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ORIGINAL STUDIES

WILEY

Single trans-septal access technique for left atrial intracardiac echocardiography to guide left atrial appendage closure

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Abstract

Objective: This registry aimed to describe the safety and feasibility of a single trans-septal (TS) access technique for left intracardiac echocardiography (ICE) guidance of left-atrial appendage (LAA) closure procedure.

Background: LAA closure is currently accepted as an alternative to oral anticoagulation (OAC) in patients with non-valvular atrial fibrillation (NVAF) who are at high-risk for bleeding. Currently, LAA closure procedure is typically performed under trans-esophageal echocardiogram (TEE) guidance. Although, ICE has the advantage of not requiring profound sedation/anesthesia, ICE-LAA imaging quality is often limited from the right atrium requiring double TS access.

Methods: Twenty-two patients with NVAF underwent LAA closure using the Amplatzer Amulet™ device (St Jude Medical) under ICE guidance from the left atrium. The ICE AcuNav catheter (Biosense Webster) and the Amulet delivery sheath were advanced into the LA through single TS puncture technique.

Results: The population was predominately male (59.1%) with a mean age of 74 ± 9.3 years, at high-risk for stroke (mean CHADS2 score of 3.8 ± 1.1) and bleeding (mean HAS BLED score of 3.5 ± 1.3). The Amplatzer Amulet™ device was successfully implanted in all patients. No procedural related complications including device embolization were noted. No major cardiovascular events occurred and all patients were discharged alive. At 30-day follow-up all patients remained alive, free of ischemic stroke and with no residual leak or device thrombus on TEE.

Conclusions: This initial experience suggests that LAA occlusion with the Amplatzer Amulet device using ICE guidance from the left atrium via a single trans-septal technique is feasible and safe.

KEYWORDS
intracardiac echocardiogram, left-atrial appendage closure, trans-septal

1 | INTRODUCTION

Atrial fibrillation accounts for 15–20% of all ischemic strokes [1]. Most of these events are related to thromboembolic sources rising from the left-atrial appendage (LAA). The occlusion of the LAA has proven to be a non-inferior strategy to oral anticoagulation (OAC) in preventing ischemic stroke in patients with chronic non-valvular atrial fibrillation (NVAF) [2]. The use of this technology is currently indicated in patients with NVAF unable to receive OAC therapy due to formal contraindication for OAC or unacceptable risk for bleeding [3].

Although Transesophageal echocardiogram (TEE) is currently the standard procedural imaging tool used to guide LAA closure [4], its use

Abbreviations: CVA, cerebral vascular accident; ICE, intracardiac echocardiography; LAA, left atrial appendage; NVAF, non-valvular atrial fibrillation; OAC, oral anticoagulation; TEE, trans-esophageal echocardiogram; TS, trans-septal.

usually requires deep sedation or general anesthesia. Intracardiac echocardiography (ICE), is an accepted imaging method for atrial and ventricular septal defect closures and catheter ablation for various arrhythmias, and has the advantage of not requiring profound sedation/anesthesia [5,6]. The use of ICE from the right heart to guide LAA closure has been reported [7,8]. Nonetheless LAA images obtained with the ICE probe not placed in the left atrium are frequently suboptimal, leading to the need for a second trans-septal (TS) puncture [9]. This multicenter registry aimed to describe the feasibility and safety of a single TS access technique for left intracardiac echocardiography to guide LAA closure using the Amplatzer Amulet™ device.

2 | METHODS

2.1 | Patient population

In this initial study of a series of cases, we prospectively collected data from 22 consecutive patients in 4 referral centers in Chile, with NVAF at risk for stroke who underwent LAA closure using the Amplatzer Amulet™ device (St Jude Medical, Inc, St Paul, MN) under ICE guidance from the left atrium, from June to September 2016. All patients gave written informed consent for the procedure and data collection, as the study was conducted under approval of the Institutional Review Board at each institution.

2.2 | Preprocedural assessment

All patients underwent TEE examination within a week before the procedure to rule out the presence of thrombus in the LAA and to assess the LAA anatomy, including the ostium, landing zone diameters and length.

2.3 | LAA occlusion device

The Amplatzer Amulet device is the improved generation of the CPA Amplatzer LAA occlusion device and is composed of a distal lobe and a proximal disc connected by an articulating waist pre-loaded for streamline device preparation. The Amulet LAA occluder is available in 16, 18, 22, 25, 28, 31, and 34 mm landing zones diameters. It has a recessed pin on the disc to minimize the risk of thrombus formation and a longer waist for more flexible placement within the appendage. In addition, it has stabilizing wires around the lobe to improve stability and minimize embolization.

