



Case report

Emergent surgical retrieval of a left atrial appendage occluder migrated into the left ventricular outflow tract with secondary massive mitral regurgitation: A case report and literature review

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ABSTRACT

Thrombotic complications of atrial fibrillation continue to pose a significant challenge in clinical practice today. Left atrial appendage occlusion (LAO) has emerged as a promising alternative to oral anticoagulation for high-risk patients with atrial fibrillation. However, despite the potential benefits, there is still the possibility of life-threatening complications such as device dislocation. In this case study, we present a patient who experienced severe hemodynamic disturbances due to the embolization of LAO device into the left ventricular outflow tract, resulting in a torn mitral valve and secondary massive mitral regurgitation, just 3 hours after the procedure. As a result, emergent surgical intervention was required to remove the device and repair the mitral valve. We also conducted a review of previous studies on the retrieval of dislodged left atrial appendage occluders through surgical procedures. It is crucial to maintain vigilance, foster interdisciplinary collaboration, and respond promptly to ensure the safety and efficacy of LAO procedures.

1. Introduction

The aging population has witnessed a steady rise in the incidence of chronic atrial fibrillation, a condition that poses an escalating healthcare challenge. Individuals with atrial fibrillation lacking regular anticoagulant therapy or experiencing suboptimal anticoagulant effects are susceptible to cardiogenic stroke, which often leads to serious complications, affects the quality of life, and even pose a

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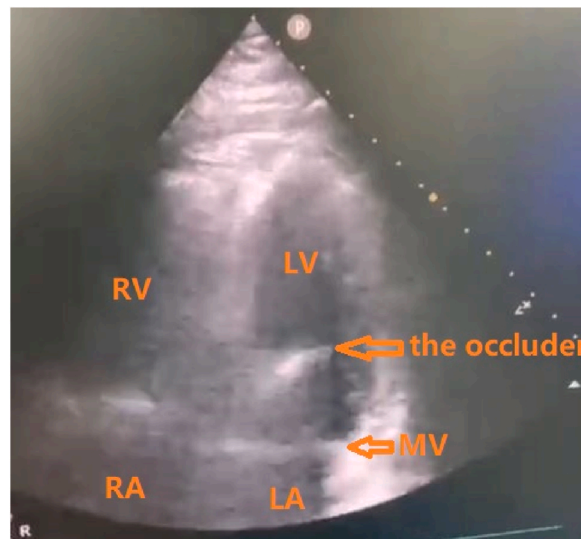


Fig. 1. TTE images showing the LAA occluder dislodged to below the MV.

TTE: transthoracic echocardiography; LAA: the left atrial appendage; RV: right ventricular; RA: right atrium; LV: left ventricular; LA: left atrium; MV: mitral valve.

threat to life. Previous research has indicated that approximately 90% of thrombi in patients with non-valvular atrial fibrillation originate from the left atrial appendage (LAA) [1]. Percutaneous left atrial appendage occlusion (LAAO) has emerged as an effective and convenient strategy to prevent LAA thrombi from entering the systemic circulation, thereby reducing the incidence of cardiogenic stroke [2]. Performing a thorough preoperative assessment of left atrial through computed tomography (CT) angiography to evaluate the anatomical structure of the LAA, along with intraoperative transesophageal echocardiogram (TEE) monitoring during LAAO, can effectively reduce surgical risks. However, there are occasional instances where the occluder may become dislodged after surgery, leading to potentially severe device embolism events with varying clinical manifestations [3].

Herein, we report a life-threatening emergency case of successful rescue in which an occluder device embolized into the left ventricular outflow tract (LVOT) 3 hours after implantation, resulting in the tearing of a mitral valve leaflet and the onset of massive mitral regurgitation. This unforeseen complication precipitated violent hemodynamic fluctuations and led to a state of severe shock in the patient. With the support of emergency cardiopulmonary bypass (CPB), the surgeons retrieved the migrated occluder, ligated the LAA, and repaired the torn mitral valve leaflet. In addition, we searched on PubMed about the previous literature on retrieval of dislodged left atrial appendage occluder using keywords “left atrial appendage occlusion” or “left atrial appendage occluder” with “dislodge” or “displace” or “embolization”, and made a brief review on the left atrial appendage occluder retrieval through surgical procedures.

