

# CASE REPORTS

**POTENTIAL EFFECT OF BOX-SHAPED PULMONARY VEIN ISOLATION  
ON PERSISTENT ATRIAL FIBRILLATION IN A PATIENT WITH SEVERE  
PECTUS EXCAVATUM**

## Potential Effect of Box-Shaped Pulmonary Vein Isolation on Persistent Atrial Fibrillation in a Patient with Severe Pectus Excavatum

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### Abstract

In patients with atrial fibrillation and pectus excavatum, a box-shaped pulmonary vein isolation may be preferred over a regular circumferential isolation, as the posterior wall of the left atrium appears to be involved. It must be noted that this approach requires additional ablation of the roof and bottom. Therefore, preoperative imaging and the use of contact force-sensing catheters with three-dimensional mapping are very important to help ensure a safe and effective procedure.

### Keywords

atrial fibrillation, box-shaped pulmonary vein isolation, cavo-tricuspid isthmus ablation, left atrial posterior wall, pectus excavatum, and radiofrequency ablation

### Introduction

Pulmonary vein isolation (PVI) is an established and effective treatment for atrial fibrillation (AF), regardless of whether it is paroxysmal or persistent [1],[2]. While pulmonary veins are the primary foci of AF, non-pulmonary vein (non-PV) foci, including the left atrial posterior wall (LAPW), have also been identified as major triggers [3]. The box-shaped PVI (box-PVI) technique, which isolates both the pulmonary veins and Law in a single

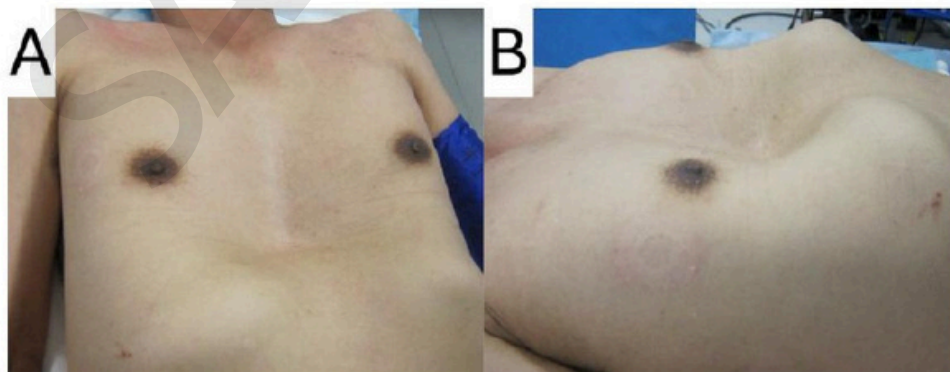
isolation procedure, was first described by Kumagai and represents an advanced approach for managing AF of complex origins In patients with PE, the left atrium, including Thela PW, is often considerably compressed between the sternum and vertebral bodies, which may be responsible for the electrical instability resulting in AF foci. Patients with PE are at a higher risk of developing AF [3]

## Case Presentation

A 57-year-old man with well-controlled hypertension, diagnosed 5 years ago and managed non-pharmacologically at a local clinic, presented at our institution with heart failure. Physical examination revealed PE (Figure 1). Laboratory investigations revealed a B-type natriuretic peptide level exceeding 700 pg./mL, and transthoracic echocardiography showed a mildly reduced left ventricular ejection fraction (LVEF) of 43%, accompanied by pleural effusion. The sinus rhythm was achieved; however, persistent AF recurred.

Coronary angiography (CAG) revealed no abnormal anatomy or significant coronary artery stenosis. Before performing catheter ablation, contrast-enhanced chest computed tomography (CT) was performed to evaluate the anatomical structure of the heart, including a pre-procedural assessment of the left atrial morphology. As AF tachycardia is a major contributing factor to heart failure exacerbation and LVEF reduction, catheter ablation was considered the most appropriate therapeutic approach. Evidence suggests that the absence of surgical repair for PE may result in symptoms, such as dyspnoea or palpitations, in older adult patients [4].

As the previous institution did not have an affiliated cardiovascular surgery department capable of performing emergency interventions, and considering the anatomical deviations associated with PE that could increase the risk of complications during ablation, the patient was referred to our hospital, which is fully equipped to provide immediate surgical management. Using a THERMOCOOL SMARTTOUCH Surround Flow (Bio sense Webster) contact force-sensing catheter, we delivered an RF energy of 30–40 W to the anterior and roof regions and 25–30 W to the posterior region of the PVs while measuring the contact force, which was maintained between 5 and 20 g for all RF applications with target ablation indices of 500 and 450, respectively. The LASSO (BioSense Webster) and A focus catheter (St. Jude Medical, Little Canada, MN, USA) were positioned sequentially at the superior and inferior pulmonary veins, respectively. Subsequently, we used the double-Lasso technique to confirm PV isolation [5] and applied RF energy to the anterior portion of each PV along with the left atrial roof and bottom regions to create a box-shaped single ring encircling all PVs and LAPW (box-PVI).



