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ORIGINAL PAPER

Contrast-free, echocardiography-guided left atrial appendage occlusion (LAAo): a propensity-matched comparison with conventional LAAo using the AMPLATZER™ Amulet™ device

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Abstract

Aims Percutaneous left atrial appendage occlusion (LAAo) is commonly performed under fluoroscopy including the use of contrast dye. In this study, we aimed to assess feasibility and safety of contrast-free, 3D-echo-based LAAo with the use of the AMPLATZER™ Amulet™ device.

Methods and results We analyzed 20 patients (74 ± 10 years, 65% males) at an increased thromboembolic and bleeding risk (CHA_2DS_2VASC 4.0 ± 1.3; HAS-BLED 3.5 ± 0.9) with chronic renal failure (GFR 41 ± 21 ml/min) undergoing LAAo without the use of contrast dye at our center and compared the results with a propensity-matched cohort (1:1 matching) of conventionally treated patients receiving contrast agent. Contrast-free LAAo was associated with less radiation exposure (13.1 ± 19.2 vs. 32.9 ± 21.2 Gy*cm^2, $p < 0.01$) and fluoroscopy time (5.0 ± 3.4 vs. 11.6 ± 4.9 min, $p < 0.01$). Procedural success rates were excellent in both groups (100%) without severe periprocedural complications (i.e. procedural death, stroke/systemic embolism, myocardial infarction, cardiac tamponade or major bleeding).

Conclusions Echocardiographically guided LAAo without the use of contrast dye appears safe and feasible. This approach appears to be associated with reduced radiation exposure and may represent an alternative to traditional LAAo, especially in patients in whom the avoidance of contrast dye is warranted.

Keywords Left atrial appendage occlusion · LAA · Contrast-dye · TEE

Abbreviations

BMI	Body mass index
CHA_2DS_2VASC	CHA_2DS_2VASC-score
CT	Computed tomography
*D*max/*D*min	Maximal/minimal diameter (of the LAA ostium)
DRT	Device-related thrombus
HAS-BLED	HAS-BLED-score
GFR	Glomerular filtration rate
LAA	Left atrial appendage
LAAo	Left atrial appendage occlusion
LVEF	Left ventricular ejection fraction
MAE	Major adverse event
TEE	Transesophageal echocardiography
VARC	Valve academic research consortium

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Background

Percutaneous occlusion of the left atrial appendage (LAAo) has been considered as an alternative to oral anticoagulation (OAC) for stroke prevention in patients with non-rheumatic atrial fibrillation (AF) and contraindications for OAC [1–3]. In the context of LAAo, the use of several imaging modalities has been suggested for the evaluation of landing zone indices and thus device-sizing. Cardiac MRI and cardiac computed tomography [4, 5] are restricted to the pre-procedural setting, whereas intracardiac and transesophageal

echocardiography (TEE) and fluoroscopy are applicable during the procedure [6]. Although 3D imaging has been found to be superior to 2D modalities with regard to device sizing and device selection [4, 7], a clear "gold-standard" remains to be defined. Among the available imaging techniques for LAAo, TEE provides several advantages with excellent guidance during transseptal puncture, reproducible sizing of LAA indices, as well as evaluation of procedural success and potential complications. Given the high incidence of renal dysfunction in patients undergoing LAAo, the deleterious effects of contrast-induced acute kidney injury [8] as well as fluoroscopy-associated radiation exposure for both patients and physicians, strategies aiming at a reduced pre- and periprocedural use of contrast-dye and radiation in the context of LAAo are warranted. In this study, we aimed at the following:

a) Determining the feasibility and safety of contrast-free, real-time 3D-TEE guided LAA occlusion in patients undergoing LAAo with the use of the AMPLATZER™ Amulet™ device and
b) Evaluating the clinical and echocardiographic outcome of these patients.

Methods

Study population

In this feasibility study, we prospectively evaluated unselected patients with non-valvular AF undergoing LAAo with the use of the AMPLATZER™ Amulet™ (Abbott, Chicago, IL, USA) device at the Heart Center Bonn between March 2015 and July 2017. The decision to perform contrast-free LAAo was based on the presence of reduced renal function or a high likelihood for contrast-induced kidney injury. Prior to LAAo, all patients were evaluated for the indication of LAAo in a local interdisciplinary team including interventional and non-interventional cardiologists as well as an electrophysiologist. Preprocedural work-up included laboratory testing, as well as routine TEE to rule out clinical or anatomic contraindications against LAAo, such as solid thrombi or endocarditis.