2. Case/Case series presentation

2.1. Patient presentation and diagnostic findings

A 60-year-old male patient without history of cardiac surgeries has experienced exercise-induced dyspnea for the past 10 years, which would alleviate after rest. In early July 2023, the patient sought medical attention at Jiangsu Provincial Hospital of Traditional Chinese Medicine, where the electrocardiogram (ECG) indicated atrial fibrillation, and cardiac ultrasound examination showed left atrial enlargement (49 mm), right atrial enlargement (28 mm), mild mitral and tricuspid regurgitation, ventricular septal thickening (13 mm), and EF 66.9%. No signs of structural heart diseases were indicated. The patient chose to pursue further treatment at his hometown-the Hongze District People's Hospital. After admission, the patient started taking rivaroxaban 20 mg orally every day. On July 22, 2023, the LAAO procedure was implemented, which was uneventful. The device was advanced into the left atrium, and a pigtail catheter was inserted into the left atrial appendage. Left atrial appendage angiography was carried out with the working position at RAO 30° and CAU 20°, measuring the outer diameter of the LAA as 30 mm, the inner diameter as 27 mm, and the depth as 22 mm. Radiofrequency ablation and closure of the LAA (LAAO-I28 model [28–38 mm] from Shanghai Pushi Medical Instrument Co., Ltd.) were performed subsequently. After three-dimensional transesophageal echocardiography examination showing no significant shunt signals around the occluder, the procedure was successfully completed, and the patient was safely returned to the ward.

Three hours following the procedure, the patient experienced sudden chest tightness, palpitations, and dyspnea, along with transient amaurosis. Vital signs indicating blood pressure 82/57 mmHg, heart rate 110 beats/min, and SpO₂ 95% were observed. ECG showed sinus tachycardia and non-sustained ventricular tachycardia. Immediate bedside transthoracic echocardiography (TTE) exhibited that the occluder was trapped into the annulus of the mitral valve, limiting opening and closing of the mitral valve (TTE

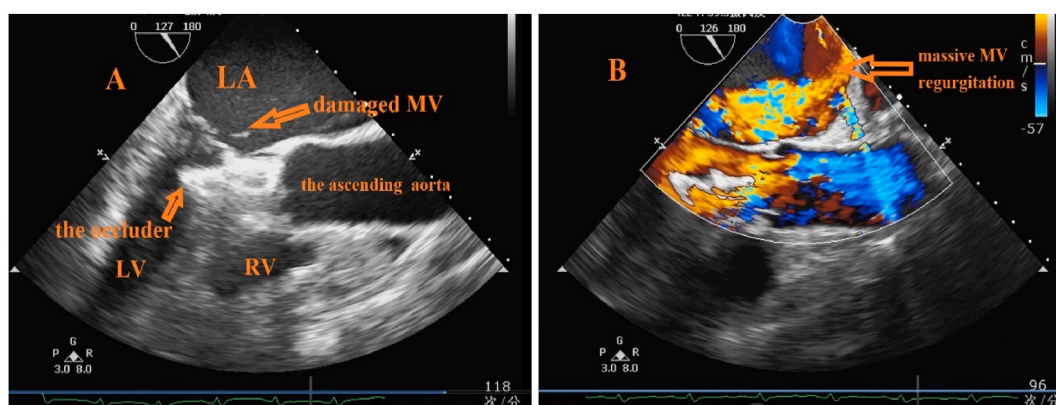


Fig. 2. TEE images of the dislodged occluder and secondary mitral regurgitation. The occluder entrapped into the LVOT and under the aortic valve is indicated by a smaller arrow, and the damaged MV leaflets and the torn chordae are indicated by a bigger arrow (A). Massive MV regurgitation is presented (B). TEE: transesophageal echocardiogram; LVOT: left ventricular outflow tract; MV: mitral valve; RV: right ventricular; LV: left ventricular; LA: left atrium.