2.4 | Intracardiac echocardiography and single TS access technique

All procedures were performed under local anesthesia with fluoroscopy guidance and ICE monitoring using the 8-F AcuNav catheter (Biosense Webster, Inc., Diamond Bar, California) and a VIVID I console (GE Healthcare, GE, Fairfield, Connecticut). Transducer frequency can be modified from 5.5 to 10 MHz, as the color flow and spectral Doppler can be added. The catheter handle allows the catheter to be directed in 4 directions (anterior, posterior, left, and right). The ICE probe was positioned in the right atrium to guide TS puncture. After gaining TS access, a stiff Amplatz 0.035″ wire was positioned in the left-superior pulmonary vein. Following this, the selected sheath and dilator, based on preprocedural TEE, was used to dilate the interatrial septum by 3 times (Figure 1). Leaving the sheath/dilator back in the right atrium floor with the stiff wire in the left superior pulmonary vein, the ICE probe located in the right atrium was aligned under fluoroscopy in a AP view (Figure 2A) and 40° LAO view (Figure 2B) following the wire orientation. The ICE probe was then gently advanced into the LA through the dilated interatrial septum (Figure 2C and Video 1).

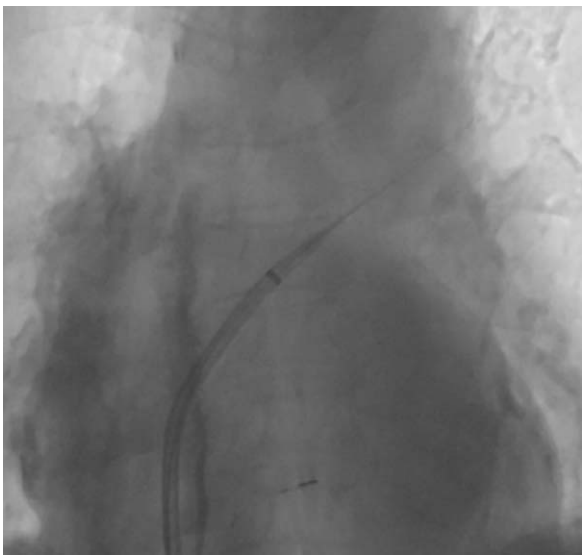

FIGURE 1 Interatrial septum dilation. Amplatz stiff wire located across the interatrial septum into the left-superior pulmonary vein. The 14F dilator of the Amulet device was advanced across the septum

ICE imaging was used to guide TS puncture, confirm the absence of LAA thrombus, identify the LAA dimensions (orifice, landing zone and length), verify the delivery sheath position, confirm the location and stability of the device before and after release and to monitor for procedural complications such as cardiac tamponade or device embolization.

2.5 | Procedure

Device size was chosen based on ICE and angiographic measurements and the manufacturer suggested size. Device size was recommended to be oversized approximately 2 to 3 mm in relation to the LAA landing zone dimension. Device positioning and deployment was performed under combined fluoroscopic and ICE guidance. The lobe of the device was placed inside the LAA until the chosen landing zone while the disc was positioned covering the LAA orifice to achieve sealing and exclusion of the appendage.

Appropriate implantation criteria included: (1) tire-shaped lobe into the landing zone; (2) separation between the device lobe and the disc; (3) concave shape of the disc; (4) axis of the device lobe aligned with the axis of the LAA neck; (5) two-thirds of the device lobe distal