Patient demographics and clinical characteristics, including the CHA_2DS_2VASC-Score and the HAS-BLED-Score, as well as laboratory parameters, were assessed for each patient. All patients had to provide informed consent for participation to our local LAAo registry, which was approved by the local ethics committee of the University Hospital of Bonn /Germany. After inclusion of the contract-free cohort, results were compared with a conventional cohort using the Amulet™ device treated at another heart center (Marienhospital Bonn, Bonn, Germany). In order to allow comparison of procedural parameters, patients were matched in a 1:1 ratio by the means of propensity-score matching.

Procedural characteristics

In all contrast-free cases, the LAAo procedure was performed under conscious sedation using intravenous midazolam (intravenous bolus of 5 mg) and propofol adapted to the patient's bodyweight (bolus of 1 mg/kg followed by continuous infusion of 5–10 mg/kg/h). The AMPLATZER™ Amulet™ LAA occluder was implanted via transfemoral venous access using either a 12 or 14F sheath. Transseptal puncture and device implantation were guided by periprocedural transesophageal echocardiography. Fluoroscopic guidance was limited to crucial aspects of the procedure including transseptal puncture, secure positioning of the guidewire in the pulmonary veins, confirmation of adequate device deployment (device deformation) during tug tests. After deployment of the occluder device, device stability and position was additionally confirmed in echocardiography.

Study endpoints

Procedural performance and echocardiographic parameters, as well as the clinical outcome and echocardiographic follow-up data, were collected in a prospective fashion. Periprocedural events were classified according to the updated VARC criteria [9]. Device-related complications, technical and procedural success were defined according to the Munich consensus document [10]. Hereby, technical success was defined as definite implantation of an Amulet™ device in the left atrial appendage without device-related complications and without more than moderate peri-device leaks (> 5 mm) [11]. Procedural success was defined as technical success without the presence of procedure-related complications other than minor device-embolization [10].

Procedural safety was determined describing the incidence of major adverse events (MAEs), which included periprocedural death, stroke, systemic embolism and procedure or device-related complications needing major intervention.

Echocardiographic guidance

Intraprocedural transesophageal echocardiography was performed with a commercially available ultrasound system (Vivid E95, BT12, General Electric Medical Systems, Milwaukee, WI, USA or Philips IE 33, Philips Healthcare, Best, The Netherlands) using multiplane 3D TEE probes.

Evaluation of the LAA by two-dimensional TEE followed a standardized protocol. The maximum diameter at the landing zone (D1) was obtained in different planes from 0°, 45°,

60°, 90°, and 135° from a mid-esophageal view. The LAA ostium was measured from the origin of the left circumflex coronary artery to the roof of the LAA, 1 cm inward from the apex of the ridge separating LAA and left superior pulmonary vein [12]. Eccentricity of the LAA ostium was assessed to describe landing zone anatomy and was calculated in percent with help of the following formula: Eccentricity (%) = (Dmax − Dmin)/Dmax × 100 [13].

Real-time three-dimensional images of the LAA were obtained as complete volume data sets. Particular care was taken to record the complete LAA, allowing visualization of an en-face view of the landing zone within the LAA. When applicable, 3D images of the LAA were assessed using multiplanar reconstruction allowing optimal visualization of the LAA in multiple dimensions. With the help of a live multiplanar reconstruction feature (FlexiSlice), 2D planes were reconstructed from the 3D dataset to determine dimensions of the LAA ostium as well as LAA perimeter (P) and the area (A) at the location of the intended landing zone. Sizing of the closure device based on 3D imaging was hereby determined on the basis of the mean perimeter-derived diameter of the landing zone (D_P) using the following formula: D_P=P/π [13]. Selection of device size was based on this measurement incorporating an oversizing range of approximately 10 percent (Fig. 1).

