

MINI-FOCUS ISSUE: PROCEDURAL COMPLICATIONS

ADVANCED

CASE REPORT: CLINICAL CASE SERIES

Pneumopericardium— An Unusual Complication Following Transseptal Puncture

A Series of 3 Cases

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ABSTRACT

Transseptal puncture (TSP) is performed to access the left side of the heart from the venous circulation. Performed under fluoroscopy with echocardiographic guidance, it is a procedure associated with complications. Pneumopericardium leading to cardiac tamponade is rare following TSP. We present 3 cases of pneumopericardium during TSP and its identification, probable mechanism, and management. (**Level of Difficulty: Advanced.**) (J Am Coll Cardiol Case Rep 2022;4:671-676) © 2022 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

INTRODUCTION

Transseptal puncture (TSP) is performed to access the left side of the heart from the venous circulation. It was initially done for hemodynamic assessment.¹ Advances in structural cardiac interventions have made TSP essential for treating the modern patient.²

TSP in a hospital in Bangalore, India is performed under fluoroscopic guidance, in an unsedated patient and using the modified Hung method after systemic

anticoagulation.³ TSP is associated with complications, ranging from iatrogenic atrial septal defect and inadvertent aortic root or pericardial puncture to cardiac tamponade and injury to the adjacent structures.⁴ Transesophageal echocardiogram (TEE) or intracardiac echocardiogram (ICE) assistance can enhance the safety of TSP, but it is not always essential. Additionally, the use of TEE and ICE in low-income countries is limited by availability and added cost.

Pneumopericardium is a rare complication of TSP. Although lesser amounts of air resolve spontaneously, large amounts lead to cardiac tamponade and hemodynamic collapse and can be life-threatening. Here we report 3 cases of iatrogenic pneumopericardium during TSP and discuss the probable mechanism of air entrainment and its emergent management.

LEARNING OBJECTIVES

- To be able to recognize pneumopericardium, a complication of transseptal puncture.
- To understand the importance of early detection and emergency management of pneumopericardium.

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**ABBREVIATIONS
AND ACRONYMS**

BMV = balloon mitral valvotomy

ICE = intracardiac echocardiography

LA = left atrial

MS = mitral stenosis

RA = right atrial

RAA = right atrial appendage

TEE = transesophageal echocardiography

TSP = transseptal puncture

PATIENT 1

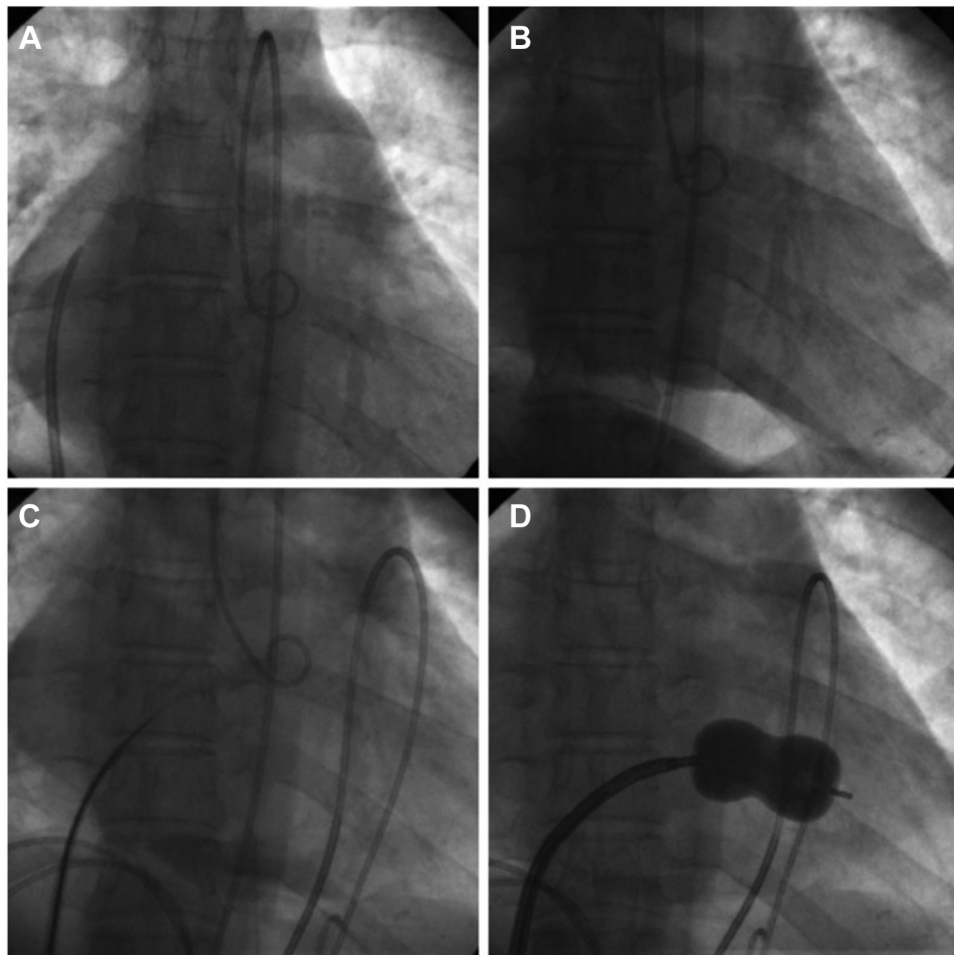
A 26-year-old woman with severe rheumatic mitral stenosis (MS) was referred for balloon mitral valvotomy (BMV). Using the standard fluoroscopic method, TSP was performed with a Brockenbrough needle. Soon after the puncture, she developed tachycardia, hypotension, and perspiration. Fluoroscopy showed a large pocket of air in the pericardium suggesting pneumopericardium with tamponade (Figures 1A to 1D). Immediate pericardiocentesis was performed, air was aspirated with a 50-mL Luer-lock syringe,

