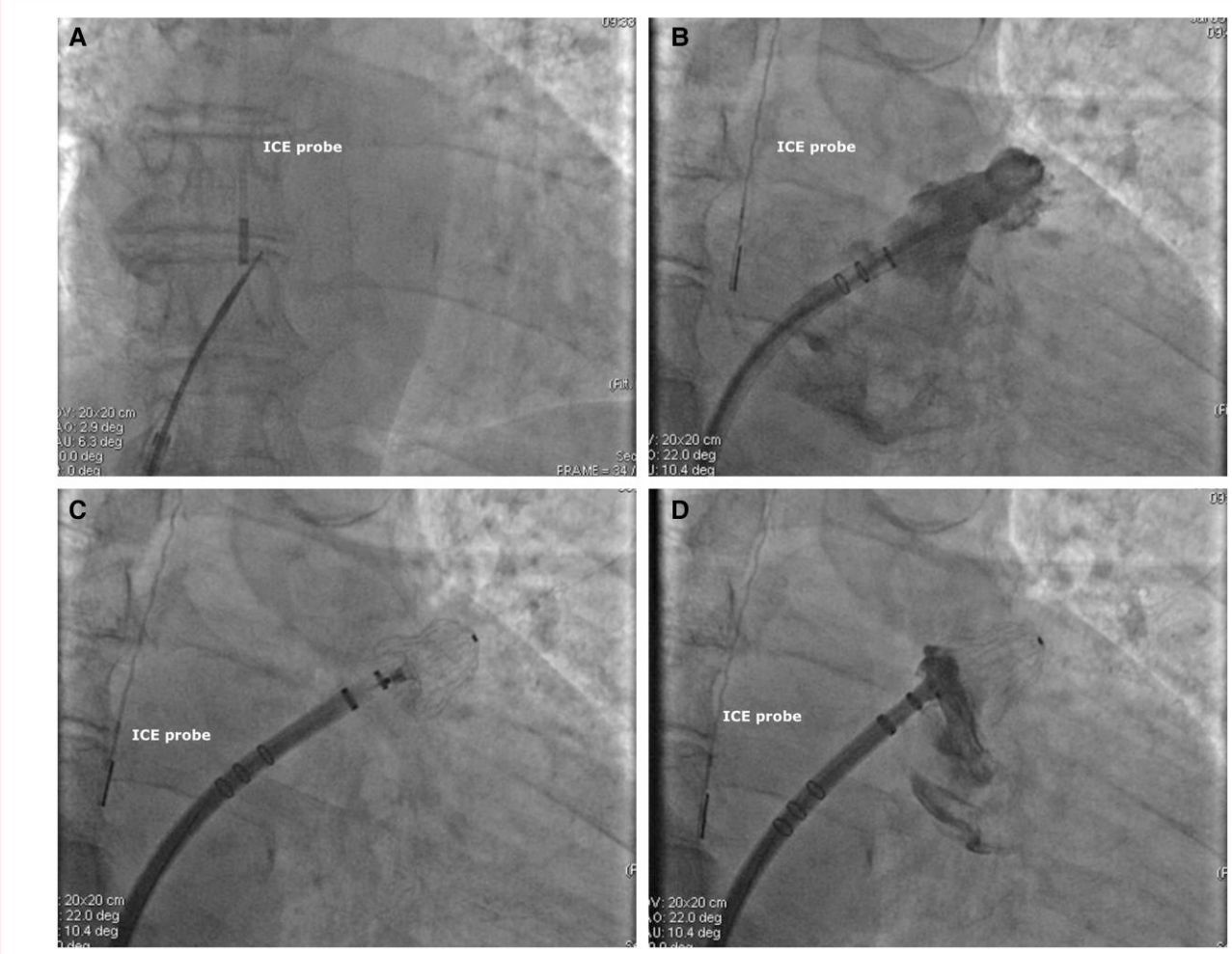

Figure 3 A fluoroscopic illustration of the intracardiac echocardiography catheter positions during left atrial appendage occlusion (*A*) transseptal puncture; (*B*) angiographic image to establish final LAA device size (*C*) device deployment; (*D*) check of the device with angiography.

No periprocedural complications occurred, and the patient was discharged on DAPT (aspirin 100 mg once a day and clopidogrel 75 mg once a day) the day after the procedure. In the 45-day follow-up by ICE-TEE, no clinical and device-related complications occurred.

Discussion

We report the first case series on ICE-TEE-guided LAAC.