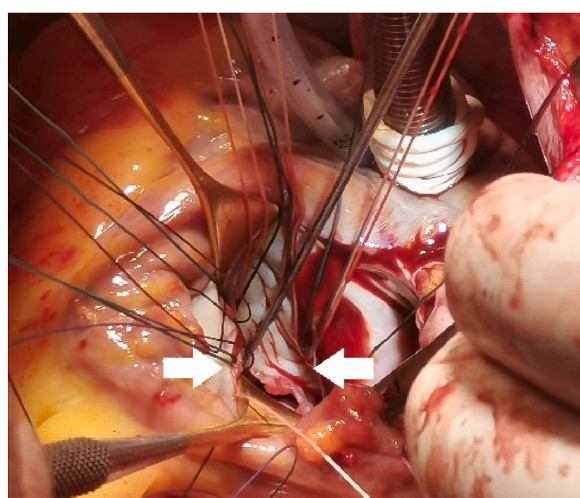


Fig. 3. The damaged mitral valve is indicated by white arrows.

imaging data were not retained). Then, the patient was transferred to our institution of Huai'an Hospital Affiliated to Yangzhou University urgently, during which he experienced vomiting. No inotropics were used during the transition process.

The patient was admitted to our hospital at 19:30 consciously but slightly irritable, and was sent to the hybridization operating room emergently, presented with a blood pressure of 80/50 mmHg, heart rate of 105 beats/min, respiration 25 times/min, SpO_2 95%, and symptoms of whole body clammy, sweating profusely, chest tightness, and shortness of breath. Bedside TTE confirmed that the occluder had dislodged below the mitral valve (Fig. 1). No clear enough image data was obtained due to the emergency condition). Prompt establishment of a basilic venous channel with a 14 G puncture needle was established for fluid infusion and phenylephrine intermittent injection. At the same time, right internal jugular venous catheterization with a three-lumen central venous catheter was carried out at 19:35. Intravenous infusion of epinephrine and norepinephrine was initiated then through the central venous line to maintain myocardial contractility and vascular tension. The left radial artery was simultaneously punctured for pressure measurement under ultrasound guidance. Blood gas analysis showed pH 7.31, lactate acid (Lac) 4 mmol/L, and BE -9 mmol/L. Intravenous sodium bicarbonate 5% of about 120 ml was given empirically.

General anesthesia was induced at 19:40, followed by endotracheal intubation and mechanical ventilation. The maintenance of general anesthesia involved the administration of propofol, remifentanyl, dexmedetomidine, and rocuronium bromide via intravenous infusion. A TEE transducer (X7-2T, Philips Ultrasound, Inc, Bothell, USA) was then inserted and revealed that the occluder had migrated into the LVOT and under the aortic valve, presenting with massive mitral valve regurgitation and damage to the mitral valve leaflets (Fig. 2 A, B).