and the patient was stabilized (Videos 1 to 4). No blood was aspirated. After hemodynamic improvement, the septum was punctured again, and BMV was completed with a 24-mm Accura balloon catheter (Vascular Concepts), with a good result. The pneumopericardium probably was caused by right atrial (RA) roof or RA appendage (RAA) puncture during TSP. The patient did well and was later discharged.

PATIENT 2

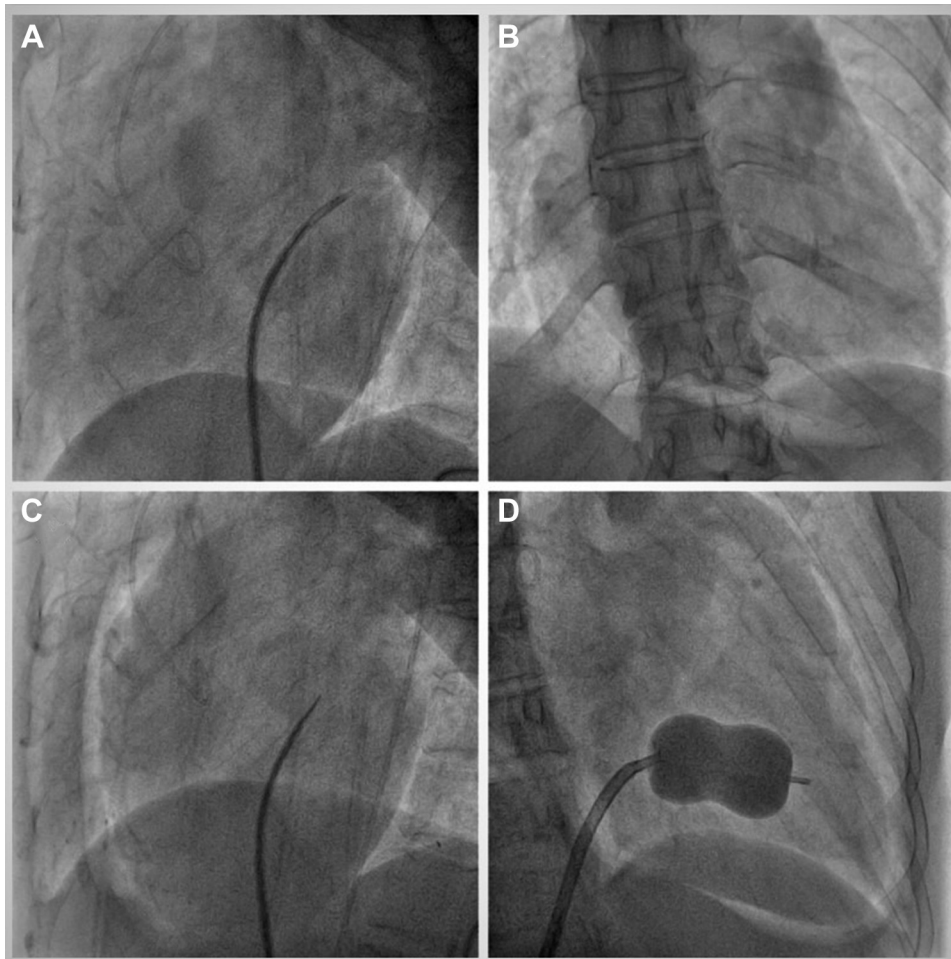
A 43-year-old woman with chronic rheumatic MS and moderate aortic regurgitation was taken up for BMV. BMV in such multivalvular lesions is commonly

