

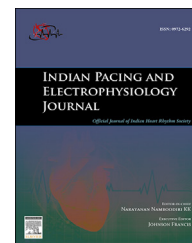
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# Double-gap-in-roof reentrant tachycardia following surgical thoracoscopic atrial fibrillation ablation

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## ABSTRACT

A case of macro-reentrant tachycardia associated with a box lesion after thoracoscopic left atrial surgical atrial fibrillation (AF) ablation yet to be described. The goal was to clarify the mechanisms and electrophysiological characteristics of this type of tachycardia.

A patient was admitted for an EP study following surgical thoracoscopic AF ablation (box lesion formation by right-sided Cobra thoracoscopic ablation). Thoracoscopic ablation was done as the first step of the hybrid ablation approach to the persistent AF; the second step was the EP study. At the EP study, he presented with incessant regular tachycardia (cycle length of 226 ms). An EP study with conventional, 3D activation and entrainment mapping was done to assess the tachycardia mechanism. Two conduction gaps in the superior line (roofline) between the superior pulmonary veins were discovered. The tachycardia was successfully treated with a radiofrequency application near the gap close to the left superior pulmonary vein; however, following tachycardia termination, pulmonary vein isolation was absent. A second radiofrequency application, close to the roof of the right superior pulmonary vein closed the gap in the box and led to the isolation of all 4 pulmonary veins. No atrial tachycardia recurred during the 6-month follow-up.

Conduction gaps in box lesion created by thoracoscopic ablation can present as a novel type of man-made tachycardia after surgical ablation of atrial fibrillation. Activation and entrainment mapping is necessary for an accurate diagnosis.

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## Introduction

Pulmonary vein isolation (PVI) is a well-established treatment option for patients with symptomatic paroxysmal atrial fibrillation. The success rate of PVI in patients with persistent

or even long-lasting persistent atrial fibrillation, however, is less than satisfactory [1,2]. Therefore, alternative techniques, including a combination of surgical thoracoscopic ablation followed by catheter ablation (e.g. hybrid approach), have been developed [3,4]. However, more complex left atrial

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ablations, especially with incomplete lesion formation, can be pro-arrhythmogenic and give rise to certain types of man-made tachycardias. In this case we report on a type of man-made reentrant tachycardia caused by a double gap in the roofline section of a box lesion created during surgical thoracoscopic AF ablation.

## Case report

A 59-year old patient with symptomatic long-lasting persistent atrial fibrillation presented to the outpatient department of the Cardiocenter. A hybrid ablation, i.e. a combination of surgical thoracoscopic ablation, followed by catheter ablation, was offered for treatment of the patient's condition; this treatment approach was offered as part of a research project being conducted by the Cardiocenter, University Hospital Kralovske Vinohrady in Prague, Czech Republic. The research project was approved by the local Ethics Committee of the University. The procedure consisted of a surgical thoracoscopic ablation (box lesion) followed by catheter ablation (to insure the completeness of the box lesion, ganglionated plexi ablation and right cavotricuspid isthmus ablation). After a written informed consent was obtained, a surgical

thoracoscopic video-controlled ablation was performed as described previously [5,6].

In brief, after general anesthesia induction, and with selective lung ventilation, the right chest was entered with three thoracoscopic working ports. The pericardium was opened and the transverse and oblique sinuses were dissected. A COBRA Fusion™ 150 (Estech, Atricure, Inc., West Chester, Ohio, USA) catheter was then placed into the transverse sinus, behind the left atrial appendage and into the oblique sinus, encircling the four pulmonary veins (PV). The epicardial fat pad in the atrial septum and in the atrial groove was dissected and a box lesion was created using both a unipolar and bipolar ablation (three cycles of 60 s radiofrequency energy application).

As a second part of the hybrid procedure, an EP study was scheduled until 3 months following surgical ablation. The ECG of the patient before EF study is shown on Fig. 1.

Using the left femoral vein, a 10-polar catheter was inserted into the coronary sinus (CS) and intracardiac echocardiography (ICE) probe was inserted into the right atrium (RA). In the RA, a tachycardia of cycle length of 226 ms, and the activation sequence on the CS catheter was proximal-distal. Therefore, from the right femoral vein, two SL1 sheaths (8 and 8.5 F) were inserted into the RA, and activation mapping of the RA was carried out using a 3.5 mm mapping catheter