In randomized clinical LAAC trials, intraprocedural TEE is mandatory to guide the LAAC procedure and the device release. More recently trials have demonstrated that ICE is also an efficient and safe modality for guiding LAAC.[17] So, currently LAAC device is placed at the appendage ostium by using a combination of fluoroscopy and either ICE or TEE under general anaesthesia.[18]

TEE-guided LAAC usually requires the administration of anaesthetic drugs to manage the discomfort of the probe during the procedure and to avoid patient movement. Patients indicated for LAAC procedure are usually elderly and they may have complications related to anaesthesia (such as preoperative pulmonary complications, and cognitive decline).[17]

ICE may result in inferior image quality compared with that of TEE, so recording key information during the pre-procedural TEE is often necessary to ensure the correct device sizing.[19] LAA imaging with the available ICE systems has proven challenging because of the variability in the shape and orientation of the LAA.[20] Therefore, an ICE catheter position in the left atrium, rather than in the right atrium, is often needed for clear and reproducible images.[20] Additional transseptal crossing causes more residual atrial septal defects compared to TEE (35% vs. 26%).[20]

It is already known that ICE-TEE allows a satisfactory analysis of the IAS structure and that it can be safely used to monitor PFO closure without requiring general sedation.[11] Moreover, in patients with AF, ICE-TEE compared with standard TEE can accurately identify the presence of LAA thrombi, when the LAA could be adequately imaged, with a sensitivity of 100% and a specificity of 97%.[10]

We have tried this technique in three patients considering its feasibility and safety, already reported by its use in children or infants with oropharyngeal abnormalities to guide the repair of congenital heart disease.[12,13]

In Patient 1 there was no absolute contraindication to general anaesthesia so if necessary it would have been possible to switch to classic TEE. However, ICE-TEE-guided procedure has guaranteed both good

