

Analysis of 15 Cases of Patent Foramen Ovale Complicated with Atrial Septal Lambl's Excrescences Diagnosed by Three-Dimensional Transesophageal Echocardiography

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Abstract: ***Objective:** To observe linear echoes on the right atrial side of the atrial septum in patients with patent foramen ovale using three-dimensional transesophageal echocardiography, and to explore their pathogenesis and diagnostic value. **Methods:** A retrospective analysis was conducted on 1013 patients diagnosed with patent foramen ovale by transesophageal echocardiography from March 2020 to September 2025. Under TEE, the atrial septum structure, foramen ovale tunnel length, bilateral opening sizes, and abnormal echo attachments were observed. **Results:** Among 1013 patients, 15 (1.48%) showed linear isoechoic structures fluttering on the right atrial side of the atrial septum. TEE revealed isoechoic attachments at the fossa ovalis that swung with the cardiac cycle: 12 patients had single and 3 had multiple excrescences, ranging from 1.9 mm×1.3 mm to 5.3 mm×2.3 mm. All 15 patients received dual antiplatelet therapy; 3-month follow-up TEE showed no significant changes in morphology, size, or location. Subsequent interventional procedures were performed, with no embolism or adverse events during follow-up. **Conclusions:** Patent foramen ovale complicated with right atrial linear echoes has low incidence. The ultrasound manifestations and pathogenesis closely resemble Lambl's excrescences, suggesting these are non-thrombotic and non-infectious. Transesophageal echocardiography can sensitively detect such excrescences, offering important value for diagnosis and clinical treatment guidance.*

Keywords: Atrial septum, Patent foramen ovale, Three-dimensional transesophageal echocardiography, Lambl's excrescences.

1. Introduction

Patent foramen ovale (PFO) is a common congenital structural abnormality of the heart in adults and is closely associated with conditions such as migraine and cryptogenic stroke. During transesophageal echocardiography, excrescence-like structures can be observed on the right atrial side of the atrial septum in some patients with PFO. The differential diagnosis of such structures includes thrombus, infectious vegetations, non-infectious excrescences, myxoma, etc., and the treatment strategies differ significantly; therefore, accurate identification is crucial. Currently, transthoracic echocardiography (TTE) has limited resolution for detecting subtle structures of the atrial septum. Three-dimensional transesophageal echocardiography (3D-TEE) can provide a unique "surgical view," enabling three-dimensional visualization of intracardiac anatomical structures. This study retrospectively analyzed 15 cases of PFO complicated with atrial septal excrescences diagnosed by 3D-TEE, summarized their three-dimensional echocardiographic features, and explored the nature and formation mechanism of the excrescences in conjunction with clinical treatment outcomes. Furthermore, the safety of cardiac interventional procedures in these patients was evaluated, aiming to provide reliable imaging evidence for accurate clinical diagnosis and treatment decisions.

2. Materials and Methods

2.1 Clinical Data

A retrospective selection was conducted on 1013 patients

diagnosed with patent foramen ovale (PFO) by transesophageal echocardiography (TEE) in the Department of Ultrasound, Hebei General Hospital from March 2020 to September 2025. These included 126 patients with atrial fibrillation scheduled for radiofrequency ablation, 257 patients with cryptogenic stroke, 591 patients with migraine, and 39 patients suspected of having PFO by transthoracic echocardiography who required TEE for confirmation. Among the 1013 patients with PFO, 15 were found to have excrescences on the right atrial side of the atrial septum, including 9 males and 6 females, aged 30-65 (55.47±9.98) years. Among these 15 patients, there were 5 cases of atrial fibrillation, 7 cases of migraine, and 3 cases of cryptogenic stroke. This study was approved by the Hospital Ethics Committee (Approval No. 2025-LW-0231), and informed consent was obtained from the patients and/or their families.

2.2 Case Selection Criteria

(1) Diagnostic criteria: Two-dimensional TEE revealed fissure-like echoes at the fossa ovalis, and color Doppler showed left-to-right or bidirectional shunting. (2) Inclusion criteria: Patients who were conscious, able to cooperate with TEE examination, and diagnosed with PFO. (3) Exclusion criteria: 1) Patients with cardiac insufficiency or those unable to cooperate with TEE examination; 2) Patients with other congenital cardiac malformations besides PFO.

2.3 Transesophageal Echocardiography Examination

Patients fasted for 6-8 hours before the examination. Local pharyngeal anesthesia was applied using Oxybuprocaine Hydrochloride Gel. Patients were placed in the right lateral

position with a bite guard. A Philips EPIQ7 color Doppler ultrasound diagnostic system equipped with an X7-2t transesophageal echocardiography probe (frequency range 2-7 MHz) was used. The probe was inserted into the mid-esophagus, approximately 30-45 cm from the incisors. The atrial septum was visualized from multiple angles and sections to observe any gaps between the septum primum and septum secundum, and to detect any abnormal echoes attached to the left or right atrial side of the atrial septum. Color Doppler was used to detect any shunting at the atrial level.