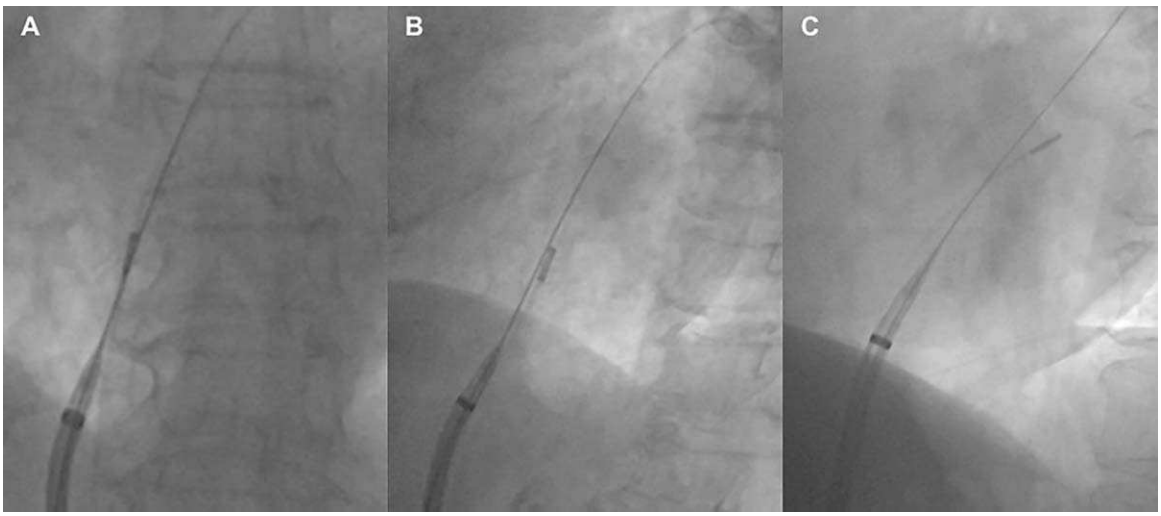

FIGURE 2 Intracardiac echocardiogram probe alignment and crossing of the interatrial septum. The device dilator was placed back in the right atrium floor with the stiff wire in the left superior pulmonary vein. The ICE probe located in the right atrium was aligned under fluoroscopy in a AP view (A) and 40° LAO view (B) following the wire orientation. The ICE probe was advanced into the LA through the dilated interatrial septum (C)

to the left circumflex artery as identified by echocardiography; and (6) effective LAA occlusion on angiography.

2.6 | Definitions

"The Munich consensus document" [10] *was used to define the patient and procedural results as follows. Successfully implanted device* was defined as a deployed and implanted device in correct position, meeting all criteria. *Technical success* was defined as exclusion of the LAA, achieved with no device-related complications and a residual leak less than 5 mm on color Doppler. *Procedural success* was defined as technical success obtained without procedural related complications.

Death was defined as all-cause mortality. *Myocardial infarction* (MI) was defined as the association of $\geq$1 clinical and $\geq$1 biological criteria: acute onset of chest pain and/or typical ischemic changes on electrocardiogram (ST or T wave changes or new left bundle branch block) and an elevation of troponin-I value above the 99th percentile of the upper reference limit [11] *Cerebral vascular accident* (CVA) was defined as any new major neurologic deficit present for more than 24 hr and associated with objective evidence of injury on brain CT or magnetic resonance. *Major bleeding and severe vascular complication* were defined by the BARC consensus [12]. *Severe pericardial effusion* was defined as a new pericardial effusion requiring surgical or percutaneous drain. *Acute renal failure* was defined as >25% increase in serum creatinine level within 72 hr after the index procedure. *Residual atrial septal defect* was defined as a new septal defect larger that 1.0 mm on color Doppler on TEE follow-up.

2.7 | 30-day follow-up transesophageal echocardiogram

All patients underwent a transesophageal echocardiogram 30 days after the LAA closure procedure. Images were collected and processed "off-line" by an expert in echocardiogram (MA) who was blinded to the clinical results. Data related to appropriate implantation criteria, residual leak and pericardial effusion was collected in a standardized manner.

2.8 | Statistical analysis

All data management and analyses were performed by a dedicated data-coordinating center. Continuous variables were expressed as mean ± standard deviation, either median or interquartile range, for non-normal distributed variables. Discrete variables were presented as absolute numbers and percentages.

3 | RESULTS

The baseline characteristics of the study population are displayed in Table 1. The mean age of the population was 74.3 ± 9.3 years, predominately male (59.1%), majority with a history of systemic hypertension (90.5%), with mean CHADS2 score of 3.8 ± 1.1 and mean HAS BLED score of 3.5 ± 1.3. Left atrial appendage closure was indicated due to severe bleeding on OAC (50%), high-risk for bleeding (36.3%), or stroke despite OAC (13.6%).

Anatomic characteristics of the LAA and procedural details are described in Table 2. LAA dimensions were consistent with assessments made by angiography and ICE, with a mean landing zone dimension of 21.5 ± 4.3 mm based on ICE and 22.0 ± 3.8 mm based on angiography. Consistently the mean implanted device size was 24.8 ± 4.5 mm. Adequate quality ICE images were obtained in all patients, including reliable left circumflex coronary artery in the short axis view, utilized as land mark for device positioning (Figure 3). The procedure had a mean duration of 88 ± 32 min and a mean fluoroscopy time of 14.6 ± 5.7 min. Successful procedure and device implant was achieved