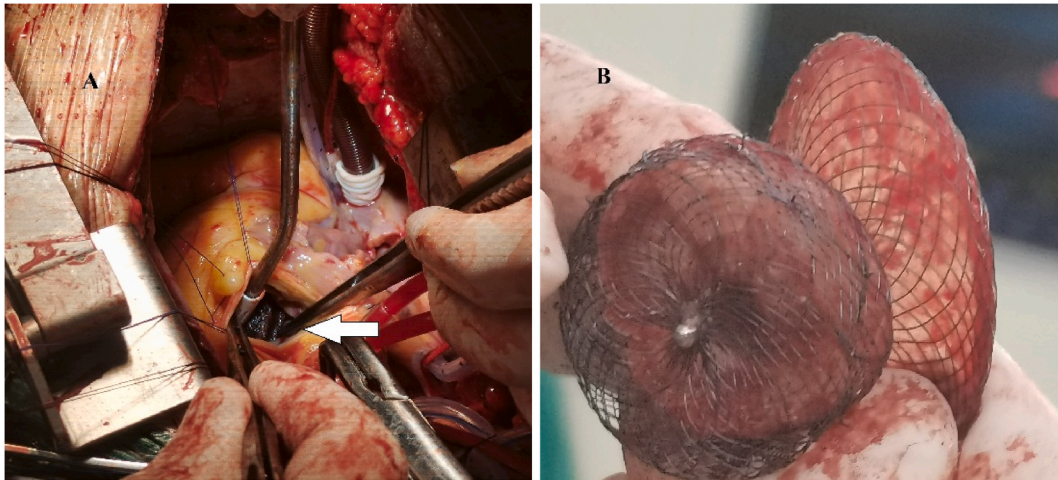


Fig. 4. Intraoperative image showing the embolized occluder being removed from the LVOT via the aortic valve indicated by the white arrow (A) and the retrieved occluder with intact anchoring bars (B). LVOT: left ventricular outflow tract.

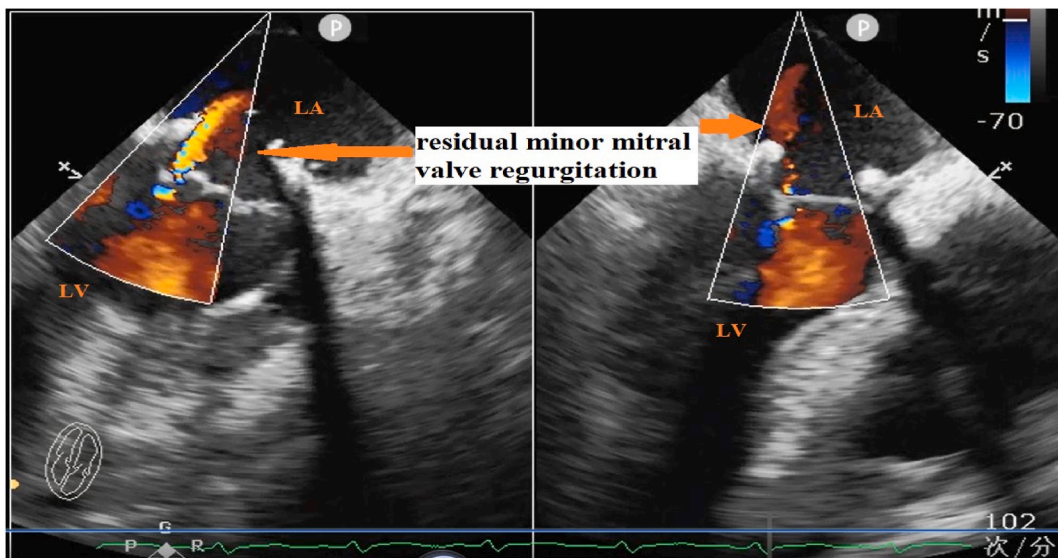


Fig. 5. The biplane images showing residual minor MV regurgitation after surgical MV repair. LV: left ventricular; LA: left atrium.

2.2. Treatment

After multidisciplinary quick consultation from the Departments of Heart and Great Vessels, Cardiology, Anesthesiology, and Critical Care Medicine, emergency surgery was deemed necessary.

The operation was started at 20:10 with constant TEE monitoring. During the systole period, the occluder partially obstructed the aortic valve orifice, leading to a nadir in invasive blood pressure (67/35 mmHg). Norepinephrine was given intermittently as needed. The fluctuations of invasive blood pressure at about 100/60 mmHg and heart rate at about 90 beats/min were maintained by adjusting the infusion doses of norepinephrine, epinephrine and nitroglycerin according to hemodynamic indicators and TEE monitoring. Blood gas and electrolyte analysis were detected intermittently. CPB was established at 20:31, accompanied by hypothermia (32 °C). The ascending aorta was cross-clamped, and the heart was arrested after antegrade cold blood cardioplegia infusion. Ice slush was used to provide topical cooling. Surgical exploration revealed that the occluder was located under the aortic valve in the LVOT, along with torn mitral valve leaflets and ruptured subvalvular chordae. Fig. 3 shows the damaged MV of intraoperative images. The occluder was carefully removed through an incision in the ascending aorta, followed by repair of the damaged mitral valve and ligation of the LAA. The surgery was successful. Fig. 4 (A, B) shows the course of the occluder retrieval through the aortic valve and the retrieved occluder with intact anchors.