After successful device deployment, 3D en face views were obtained to visualize the occluder device and to ascertain complete closure of the LAA. Furthermore, pulsed-wave (PW) and color-Doppler analyses were performed to evaluate for residual peri-device leak [14] and residual blood flow distal to the occluder. In order to provide an objective measure of device position, distances of the device-disc from both the edge of the LUPV and the LAA ostium at the level of the RCX were determined in a post-hoc analysis of intraprocedural data. Furthermore, the angle between the occluder disc and the LUPV was determined from TEE imaging in intercommisural views at 60–90°. The angle between the apex of the ridge separating LUPV and LAA and the disc plane was calculated using the cosine theorem: $b^2 = a^2 + c^2 - 2ac\cos(\beta)$. Setting the straight line from the apex of the LUPV-ridge to the base of the disc as "a", the straight line on orifice plane as "b" and the straight line on the disc plane as "c", the β angle was calculated by the conversion of the formula as follows: $\beta = \arccos\left(\frac{b^2-a^2-c^2 2}{-2bc}\right)$. In patients with ostial positioning of the device, β was set as 0. For the purpose of this study, device positioning was defined as either ostial or subostial, depending on the distance between the occluder disc and the left upper pulmonary vein (LUPV) ridge (Fig. 2a, b).

Echocardiographic follow-up

All patients were scheduled for routine TEE follow-up at 3 months after LAAo to assess the position of the closure device, to detect peri-device leaks, device-related thrombus (DRT) and persisting atrial septal defects. During follow-up, the LAA was systematically scanned in multiple views (0°, 45°, 90°, 135°) for peri-device leaks, also pulsed-wave (PW) Doppler distal to the occluder device. Observed leaks were classified according to the width of the color jet-flow as previously published: trivial leak (jet-flow < 1 mm), mild leak (jet-flow = 1–3 mm), or significant leak (jet-flow > 3 mm) [14]. Flow velocities more than 0.2 m/s distal to the occluder as determined by pulsed-wave Doppler as well as DRT were described as either present or absent. Residual atrial septal defects were evaluated using color Doppler analysis of the inter-atrial septum in at least two imaging planes (45–60°, 90–105°).

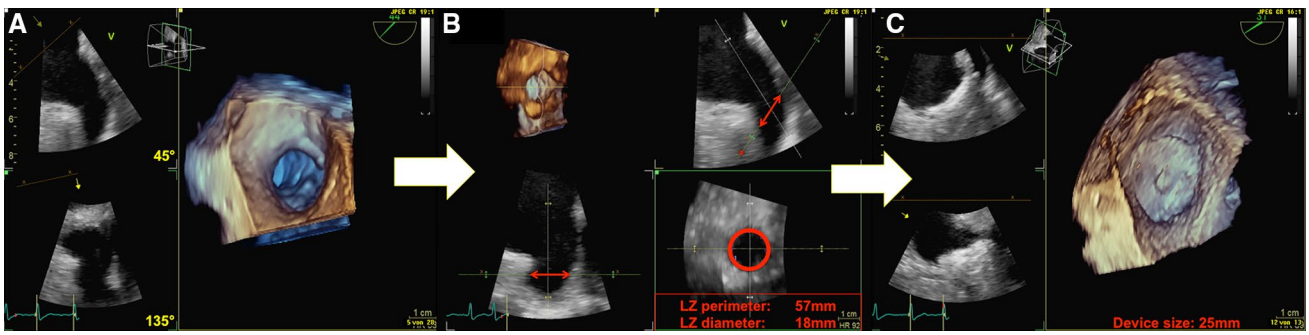

Fig. 1 Exemplary multiplanar (3D) TEE imaging of the left atrial appendage (LAA).After optimal biplanar visualization of the LAA (**a**), the desired landing zone is determined and measured for perimeter and maximal diameter (**b**). 3D reconstruction after successful LAAo shows satisfactory positioning of a 25-mm Amulet™ occluder device with occlusion of the LAA at the ostial level (**c**)