TABLE 1 Baseline clinical patient characteristics

	(*n*= 22)
Clinical characteristics, *n* (%)	
Age, *years* ± *SD*	74.3 ± 9.3
Male	13 (59.1)
Diabetes	3 (13.6)
Hypertension	20 (90.9)
Hypercholesterolemia	5 (22.7)
Chronic renal insufficiency	3 (13.6)
History of prior MI	4 (18.2)
History of prior PCI	4 (18.2)
History of prior CABG	0
Congestive heart failure	4 (18.2)
Prior CVA/TIA	9 (40.9)
LV ejection fraction, *%* ± *SD*	54 ± 10
CHADS2 score, *score* ± *SD*	3.8 ± 1.1
HAS BLED score, *score* ± *SD*	3.5 ± 1.3
Laboratory characteristics	
Baseline creatinine, *mg/dL* ± *SD*	1.0 ± 0.3
Baseline hemoglobin g/dL ± *SD*	12.7 ± 2.5
Baseline hematocrit, % ± *SD*	39.1 ± 7.1
LAA Closure indication, *n* (%)	
Prior bleeding on OAC	11 (50.0)
Poor OAC compliance	4 (18.2)
Rurality	4 (18.2)
Stroke despite OAC	3 (13.6)

BMI, body mass index; CVA, cerebral vascular accident; CABG, coronary artery by-pass graft; LAA, left-atrial appendage; LV, left ventricle; MI, myocardial infarction; OAC, oral anticoagulant; PCI, percutaneous coronary intervention; SD, standard deviation; TIA, transient ischemic attack.

TABLE 2 LAA anatomy and Index procedural details

	n = 22
LAA characteristics, *n* (%)	
LAA orifice diameter by ICE	25.2 ± 5.1
LAA orifice diameter by Angiography	23.4 ± 3.9
LAA landing zone by ICE	21.5 ± 4.3
LAA landing zone by Angiogiography	22.0 ± 3.8
Index procedure characteristics, *n* (%)	
Heparin use	22 (100)
ICE guided TS puncture	22 (100)
Amulet size, mm ± *SD*	24.8 ± 4.5
Successful implant	22 (100)
Complete recapture	3 (13.6)
Device switch	1 (4.5)
Procedural complications (*n* = 22)	
Death	0
Ischemic CVA	0
Myocardial infarction	0
Severe pericardial effusion	0
Device embolization	0
Severe vascular complication/bleeding	0
Vascular complication- no severe	1

CVA, cerebral vascular accident; ICE, intracardiac echocardiogram; LAA, left-atrial appendage; TS, trans-septal; SD, standard deviation.

in all 22 cases, with complete recapture being required in 3 patients and device switch in one case.

In hospital and 30-day outcomes are presented in Table 3. No major complications occurred during the index procedure. No major predefined cardiovascular events were noted during the hospitalization. One patient, who had baseline renal dysfunction developed acute renal failure, not requiring acute dialysis. Most patients were discharged the day after the procedure following strict follow-up protocol in the cardiovascular unit. At 30-day follow-up, all patients remained alive and free of ischemic CVA or major bleeding. The absence of residual leak or device thrombus was confirmed by 30-day TEE in all subjects. In addition, no residual atrial septal defect was identified in 15 of the 22 studied subjects (68.2%), while residual atrial septal defect was identified in 7 of the 22 patients (31.8%) on 30-day TEE. All identified atrial septal defects were small, ranging from 1.3 mm to 3.0 mm, with no evidence of detrimental impact on right ventricular function.

4 | DISCUSSION

This initial experience proposes that LAA occlusion with the Amplatzer Amulet device using ICE guidance from the left atrium via a single TS technique is feasible and safe. As per our best knowledge this is the first report of a series of patient clinical outcomes using the described technique.