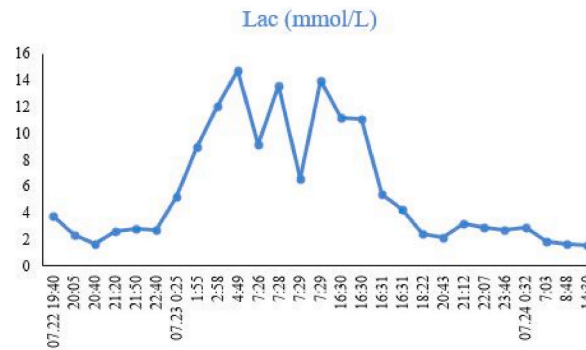


Fig. 6. The changes of Lac levels during the treatment procedure.

2.3. Outcome

After the return of circulation, the re-beating heart was evaluated by TEE, which indicated that the heart displayed good systolic and diastolic competence, the aortic valve and the tricuspid valve functioned well, and the mitral valve had residual minor regurgitation (Fig. 5). The patient was successfully weaned from CPB. Epinephrine $0.02\text{--}0.04\text{ }\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, norepinephrine $0.02\text{--}0.06\text{ }\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, and nitroglycerin $0.3\text{--}0.5\text{ }\mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ were administered to maintain cardiac function, hemodynamic stabilization, and coronary artery perfusion. The invasive blood pressure fluctuated between 110 and 120/60–70 mmHg, and the heart rate between 80 and 100 beats/min.

At 00:02 on July 23, the patient was transferred to the ICU and received appropriate supportive treatments, including myocardium nourishing, diuresis, anti-infection, and homeostasis maintenance. During the ICU retention, the Lac levels increased gradually, reaching a maximum of 14.7 mmol/L at 4:49 that night after transferring to ICU. The changes of Lac levels are presented in Fig. 6. The patient was extubated at 21:56 on July 23 and discharged uneventfully two weeks later. After being discharged, the patient consistently took warfarin and amiodarone. There was no adverse change in the cardiac ultrasound during the follow-up period.

3. Discussion

Atrial fibrillation is a common cardiac arrhythmia in the elderly and increases the risk of cardioembolic stroke significantly [4]. Currently, the primary treatment strategies for atrial fibrillation involve managing the ventricular rate and implementing long-term anticoagulation therapy. However, it is important to note that anticoagulant therapy carries the potential risk of bleeding, and there are certain patients who may be reluctant to undergo long-term anticoagulation or have contraindications for such treatment. Percutaneous LAAO has gradually emerged as a promising alternative method to anticoagulation for patients with non-valvular atrial fibrillation due to its minimal trauma, simple operation, less time consuming, high success rate of implantation, and effect on preventing thromboembolic events non-inferior to anticoagulant drugs [5].

However, percutaneous LAAO has the risks of related complications, such as pericardial effusion, pericardial tamponade, thrombosis, residual shunt, and occluder dislodgement, etc. [2] Among them, the occluder dislodgement and embolization stand out as severe and potentially life-threatening. In this case, chest tightness and dyspnea occurred suddenly 3 h after the LAAO operation, and emergent bedside TTE confirmed that the occluder had fallen off into the mitral annulus, resulting in severe hemodynamic fluctuations. The patient was urgently transported to our hospital taking about 40 min on the way. All anesthesia induction procedures were implemented successfully in the shortest time. TEE examination found that the device had migrated below the aortic valve leaflet, causing left ventricular outflow tract obstruction. Meanwhile, with the ruptured MV and massive regurgitation, surgery was indispensable. Fortunately, the occluder did not completely block the mitral valve orifice or the aortic valve orifice during the migration process.