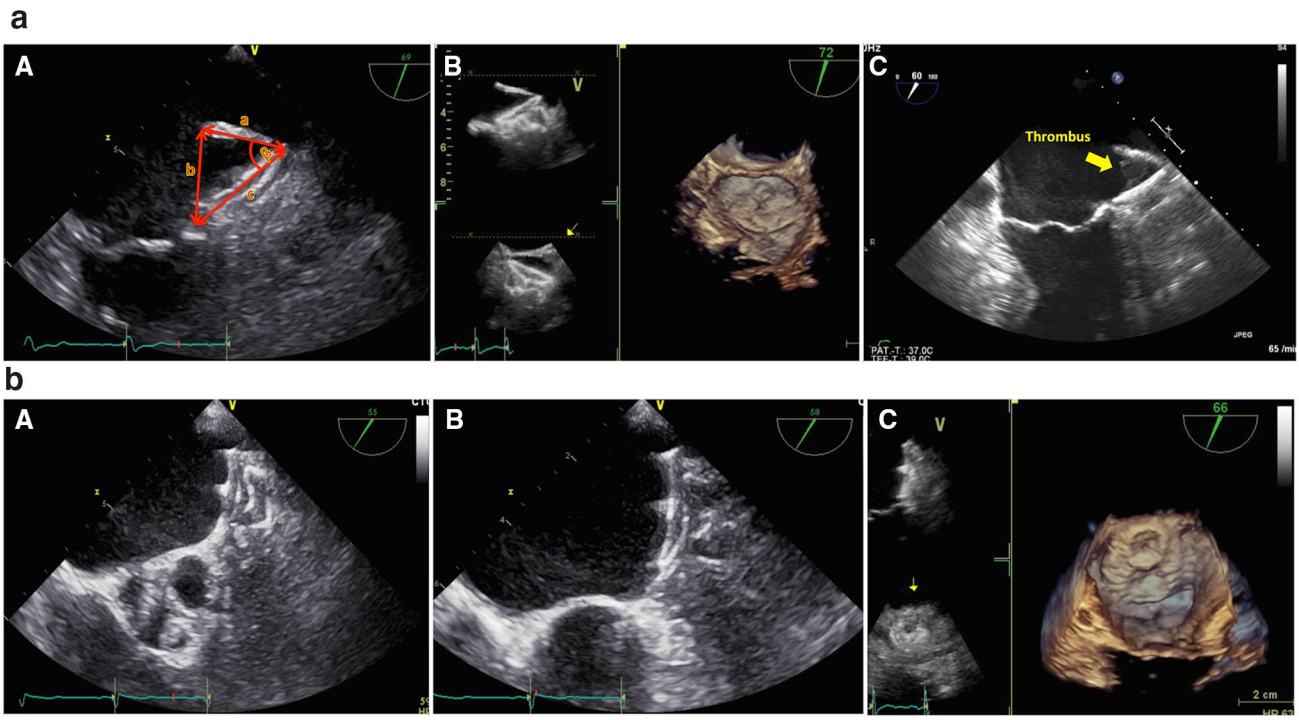

Fig. 2 Ostial (**a**) and sub-ostial (**b**) device position is depicted. Measurement of implantation depth from the LUPV ridge (**a**), the ostial level (**b**) as well as the angle between the occluder disc and the LUPV ridge (ß) are shown. Hereby the angle ß was calculated by the conversion of the cosine theorem: $\beta = \arccos\left(\frac{b^2-a^2-c^2 2}{-2bc}\right)$. In this case of suboptimal device positioning, a thrombus was seen in the "cule-de-sac" between LUPV ridge and occluder disc at a follow-up of 3 months

Statistical analysis

Continuous variables are presented as means ± standard deviation (SD) if normally distributed. Categorical variables are presented as frequencies and percentages. Propensity score matching (PSM) was performed with the use of a logistic regression model (nearest-neighbor selection) in a 1:1 ratio. Baseline covariates of clinical relevance were chosen for matching. For these variables (sex, age, BMI, CHA_2DS_2VASC, LVEF and device-size), PSM was performed without replacement and with a caliper of 0.2 of the standard deviation of the logit of the propensity score (The R project for statistical computing, Vienna, Austria). Comparison of both groups was performed using paired data analyses, i.e. McNemar test for categorical and a paired t test for continuous variables using SPSS version 22.0 (IBM Corporation, Somer, NY). Significance was assumed when the null hypothesis could be rejected at $p < 0.05$.