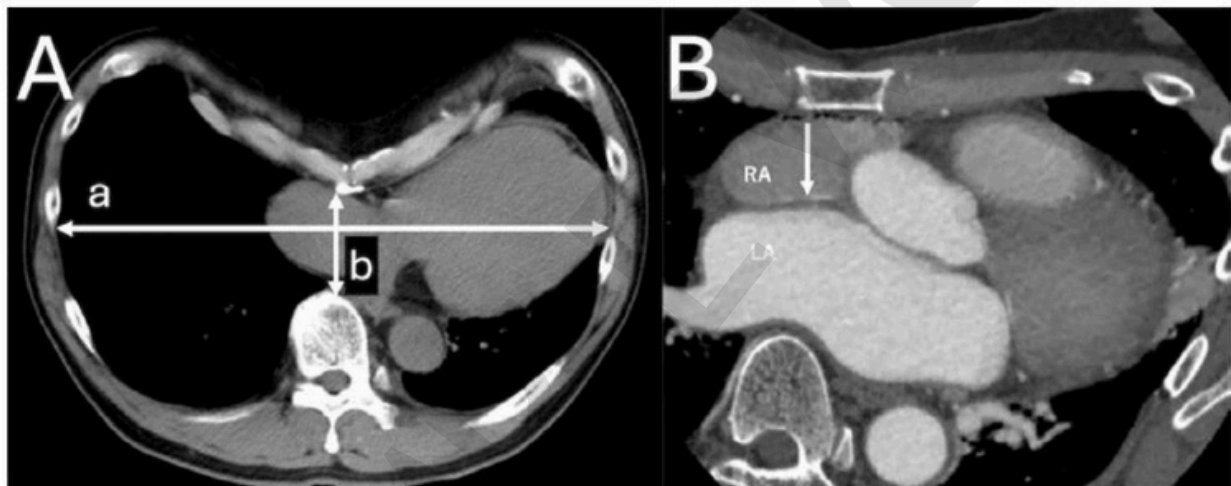
**FIGURE 1:** Pectus excavatum. The chest was severely sunken, exhibiting signs of pectus excavatum. (A) Caudal view. (B) Right anterior oblique.

## Methods

All ablation procedures were performed with the patients under deep sedation using dexmedetomidine, propofol, and buprenorphine, with oesophageal temperature and direct blood pressure monitoring.

### Box-Shaped Pulmonary Vein Isolation

Based on preoperative contrast-enhanced CT findings, the radiofrequency (RF) needle (standard curve; Baylis Medical Technologies, Ontario, Canada) was precisely positioned at the level of the fossa ovalis and directed toward the vertebral body, specifically at the 6 o'clock position on the CT axial plane, which differs from the usual approach, under the guidance of intracardiac echocardiography (ICE) (Figure 2B). An electroanatomic CARTO3 Mapping System and CARTOSOUND Module (BioSense Webster, Diamond Bar, CA, dormant exit conduction using adenosine triphosphate, which can explain the robust lesion [6].



**FIGURE 2:** Haller index and Brockenbrough site. (A) Chest computed tomography (CT) suggests severe pectus excavatum. (a) Maximum transverse diameter: 272.84 mm. (b) Minimum anterior–posterior diameter: 51.29 mm. Haller index =  $272.84/51.29 = 5.31$ . Cardiac CT shows a depressed thoracic cage, resulting in significant compression of the left atrium against the vertebral body. Furthermore, the spatial relationship between the inferior vena cava and heart is markedly altered, deviating from the normal anatomical configuration. (B) The white arrow indicates the direction in which the radiofrequency needle was oriented during the Brockenbrough procedure, demonstrating the necessity of advancing the needle toward the vertebral body.

## **Cavo Tricuspid Isthmus Ablation**

We performed Cavo tricuspid isthmus (CTI) ablation following coronary sinus venography and right ventriculography owing to its unusual anatomical configuration. Despite these complexities, a bidirectional block across the CTI was successfully achieved, thus confirming the procedural endpoint. The patient was monitored postoperatively using continuous electrocardiographic surveillance. The electrocardiography (ECG) and echocardiography tests performed on the day after the procedure confirmed the maintenance of sinus rhythm, with no evidence of pericardial effusion suggestive of cardiac tamponade.

## **Outcome and Follow-Up**

The patient was monitored postoperatively using continuous electrocardiographic surveillance. The electrocardiography (ECG) and echocardiography tests performed on the day after the procedure confirmed the maintenance of sinus rhythm, with no evidence of pericardial effusion suggestive of cardiac tamponade. The patient had an uneventful postoperative course and was discharged on postoperative day 3. In the first 3 months, the patient made outpatient visits once a month. The patient's blood pressure remains well-controlled without any issues. Every 3–6 months, 24-hour ambulatory ECG monitoring is performed in the outpatient setting. To date, over 8 years of follow-up, the patient has had no AF recurrence.

## **Discussion**

This report makes a novel contribution to the literature by underscoring the feasibility and potential utility of box-PVI for patients with PE. Although similar considerations have been made in previous cases of PVI, anatomical variations associated with PE pose unique procedural challenges in this case; considerable difficulties were encountered during the insertion of the coronary sinus (CS) catheter owing to the altered anatomical structure. CAG was performed to accurately identify the CS ostium and to guide catheter placement. Catheter insertion proved challenging owing to anatomical variations, necessitating careful reference to preoperative contrast-enhanced CT images to ensure precise navigation and procedural success. These challenges were mitigated by the detailed and anatomical imaging obtained via CT scan. Although CTI pouches can pose procedural difficulties in patients without PE, it has been hypothesized that the mechanical compression caused by PE potentially increases the likelihood of pouch formation [6]. [7]

## Conclusions

We report a patient with AF and PE who underwent box-PVI, with no recurrence of AF during an extended follow-up period. This case underscores the feasibility and effectiveness of box-PVI as a treatment for AF even in the presence of significant anatomical abnormalities associated with PE. The procedure demonstrated favourable long-term outcomes, suggesting that box isolation may serve as a durable and reliable therapeutic option for managing AF in this unique subset of patients. For safe and effective box-PVI ablation, obtaining detailed preoperative anatomical information using CT and various angiographic techniques, along with the integration of contact force-sensing catheters and 3D imaging, is crucial.

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