Previous studies have reported that the incidence of embolism caused by LAA occluder dislodgement was about <4% [6]. The occluder can be displaced from the LAA to the left atrium, left ventricle, or aorta, which may be related to improper selection of the occluder type, too large LAA, unstable pre-installation of the occluder, shallow landing area, severe traction test, and active or passive movement before complete endothelialization [7]. In addition, changes in cardiac rhythm may also be an underlying cause of displacement [8]. Paroxysmal atrial fibrillation, sinus arrhythmia, and the irregular contraction of the atrium occurring during the operation may cause the displacement of the device. In the published case reports of LAA occluder displacement, most of the patients were over 60 years old, and most of them were male. Sex differences in postoperative outcomes were explored in an observational study of 49,357 patients who underwent LAAO using the Watchman device [9]. The study showed no significant difference between men and women in the incidence of device migration, transcatheter or surgical removal of embolic devices.

A case report and systematic review concluded that occluder embolization occurred mainly during the perioperative period [3], although cases occurring one month or more post-surgery have been documented [10]. The clinical manifestations after the occluder dislodgement are related to the displaced position and the degree of obstruction in the blood flow channel, with severe cases that may even lead to sudden death. Displacement of the occluder with nonspecific symptoms or remaining clinically silent is challenging for

Table 1

Previous case reports on LAA occluder retrieval through surgical procedures.

	Year	Age (years)	Gender	Device type	Migrated location	Detection Time	Symptom and examination	Impairment of MV	Surgical method	Prognosis
Nunes A [13]	2021	68	male	Amplatzer Amulet, 34 mm	LVOT	1 day post-procedure	asymptomatic; routine chest X-ray and TTE	no	urgent surgical device removal (no detailed description); and appendage amputation	procedure was uneventful
Martinez-Lopez D [14]	2021	76	male	LAmbre	trapped inside the subvalvular apparatus of the mitral anterior leaflet	4 days post-procedure	cardiogenic shock and acute pulmonary oedema; TTE and TEE	laceration of a chordae and damage to the anterior leaflet	emergency surgery of device removal (no detailed description); MV replacement; and LAA suture	acute kidney injury; discharged on postoperative day 17
Moradi N [15]	2020	83	male	Watchman, 27 mm	slightly migrated into the LA	2 months post-procedure	intermittent expressive aphasia; TEE	no	urgent surgical device retrieval (no detailed description); and LAA ligation	no further complications or neurological sequelae
Sun X [16]	2020	67	male	Watchman, 32 mm	MV	after the procedure	mitral regurgitation and hemodynamic instability; TEE	severe damage to the leaflets	emergency surgical device retrieval (no detailed description); MV replacement; and LAA ligation	discharged on postoperative day 10
Yilmaz A [17]	2019	84	male	Amplatzer Amulet, 25 mm	LVOT	after the procedure	severe mitral regurgitation; TEE	chordae tendineae ruptured and papillary muscles torn	thoracoscopic retrieval of the device; MV replacement; and LAA ligation	transferred to a revalidation centre on postoperative day 45
El-Gabry M [18]	2018	82	male	Watchman, 21mm	LAA	during implantation	LAA perforation, pericardial effusion, and unstable haemodynamics	no	emergency surgical device retrieval via left atriotomy; LAA suture	low-cardiac output syndrome; multiorgan failure and death
		85	male	Watchman, 30 mm	LVOT	3 months post-procedure	Dyspnoea; echocardiography	no	device removal via aortotomy; LAA suture	uneventful
		76	male	Watchman, 24 mm	LVOT	1 year post-procedure	dyspnoea and pneumonia; echocardiography	the device was fused into the anterior mitral leaflet	MV repair; aortic valve replacement; and LAA closure	discharged 3 weeks later
Pisani P [19]	2014	70	female	Amplatzer™ Cardiac Plug	LVOT	6 months after the procedure	asymptomatic and hemodynamically stable; TTE	no	urgent open-heart surgical removal of the device (no detailed description); LAA suture	discharged in good condition
Gupta P [20]	2013	73	male	Amplatzer Cardiac Plug	LVOT	later at the procedure evening	no symptoms described; TTE	no	retrieve the device surgically; and LAA resection	discharged on postoperative day 20
González-Santos JM [8]	2013	77	female	Amplatzer Amulet, 25 mm	MV	at the end of the procedure	severe mitral regurgitation; TEE	diffuse ecchymotic lesions in both MV leaflets	remove the device surgically; and LAA suture	discharged on postoperative day 12
Stöllberger C [21]	2007	78	male	Watchman, 30 mm	LVOT and between the cusps of the AV	several min after implantation	no symptoms described; TEE	no	failure to retrieve the device by catheter-techniques; device removed from the AV emergently; AV replacement; and LAA ligation	heart failure