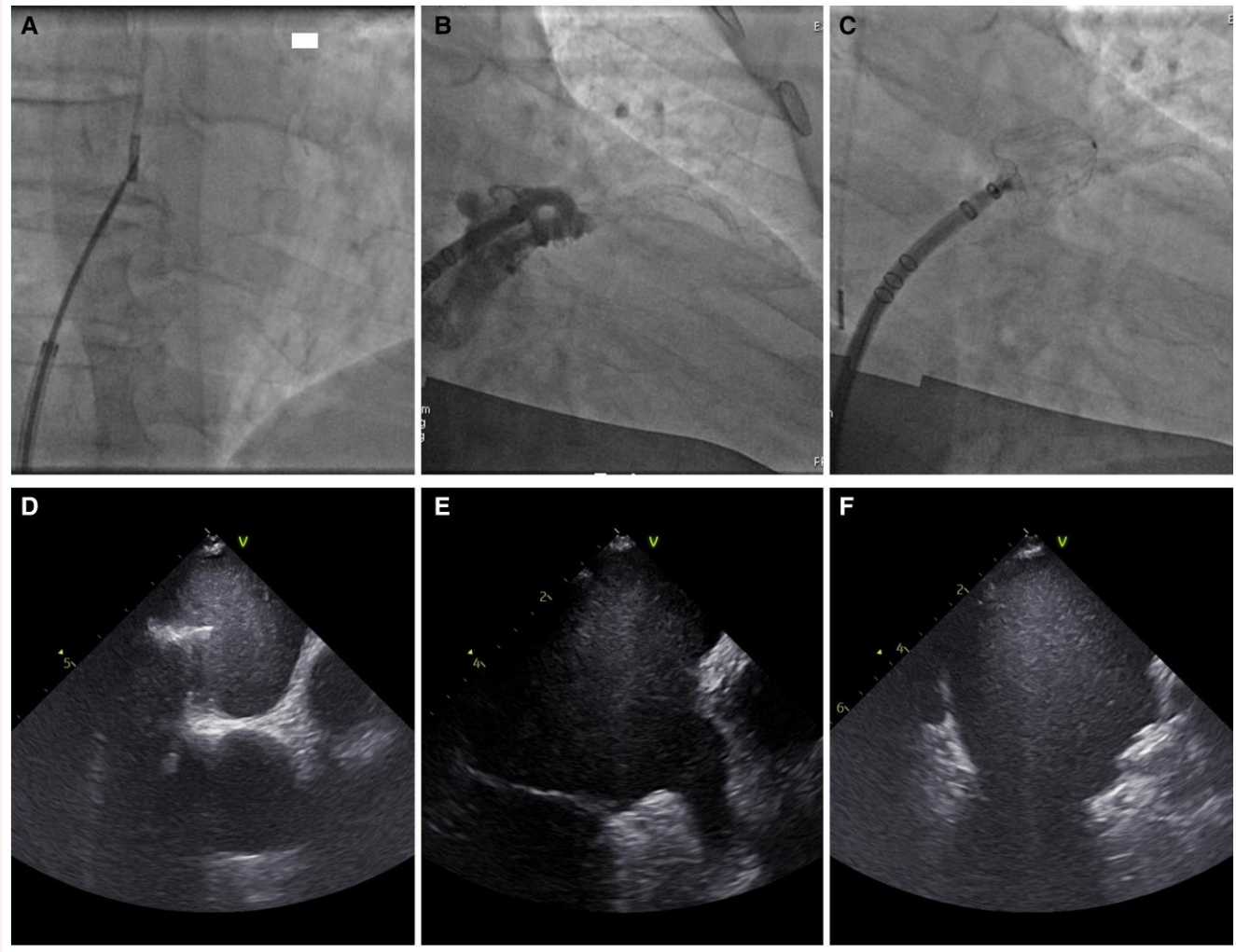

Figure 4 (*A–C*) A fluoroscopic illustration of the intracardiac echocardiography catheter positions during left atrial appendage closure; (*A*) transseptal puncture; (*B*) angiographic image to establish final LAA device size (*C*) device deployment; (*D–F*) ICE imaging of the LAAC procedure. (*D*) Transseptal puncture; (*E*) LAA view used to choose device size selection. (*F*) A WATCHMAN device was successfully deployed at the ostium of LAA.

images, and patient's compliance and it also avoided general anaesthesia. Moreover, we found correspondence between the LAA sizes obtained with pre-procedural TEE and intraprocedural ICE-TEE. The patient had no iatrogenic septal defects, peri-device leak, and device-related thrombus at the 45-day imaging.

In Patients 2 and 3, because of patient oesophageal narrowing, we decided to perform the LAAC procedure with this experimental technique with a good device deployment and without complications. No patients required conversion to TEE or abortion of the procedure due to imaging limitations.

In these cases, the ICE-TEE technique was demonstrated safe to guide LAAC intraoperative imaging. These results suggest that this method could be considered an alternative to traditional TEE or ICE guidance to perform the LAAC procedure. Significative benefits, such as avoiding general anaesthesia and obtaining quality images comparable to those obtained with TEE, were reported by the use of ICE-TEE. In fact, the thinner dimensions of the probe decrease patient discomfort during the procedure. Limitations associated with this technique could be the absence of standard views characterized by known transducer angles. Thus, ICE-TEE requires simple intuitive and small movements of the probe in the oesophagus. For this reason, this technique requires a short learning curve for cardiologists who are familiar with TEE.

Therefore, despite the ICE probe being more flexible, techniques for introducing and advancing it in mid-oesophagus are similar but easier than TEE with its thinner dimensions. In fact, the probe introduction is not influenced by the reflex spasm. Currently, the ICE probe can only be used once. Further developments could lead to the possibility to sterilize and re-use it in order to reduce procedural cost. However, some studies have demonstrated that the higher cost of the ICE probe may be balanced with the saving of expenses deriving from TEE complications, and total recovery time thanks to shorter post-anaesthesia recovery. Thanks to the comfort associated with and the easiness of this technique, the ICE-TEE guide could be extended to several interventional procedures, actually guided by TEE.

A registry on ICE-TEE-guided LAAC is ongoing to compare procedural outcomes with those obtained with traditional TEE. These results will be evaluated also at 45 days and 1 year follow-up performed with computed tomography or TEE.

Conclusion

This is the first report on ICE-TEE to guide LAAC. We would like to highlight the potential of this technique and further studies are now ongoing to demonstrate its feasibility. ICE-TEE-guided LAAC could represent an alternative intraoperative imaging method in LAAC procedure.

Lead author biography

Dr Giulia Laterra received her medical training at the Cardiovascular University of Messina. She then completed her training at Cardiocentro of Lugano (Switzerland) in cardiovascular imaging and than at Ospedale Umberto I of Syracuse (Italy) in inteventional cardiology. Her research interests include coronary heart disease and anticoagulation therapy, interventional cardiology.

Supplementary material

Supplementary material is available at European Heart Journal – Case Reports.

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Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The authors confirm that written consent for submission and publication of this case report including images and associated text has been obtained from the patient in line with committee on publication ethics guidance.

Conflict of interest: None declared.

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Data availability

The data underlying this article are available in the article and in its online supplementary material.

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