FIGURE 1 Patient 1: Balloon Mitral Valvotomy



(A and B) The pigtail catheter in the aortic root and the septal dilator in the right atrium. After inadvertent puncture into the pericardial space, pneumopericardium with tamponade effect was seen, and the patient became hemodynamically unstable. (C) Pericardiocentesis was performed from the subxiphoid approach, air was aspirated, and the patient was stabilized. (D) A repeat transseptal puncture was performed after stabilization, and balloon mitral valvotomy was completed (Video 1).

FIGURE 2 Patient 2: Balloon Mitral Valvotomy



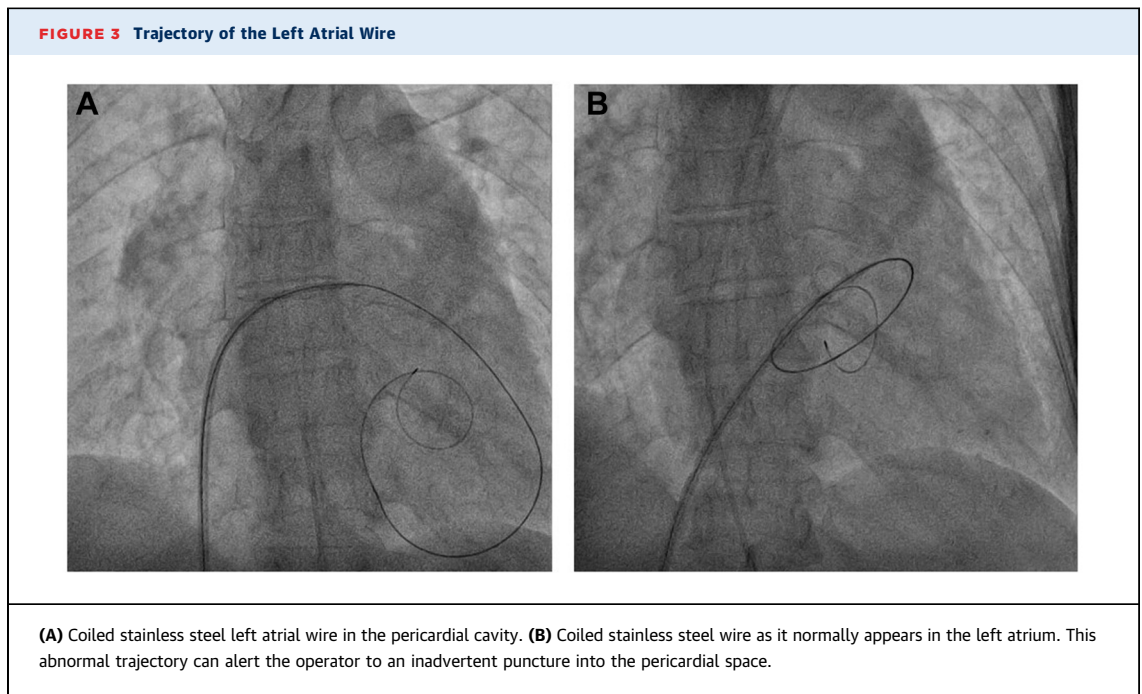
(A) Transseptal puncture performed in the left anterior oblique view. The pigtail catheter is in the aortic root. (B) Pneumopericardium after the transseptal puncture; all hardware was removed, and the patient was monitored. (C) Because the patient was hemodynamically stable, repeat transseptal puncture was performed. Note the air in the pericardium compared with A. (D) Balloon mitral valvotomy was completed (Figure 3, Video 2).

performed at our center before the inevitable double valve replacement. TSP was performed under fluoroscopy, and as the 0.025-inch coiled stainless steel left atrial (LA) wire was being introduced, the patient reported chest pain and became restless (Figures 2A to 2D, Videos 5 to 7). Fluoroscopy revealed that the coiled wire had entered the pericardial cavity (Figures 3A and 3B) instead of the left atrium. A pneumopericardium was noted, but she was hemodynamically stable. Therefore a second TSP was performed, and BMV was completed successfully in the same setting. The patient remained stable throughout the procedure. Again, in this case, a review of procedural images suggested probable inadvertent high

puncture through the RA roof as the cause. Trans-thoracic echocardiogram and fluoroscopy were repeated, and the pneumopericardium had resolved completely. She was discharged 3 days later and she is undergoing regular follow-up.