Results

A total of 20 patients at increased risk for contrast-induced acute kidney injury due to chronic renal failure undergoing LAAo between March 2015 and Juli 2017 underwent contrast-free LAAo. In brief, the patients were 74 ± 10 years of age, predominantly males (65%), with an increased thromboembolic as well as bleeding risk (CHA_2DS_2VASC score: 4.0 ± 1.3; HAS-BLED score: 3.5 ± 0.9). The majority of patients presented with permanent ($n = 6$, 30%) or persistent ($n = 9$, 45%) atrial fibrillation, and 25% ($n = 4$) had paroxysmal atrial fibrillation. The main indications for LAAo and contraindications against OAC were previous major bleeding ($n = 11$ [55%]) and severe chronic renal failure ($n = 5$ [25%]). Baseline serum creatinine concentration was 2.5 ± 2.0 mg/dl at mean with a mean GFR of 41 ± 21 ml/min, including four patients (20%) on chronic hemodialysis for end-stage renal failure. Propensity-score matching resulted in adequate matching for clinically relevant variables. Owing to the high incidence of renal disease, significant differences remained with regard to renal function. Baseline characteristics of both cohorts are summarized in Table 1.

Left atrial appendage occlusion (LAAo)

TEE-guided LAAo was successful in all patients, resulting in a complete sealing of the left atrial appendage (procedural success 100%) in both cohorts. The details of implant position of patients undergoing contrast-free LAAo are depicted in Table 2.

Table 1 Baseline characteristics

	Contrast-free LAAo *n* (%) or value (*n* = 20)	Fluoroscopy-guided LAAo *n* (%) or value (*n* = 20)	*p*-value
Age (years)	74 ± 11	75 ± 9	0.7
Male (%)	13 (65)	12 (60)	0.8
Body mass index (kg/m^2)	28.4 ± 5.2	27.8 ± 5.9	0.8
CHA_2DS_2VASC score	4.0 ± 1.3	3.8 ± 1.4	0.1
HAS-BLED score	3.5 ± 0.9	3.0 ± 1.0	0.6
Atrial fibrillation (%)			
Paroxysmal	5 (25)	4 (20)	0.3
Persistent	9 (45)	5 (25)	
Permanent	6 (30)	11 (55)	
Clinical features			
Coronary artery disease (%)	10 (50)	9 (45)	1.0
Previous Myocardial infarction (%)	5 (25)	5 (25)	0.6
Previous PCI (%)	7 (35)	6 (35)	0.6
Previous CABG (%)	2 (10)	0 (0)	0.2
LV ejection fraction (%)	55.1 ± 9.6	57.0 ± 6.9	0.6
Arterial hypertension (%)	20 (100)	19 (95)	0.2
Diabetes mellitus (%)	5 (25)	4 (20)	1
Creatinine (mg/dl)	2.5 ± 2.0	1.2 ± 0.5	0.01
GFR (ml/min)	41 ± 21	65 ± 24	0.01
INR	1.2 ± 0.4	1.2 ± 0.3	0.7
PTT (sec)	29 ± 6	28 ± 6	0.5

Table 2 Device-specific procedural data

	AMULET™ device *n* (%) or value (*n* = 20)
Device compression (mean, %)	12.2 ± 3.7
Device position (mm)	
Implantation depth from LUPV ridge (mm)	0.97 ± 0.6
Implantation depth from RCX ostium (mm)	0.04 ± 0.1
Angle between ridge and device disc	88.5° ± 15.4°
Ostial LAA coverage (Implantation depth from LUPV ridge < 1.0 cm)	13 (65)
Subostial LAA coverage (Implantation depth from LUPV ridge > 1.0 cm)	7 (35)

Overall, mean device-size was 23.0 ± 2.6 in contrast-free patients vs. 23.3 ± 3.7 in the conventional LAAo cohort ($p = 0.76$). Regarding anatomic properties, no significant difference in eccentricity of the landing zone was seen between the contrast-free and the fluoroscopy-guided group (14.7 ± 10.3% vs. 18.1 ± 5.4%, $p = 0.32$). Compared to the matched cohort, both procedural length (30.2 ± 10.0 vs. 82.8 ± 23.2 min, $p < 0.01$) and fluoroscopy time (5.0 ± 3.4 vs. 11.6 ± 4.9 min, $p < 0.01$) were significantly shorter in patients treated with the contrast-free approach. Accordingly, radiation dose determined as dose area product (DAP) was significantly lower in patients treated with mere echocardiographic-guidance (13.1 ± 19.2 vs. 32.9 ± 21.2 Gy*cm^2, $p < 0.01$). Recapturing and resizing of the initially selected device size as well as changes of delivery sheaths were not necessary in any patients. Also, no acute or late device dislocations occurred in our study. Ostial positioning of the occluder device position was achieved in a similar proportion of patients in both cohorts (65%) (Table 3). Of note, the mean amount of contrast used in the conventional LAAo cohort was 118 ± 31 ml.