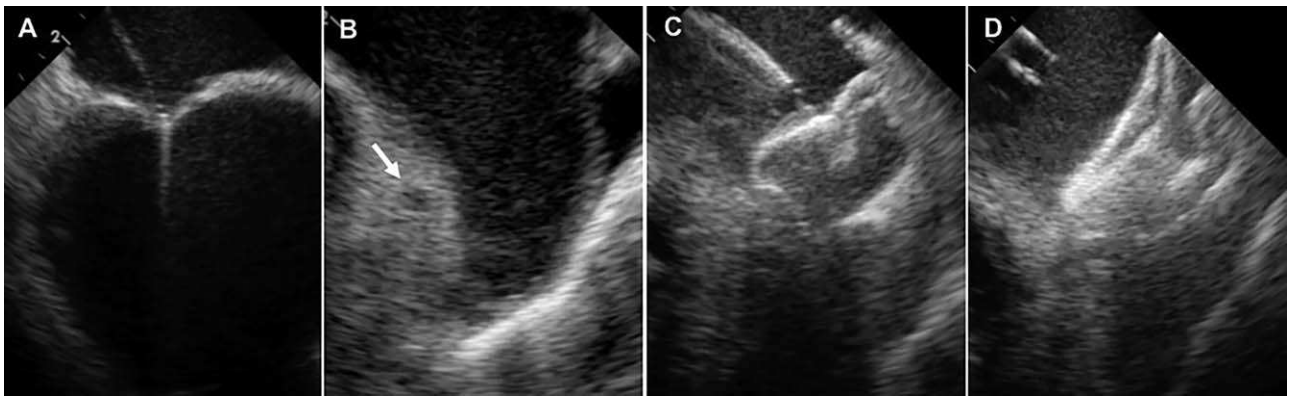

FIGURE 3 Intracardiac echocardiography images. Typical imaging obtained with intracardiac echocardiography to guide trans-septal puncture (A). Long axis view of the LAA with clear identification of the circumflex artery (arrow) (B). Partial deployment of the lobe into the landing zone (C) and complete release of the Amulet device (D)

TABLE 3 In-hospital and 30-days outcome

	(*n* = 22)
In Hospital outcomes, *n* (%)	
Death	0
Myocardial infarction	0
Ischemic CVA	0
Serious pericardial effusion	0
Acute renal failure	1 (4.5)
Length of hospitalization, *days*	1 [1–2]
30-days outcomes, *n (%)*	
Death,	0
Ischemic CVA, *n (%)*	0
Major bleeding	0
Residual flow on TEE	0
Thrombus on TEE	0
Residual ASD on TEE	7 (31.8%)

CVA, cerebral vascular accident; ICU, intensive care unit; RBC, red blood cell; TEE, trans-esophageal echocardiogram.

Prior experiences have demonstrated the utility of ICE guidance for LAA closure from the right atrium. In a series of 10 patients, ICE guided LAA occlusion was reported to be adequate with the ICE probe positioned in the coronary sinus [13]. Berti S. et al. reported the clinical results of 121 patients undergoing LAA closure with Amplatzer Cardiac Plug under ICE imaging obtained from the right atrium [7]. Of this series, 117 underwent successful LAA occlusion device implantation (96.7%), with a high correlation agreement of LAA dimensions assessed by angiography and ICE ($r = 0.94$). More recently, Matsuo Y. et al. reported a 100% success rate of LAA closure using the Watchman device with ICE guidance from the right atrium in 27 patients [8]. Although the authors claimed that satisfactory images can be obtained from the right atrium, it is our experience that these ICE images are typically inferior in terms of quality than those acquired with the ICE probe positioned in the LA, which may lead to misleading information critical for appropriate device sizing and implantation.

Thus, other authors have communicated the clinical results of ICE guidance for LAA closure from the LA. Masson JB. et al. reported the result of 37 patients undergoing LAA closure with ICE catheter probe in the LA via a second TS puncture, allowing to obtain excellent imaging of the LAA [9] However, our proposed technique allows left atrial positioning of the ICE probe by performing a single TS puncture to guide the LAA closure procedure using a simple and standardized approach. The fact that the LAA images are directly acquired from the LA allows for high quality images which facilitate accurate LAA dimensions, in contrast to the frequently suboptimal images when obtained from the right atrium. Our series reported a rate of residual iatrogenic atrial septal defect of 31.8%, which seems consistent with prior reports of left-side interventions with large catheters, usually small and not influencing patient prognosis [14] The preliminary results of our experience suggests that this technique is safe and reliable, based on the accumulative data obtained from the 4 centers contributing to the series.

5 | STUDY LIMITATIONS

The present study has several limitations. First, the sample size is small and there was no control group of patients where the procedure was performed under TEE guidance. Additionally, this was a non-randomized study. Our results may not be generalized to other LAA occlusion devices or different ICE catheters, and the procedures were performed only by experienced operators. Further study of this technique is needed in order to corroborate the proposed concept.

6 | CONCLUSION

This initial experience suggests that LAA occlusion with the Amplatzer Amulet device by using ICE guidance from the left atrium via a single trans-septal technique is feasible and safe. Left atrial ICE imaging obtained by this technique allows for a simple percutaneous LAA closure procedure, not requiring the support of anesthesiology and adding accurate determinations of LAA dimensions and procedural guidance.

CONFLICTS OF INTEREST

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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