PATIENT 3

A 55-year-old woman with multiple comorbidities was referred to us for LA appendage device occlusion. She had survived massive upper gastrointestinal bleeding before presentation, and variceal banding was performed. She had permanent nonvalvular atrial fibrillation and had been receiving warfarin



before the bleeding. TEE guidance was used in addition to the standard fluoroscopic technique for the TSP. After the TSP, a 12-F delivery sheath was introduced. As the dilator was being removed, a small pneumopericardium was noted. A 5-F multipurpose catheter was taken through the 12-F sheath, and an injection through the catheter confirmed it to be in the pericardial cavity (Figures 4A to 4D, Videos 8 to 10). There was no hemodynamic compromise, but the procedure was deferred. The pneumopericardium completely resolved by the third day, and she made an uneventful recovery. The patient did not agree to undergo a repeat procedure and so was started on factor Xa antagonist therapy.

DISCUSSION

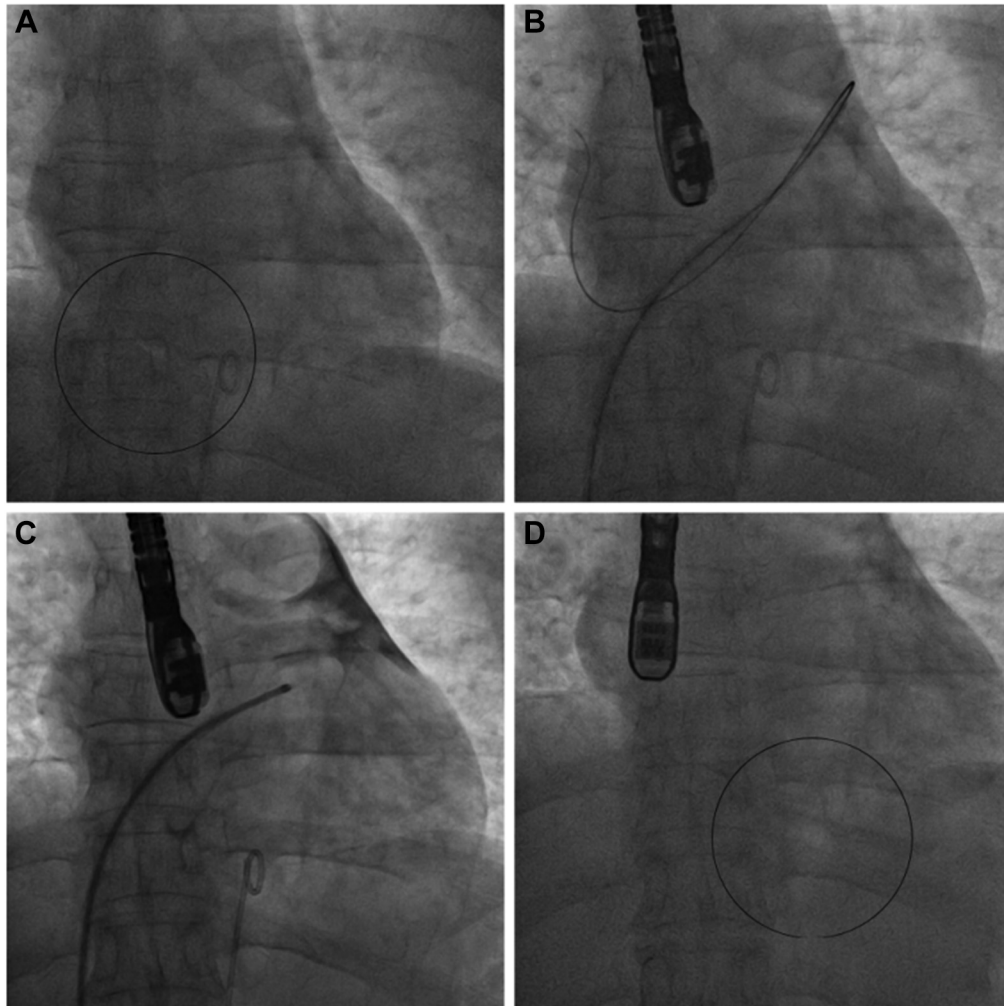
Our center has performed more than 25,000 TSPs over the last 2 decades, and pneumopericardium was documented in just 3 cases. From published studies on BMV, the incidence of hemorrhagic cardiac tamponade was approximately 1% to 2%,⁵⁻⁷ although no case of pneumopericardium was reported.