Overall, procedural safety was excellent with no major adverse events (i.e. procedural death, stroke/systemic embolism, myocardial infarction or major bleeding). Vascular complications occurred in one patient in either cohort, both of which were treated conservatively. Additionally, in the contrast-free cohort, one patient exhibited clinically non-relevant pericardial effusion. This patient was discharged uneventfully after 5 days without the need for pericardiocentesis or clinical signs of pericarditis.

Table 3 Procedural data

	Contrast-free LAAo *n* (%) or value (*n* = 20)	Fluoroscopy-guided LAAo *n* (%) or value (*n* = 20)	*p*-value
Procedural success	20 (100)	20 (100)	1
Procedure time (min)	30.2 ± 10.1	82.8 ± 23.2	< 0.001
Contrast medium (ml)	–	118 ± 31	< 0.001
Fluoroscopy time (min)	5.0 ± 3.4	11.6 ± 4.9	< 0.001
Radiation dose (Gy*cm^2)	13.1 ± 19.2	32.9 ± 21.2	< 0.001
Device/delivery heath change	0 (0)	0 (0)	1
Hospital stay (mean, days)	5 ± 4	5 ± 1	0.9
Implantation details			
Device size (mm)	23.0 ± 2.6	23.3 ± 3.7	0.8
Eccentricity (%)	14.7 ± 10.3	18.1 ± 15.4	0.3
Ostial LAA coverage (Implantation depth from LUPV ridge < 1.0 cm)	13 (65)	13 (65)	1
Subostial LAA coverage (Implantation depth from LUPV ridge > 1.0 cm)	7 (35)	7 (35)	1
Periprocedural adverse events			
Stroke/TIA	0 (0)	0 (0)	1
Major bleeding	0 (0)	0 (0)	1
Pericardial effusion (clinically non-relevant)	1 (5)	0 (0)	0.3
Vascular complication	1 (5)	1 (5)	1

Clinical and echocardiographic follow-up

Follow-up TEE at 3 months (2.6 ± 0.6 months) was available in 17/20 (85%) patients. None of the patients exhibited device embolization or relevant peri-device leaks. Residual iatrogenic atrial septal defects were detected in 5 patients (20%). In two patients, minor peri-device leak was detected and one case of device-related thrombus (DRT) was seen. This patient was treated in the initial phase of this study and showed signs of suboptimal device implantation with a residual "cule-de-sac" between the LUPV ridge and the occluder disk as a potential origin for thrombus formation (Fig. 2bc). This case of early DRT occurred under on-going DAPT and was treated with a temporary course of DOAC (edoxaban) which led to thrombus resolution after three months. Treatment with DOAC in this patient was uneventful with regard to bleeding or embolic complications. Overall, after short-term clinical follow-up, none of the patients experienced relevant bleeding complications, stroke/TIA or systemic embolism. Short-term clinical and echocardiographic follow-up in the fluoroscopy-guided LAAo cohort was available in 95% (19/20). When compared to the conventional LAAo group, no significant differences concerning clinical or echocardiographic follow-up parameters were observed. (Tables 3, 4).

Table 4 Echocardiographic outcome at follow-up

	Contrast-free LAAo *n* (%); (*n* = 17)*	Fluoroscopy-guided LAAo *n* (%); (*n* = 19)*	*p*-value
Device-related thrombus	1 (5.9)	1 (5.2)	0.34
Device embolization	0 (0)	0 (0)	1
Peri-device leaks	2 (11.7)	1 (5.2)	0.33
Severe leaks	0 (0)	0 (0)	1
Major leak	0 (0)	0 (0)	1
Moderate leak	0 (0)	0 (0)	1
Minor leak	2 (11.7)	1 (5.2)	0.33
Residual atrial septal defect	5 (29.4)	5 (26.3)	0.25

*Follow-up was available in 85% (17/20) of patients in the contrast-free cohort and 95% (19/20) in the fluoroscopy-guided cohort respectively