2.4 Treatment Methods

Patients received dual antiplatelet therapy: Aspirin Enteric-coated Tablets 0.1 g orally once daily, and Ticagrelor Tablets 60 mg orally twice daily. TEE was re-examined after 3 months.

2.5 Statistical Methods

Statistical analysis was performed using IBM SPSS Statistics 26. Count data were expressed as frequencies or constituent ratios (%). Comparisons between groups were conducted using the 2 test. Measurement data conforming to normal distribution were expressed as mean \pm standard deviation ($\bar{x} \pm s$), and comparisons between two groups were performed using the independent samples t-test.

3. Results

3.1 Characteristics of Patent Foramen Ovale in Patients with Right Atrial Linear Excrescences

Among 1013 patients with patent foramen ovale (PFO), 15 were found to have excrescences on the right atrial side of the atrial septum, with an incidence rate of 1.48%. TEE revealed that in all 15 patients, the unclosed foramen ovale presented as long tunnel-type fissure-like echoes, with a tunnel length of 10-23 mm, a right atrial side opening width of 1.0-2.7 mm, and a left atrial side opening width of 1.3-1.7 mm (Figure 1). Color Doppler showed left-to-right shunting in 11 cases and bidirectional shunting with predominantly left-to-right flow in 4 cases (Figure 2).

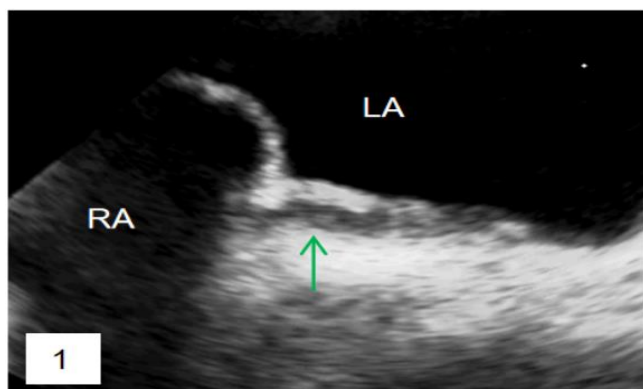


Figure 1: Two-dimensional transesophageal echocardiography shows the left atrium (LA) and right atrium (RA), and there is a visible patent foramen ovale (PFO) in the mid-septum

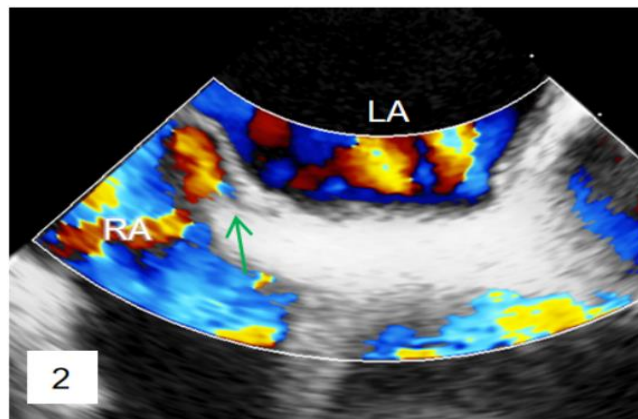


Figure 2: A left-to-right shunt through the patent foramen ovale

3.2 Echocardiographic Manifestations of Right Atrial Linear Excrescences

TEE revealed linear isoechoic attachments on the right atrial side of the atrial septum, located downstream of the atrial-level shunting, which swung with cardiac systole and diastole. Among the 15 patients, 12 had a single linear echo, 2 had two echoes, and 1 had multiple echoes. The size of the excrescences ranged from 1.9 mm \times 1.3 mm to 5.3 mm \times 2.3 mm (Figures 3 and 4).



Figure 3: Two-dimensional transesophageal echocardiography shows that two equal echoes are attached to the right side of the atrial septum

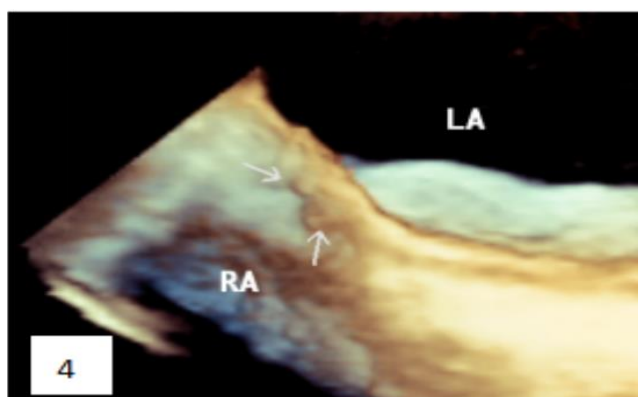


Figure 4: Three-dimensional transesophageal echocardiogram shows two equal echos

3.3 Treatment Outcomes of PFO Patients with Right Atrial Linear Excrescences

After 3 months of dual antiplatelet therapy, follow-up TEE in the 15 patients showed no significant changes in the size, morphology, or number of the right atrial linear echoes. Subsequently, the patients underwent cardiac interventional procedures: 10 received PFO closure and 5 received radiofrequency ablation. No embolic events or other adverse events occurred during post-operative follow-up.