Pneumopericardium behaves similarly to tamponade caused by blood. Although lesser amounts of air usually allow for hemodynamic stability and completion of the procedure (patient 2), large volumes can be life-threatening and can be catastrophic if not addressed immediately (Patient 1). Inadvertent entry into the pericardium can be the

result of puncture at the level of: 1) the RAA; 2) the RA roof; 3) the posterior surface of the right atrium; 4) the inferior vena cava-RA junction; or 5) LA perforation after TSP. This complication is more common in cases with challenging anatomy such as giant left atrium, gross septal bulge, or kyphoscoliosis where TSP is technically difficult. It is always prudent to confirm an optimal TSP site either with TEE or transthoracic echocardiogram or in orthogonal fluoroscopic views before puncturing the septum.

The intrapericardial pressure is at or below the atmospheric pressure, and closely follows the intrathoracic pressure, and varies with respiration. During an inadvertent puncture into the pericardium, atmospheric air can be sucked into the cavity through either the Mullins sheath or through the transseptal puncture needle during hardware exchanges. Exaggerated respiratory excursions of an anxious patient can worsen the entrainment of air into the pericardium. Puncture through a relatively low-pressure right atrium into the pericardium can be managed conservatively with pericardiocentesis and careful monitoring. Surgery can be contemplated if these measures fail. A drop in blood pressure should alert the operator to possible tamponade. On fluoroscopy, loss of LA pulsations is the earliest clue to recognize pericardial effusion, and air in the pericardium is obvious to an observant eye. Subtle symptoms such as vague discomfort or

FIGURE 4 Patient 3: Left Atrial Appendage Device Closure



(A) Transesophageal echocardiogram-guided transseptal puncture was performed, and as the dilator of the delivery sheath was being removed, pneumopericardium was noticed. (B) The coiled left atrial wire is in the pericardial cavity. (C) Contrast injection confirmed that the catheter was in the pericardial space. (D) All hardware was removed, and the patient was hemodynamically stable. A small pocket of air was present, and it resolved in a few days (Videos 8 to 10).

TABLE 1 Key Characteristics and Outcomes of the Cases

Characteristics and Outcomes	Case 1	Case 2	Case 3
Age, y	26	43	55
Diagnosis	RHD, severe MS	RHD, severe MS, moderate AR	AF with high risk for anticoagulation
Procedure	BMV	BMV	LAA device occlusion
IAS anatomy	Favorable, midline IAS; thin at fossa ovalis	IAS bulging toward RA, giant LA	Thick IAS
Management of pneumopericardium	Pericardiocentesis and aspiration of air	Conservative	Conservative
Outcome	BMV done, discharged, undergoing follow-up	BMV done, discharged, undergoing follow-up	Undergoing follow-up, with no complaints

AF = atrial fibrillation; AR = aortic regurgitation; BMV = balloon mitral valvotomy; IAS = interatrial septum; LAA = left atrial appendage; MS = mitral stenosis; RA = right atrium; RHD = rheumatic heart disease.

yawning could be harbingers of impending tamponade. Abnormal trajectory of the coiled LA wire when it enters the pericardial cavity can alert the operator to an inadvertent pericardial puncture (Figures 4A to 4D). Echocardiography during key steps should be protocolized and followed, to avoid complications. Patient characteristics are described in Table 1.

CONCLUSIONS

Pneumopericardium is a rare complication following TSP. It can result from accidental puncture of the cardiac chambers and is easily identified on fluoroscopy. Whereas lesser amounts of air in the

pericardium can be managed conservatively, larger volumes can cause hemodynamic compromise and tamponade, and pericardiocentesis is required. Image guidance can enhance the safety of TSP and should be protocolized.

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KEY WORDS mitral valve, rheumatic heart disease, tamponade

APPENDIX For supplemental videos, please see the online version of this article.