MV: mitral valve; LVOT: left ventricular outflow tract; TTE: transthoracic echocardiography; TEE: transesophageal echocardiogram; LA: left atrium; LAA: left atrial appendage; AV: aortic valve.

diagnosis and is generally found during postoperative follow-up ultrasonography, so it is impossible to accurately determine the specific time of embolization. Mansour MJ et al. [3] reported that a patient complained of ischemic stroke and unexplained foot pain 1.5 years after LAAO, whose CT examination of the chest and abdomen indicated that the LAA occluder device was embolized in the abdominal aorta. In most cases, embolization is asymptomatic. Patient education with short-term and long-term regular follow-up is critical, as the exact timing of device embolization cannot be known. In this case, we observed the development of severe hemodynamic disturbance shortly after surgery, which served as a clear indication for clinicians to promptly initiate rescue efforts.

Currently, there is a lack of consensus on the management of strayed devices, with retrieval methods determined on a case-by-case basis, taking into account device location, patient hemodynamic status, and operator's experience. Device embolization to the aorta or left atrium is usually asymptomatic and can be retrieved through percutaneous removal, while embolization in the left ventricle is a more serious complication and usually requires surgical removal [11]. In this case, our TTE examination indicated that the occluder had passed through the mitral valve annulus to reach the LVOT under the aortic valve, resulting in severe tearing of the mitral valve and severe hemodynamic disturbance. At this time, it is timely and necessary to immediately establish CPB, take out the embolization device, and repair the mitral valve. In a case report by Adel Aminian et al. [12], a 78-year-old female patient had a sudden onset of dyspnea and severe hypotension one month after LAAO. The TEE examination confirmed that the device had been entrapped in the anterior mitral apparatus, with secondary severe mitral regurgitation, and dynamic obstruction of the LVOT. Unfortunately, the patient's emergency surgery rescue had no chance to be implemented due to severe circulatory failure and then cardiac arrest before access to the operating room.

We summarized previous reports on LAA occluder retrieval through surgical procedures presented in Table 1. The relevant information includes the occluder device type, migrated location, dislodgement detection time, symptoms and examination, impaired condition of MV, surgical method, and patient prognosis.

4. Conclusion

This study represents the first systematic brief review on the dislodged left atrial appendage occluder retrieval through surgical procedures. While the development of percutaneous LAAO technology has brought hope to patients, device displacement has also become a sharp sword that stabs the patients' hearts. Given that the possible risk of device migration, the LAAO should be implemented in institutions where cardiac surgery is available. The displaced device may not cause obvious symptoms under certain circumstances. Any subtle clinical symptoms of the patient may be the canary in the coalmine. In summary, vigilance, interdisciplinary collaboration, and timely responses are vital elements in ensuring the safety and efficacy of LAAO procedures.

Patient perspective

The patient's family consistently showed agreement and support towards the team's treatment decisions, and the patient himself expressed heartfelt gratitude to us upon his safe discharge.

Ethics statement

The patient provided written consent to participate in the procedure and the publication of her images.

Data availability statement

With the patient's consent, we have accurately reported the changes in his medical condition and vital signs, without including any experimental data. If necessary, these data in this case can be made available.

CRediT authorship contribution statement

Wei Ye: Writing – original draft. **Wei Zhou:** Writing – original draft. **Weibing Zhao:** Project administration. **Jingjing Mao:** Project administration. **Wei Wang:** Project administration. **Liang Wei:** Resources, Project administration. **Linghui Zhao:** Resources, Project administration. **Yan Xu:** Project administration. **Jing Yu:** Project administration. **Zhi Fu:** Project administration. **Qiang Wang:** Writing – review & editing. **Zhuan Zhang:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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