Discussion

In the presented analysis contrast-free LAAo was safe and feasible with procedural success achieved in 100% of patients. None of the patients experienced acute major periprocedural adverse events and follow-up was uneventful. From an echocardiographic perspective, optimal occlusion of the LAAo was achieved in the majority of patients. However, especially in patients with

prominent LUPV ridges, desired sealing could not be always achieved. Whether the use of additional imaging modalities (i.e. fluoroscopy) would have been helpful in this context, or whether trans-septal puncture and/or LAA/LUPV anatomy are the main contributors in the context of device positioning, is beyond the scope of this analysis. Nonetheless, echocardiography-based sizing and implantation of the Amulet™ device proved to be a straightforward technique reflected by short procedural duration in our study. In fact, compared to a propensity-matched cohort of patients undergoing conventional LAAo at a high-volume center, contrast-free LAAo showed a similar proportion of optimally implanted occluders and compared favorably with regard to procedural length, fluoroscopy time and radiation exposure. However patients in the fluoroscopy-guided cohort were treated mostly in general anesthesia, which is likely to have at least partially accounted for this difference.

LAA occlusion without contrast-dye

The concept of LAA occlusion without the use of contrast injection has recently been described in a case report using fusion imaging [15] and is attractive for several reasons: First, patients undergoing LAA occlusion often present with severely reduced renal function as one important contraindication for long-term use of any oral anticoagulant. In fact, according to the results of the multicenter AMPLATZER Cardiac Plug registry, chronic renal failure comprises the indication for LAAo in approximately 15% of patients [14]. Especially in this subset of patients, which is at an increased risk for contrast-induced injury, omitting contrast-dye may be beneficial. Also, refraining from overt/unnecessary use of fluoroscopy will inevitably lead to a reduction in radiation exposure with potential benefits for both physicians and the patient [16].

The efficacy of a dedicated peri-procedural imaging protocol in LAAo was recently highlighted in a study by Jungen and colleagues. In their analysis, fusion-imaging integrating both echocardiography and fluoroscopy led to a significant reduction of radiation exposure in LAAo compared to conventional procedures [17]. It is, therefore, conceivable that the omission of angiography in a contrast-free procedure may even further reduce radiation exposure and the incidence of other potential complications, such as cerebral embolization [18, 19] or acute kidney injury. Nonetheless, the semi-invasive nature of TEE conveys a potential risk, which needs to be balanced against the benefits of this technique [20]. Despite its limited size, our analysis indicates safety and efficacy of a purely echocardiographic approach, especially when 3D echocardiography is used. Given the complex anatomy and broad variation of the left atrial appendage, it is likely that multidimensional imaging offers a advantage over two-dimensional modalities [4, 13]. However, owing to the lack of uniform echocardiographic criteria for optimal device position and due to the lack of clinical endpoints associated with incomplete closure [11, 21] or device-related thrombi [22] in the context of LAAo, defining a clear "gold-standard" for imaging and device-sizing remains difficult.

In summary, the results of this analysis indicate safety and feasibility of a contrast-free approach for LAAo. Still, it will be the role of future studies to assess and confirm the potential value of contrast-free echocardiography-guided LAAo with regard to both echocardiographic and clinical endpoints. Until then, the individual periprocedural imaging approach should incorporate clinical factors (e.g. real function), LAA anatomy as well as device specific characteristics (i.e. visibility on TEE) and local clinical expertise.

Conclusion

LAAo without the use of contrast-dye appears safe and feasible. In our limited clinical experience, contrast-free LAAo is associated with short procedural duration, low fluoroscopy time and minimal radiation exposure when compared to conventional LAAo. The contrast-free, echocardiography-guided approach may represent an alternative to traditional LAAo, especially in patients in whom the omission of contrast agent and radiation is desired.

Limitations

Obviously the small size and the non-randomized character of this feasibility study constitute major limitations. Also, LAA anatomy of patients undergoing LAAo in this study was rather simple, with only moderate eccentricity of the landing zone allowing reliable sizing via TEE. LAA morphology is traditionally based on fluoroscopy and/or CT. Given the contrast-free approach in the echo-guided cohort, the impact of LAA morphology on procedural characteristics could not be investigated in this study. Thus, to determine whether a contrast-free, and merely echo-guided procedure is an option for all patients, especially those with complex LAA anatomies, is beyond the scope of this analysis. In this analysis all patients underwent implantation of the same occluder device, i.e. the Amulet™. This device exhibits good visibility on transesophageal echocardiography, which is an essential prerequisite for TEE-based implantation. Thus, our results may not be transferred without restrictions to all LAAo procedures, particularly to those where other occluder devices are used or more complex anatomies are present.

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