4. Discussion

In 1856, Dr. Vilem Dusan Lambl first discovered filiform structures on the ventricular side of the aortic valve cusps [1], which were later named Lambl's excrescences (LE) by scholars. The classical formation mechanism is generally considered to be endothelial injury: due to continuous valve leaflet approximation, small tears occur on the endocardial surface under long-term stimulation, leading to fibrin deposition from the blood onto the injured surface, followed by endothelial cell proliferation forming a monolayer covering the deposits, thus resulting in excrescence formation [2,7]. This mechanism explains why LE predominantly occur on the ventricular side of the aortic valve and the atrial side of the mitral valve, where pressure impact is most significant [3]. However, the 15 cases of LE in this study were uniquely located on the right atrial side of the atrial septum in patients with patent foramen ovale (PFO). This finding presents an interesting supplement and challenge to the classical theory, offering a new perspective for in-depth exploration of LE pathogenesis.

In this study, the 15 cases of right atrial linear excrescences diagnosed by TEE were not detected by transthoracic echocardiography, demonstrating that TEE can sensitively identify such asymptomatic excrescences. Similar to valvular LE reported in previous literature, the excrescences in this study also presented as highly mobile, slender, strand-like structures. This commonality suggests that local endothelial injury caused by continuous high-velocity blood flow impact may be a shared initiating factor. In this study, all linear excrescences on the atrial septum were located at the fossa ovalis on the right atrial side, and all PFOs were of the long tunnel type. The possible explanation is that in patients with PFO, long-term shunting exists in the mid-portion of the atrial septum, with blood flow continuously impacting the right atrial endocardium of the tunnel, leading to endocardial injury, fibrin deposition, and eventual excrescence formation, similar to Lambl's excrescences on heart valves. Although LE are commonly found on valves, autopsy reports have also documented their presence in the right atrium. Schiller et al. [4] reported 2 autopsy cases where linear tissues were attached to the right atrial endocardium at the fossa ovalis, which is similar to the atrial septal excrescences we observed in our study.

The results of this study differ significantly from previous large-case analyses. For example, Bo Xiaowen et al. [3] reported that the vast majority (80%) of LE were located on the aortic valve, followed by the mitral valve (17%), with one case involving the tricuspid valve; LE have also been reported on the pulmonary valve [4], atrial septum [5], and chordae tendineae [6]. Atrial septal involvement is extremely rare. The reasons for this discrepancy may, on one hand, be related to the specificity of the included cases (all PFO patients) in this

study, introducing selection bias. On the other hand, it highlights the significant advantage of three-dimensional transesophageal echocardiography (3D-TEE) over conventional transthoracic echocardiography in detecting subtle intracardiac structures. In this study, the linear echoes in all 15 patients did not resolve after standard clinical anticoagulation therapy, and no embolic or other adverse events occurred during or after subsequent cardiac interventional procedures. This demonstrates that such linear isoechoic structures on the atrial septum are non-thrombotic and non-infectious excrescences, and that targeted interventional treatment for these patients is safe without requiring preoperative intervention. Although most scholars consider such excrescences to have no clinical significance, some reports [8-11] suggest they may cause migraine, stroke, and myocardial infarction. In these reports, the excrescences were all located on the aortic valve; whether excrescences on the atrial septum can cause such diseases has not been reported and requires further clinical observation.

This study has several limitations. First, as a retrospective study with a limited sample size, quantitative verification of the hemodynamic mechanism of LE formation was difficult. Second, all diagnoses were based on imaging findings without confirmation by the gold standard of histopathology. Future research could combine computational fluid dynamics simulations to precisely analyze blood flow patterns around the PFO and attempt to validate the detection rate and clinical associations of atrial septal LE in more diverse patient populations.

5. Conclusions

Transesophageal echocardiography (TEE), with its superior spatial resolution, is significantly superior to transthoracic echocardiography in detecting and displaying subtle atrial septal excrescences associated with PFO, making it the most sensitive and effective imaging modality for diagnosing such lesions. Furthermore, based on the echocardiographic features, response to pharmacotherapy, and clinical history of this case series, we confirm that such excrescences are benign, non-thrombotic, and non-infectious lesions. Their slender, mobile morphological characteristics are highly consistent with Lambl's excrescences (LE), supporting their identification as a benign anatomical variant possibly associated with local hemodynamic stimulation.

In summary, TEE has irreplaceable value for the accurate identification and characterization of PFO complicated by atrial septal excrescences. Although this study preliminarily confirms their benign nature, the long-term clinical outcomes, potential embolic risk, and impact on decision-making regarding PFO closure require further clarification through studies with larger sample sizes and longer follow-up periods. This represents an important direction for future research.

Author Contributions: Ronghong Jiao designed the study, was involved in the analysis and interpretation of data, revised the draft manuscript and subsequent manuscripts. Zihao Mei wrote and revised the draft manuscript and subsequent manuscripts. Li Sun and Tingting Liu assisted with drafting and revising the manuscript. All authors read and approved the final manuscript.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of Hebei General Hospital, (protocol code 2025-LW-0231).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

Not applicable.

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Conflicts of Interest

The authors declare no conflicts of interest.

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