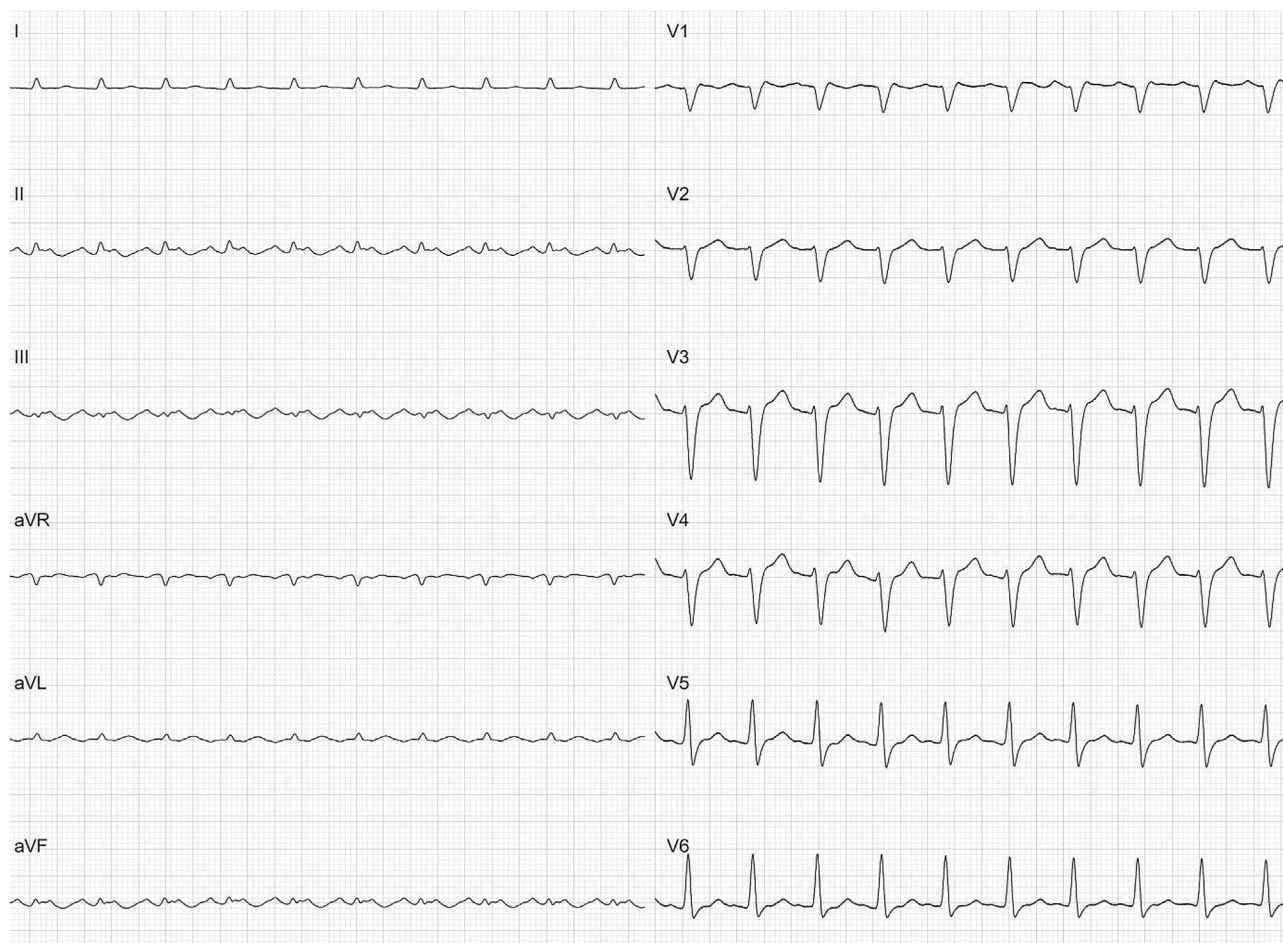


Fig. 1 – Twelve leads ECG of the patients before the EP study.

(Thermocool Navistar, Biosense-Webster, Diamond Bar, USA) using techniques published by Jais et al. [7] Both on the septal site and the lateral part of the RA, the activation sequence was cranio-caudal. Post-pacing intervals (PPI) on the cavotricuspid isthmus was +133 ms, and on the lateral part of right atrium it was +240 ms, which together with the activation sequence ruled-out right sided cavotricuspid flutter. The best PPI in the right atrium was on the septum (+42 ms). Therefore, under ICE, a double transeptal puncture was carried out. The activation sequence on the anterior wall of the left atrium (LA) was septal-to-lateral (i.e. similar to CS), thus, a peri-mitral flutter was ruled out. On both the posterior and anterior wall of the LA, the activation sequence was cranio-caudal. Therefore, a centrifugal roof atrial tachycardia was considered. However, because the 3D mapping involved almost the whole tachycardia cycle length, macro-reentry tachycardia was not ruled out and several entrainment mappings were done. The PPI in the proximal CS was 126 ms, and the PPI on the distal CS was 170 ms. However, very good PPIs were found along the entire roof; with the best being close to the anterior roof of the left superior pulmonary vein (LSPV, +10 ms) and the roof anterior aspect of the right superior pulmonary vein (RSPV, +12 ms). Furthermore, concealed entrainment was present on the roof of LA during overdrive pacing. The PPI during stimulation from a Lasso catheter inserted into the RSPV and LSPV was +30 ms. A radiofrequency (RF) ablation was started close to the roof of the LSPV (irrigation 15 ml/min, power 30 W) and led to cessation of the tachycardia and sinus rhythm restoration (Fig. 2).

All PVs were checked using a Lasso catheter, but none of the PVs was isolated. During sinus rhythm, the shortest signal, which was always measured from the proximal CS pole (CS 9–10) to the first signal on the Lasso catheter inserted into a particular pulmonary vein, was in the RSPV (40 ms), followed

by the RIPV (92 ms), the LSPV (131 ms) and the longest time was in the LIPV (157 ms). Next, different pacing maneuvers were performed during stimulation of the distal and proximal CS bipoles. The Lasso was sequentially inserted into all 4 pulmonary veins and the distance from stimulus to the signal on the Lasso catheter, inserted in the PV, was measured. During stimulation of the distal CS bipoles, the shortest distance was observed in the RSPV (167 ms), followed by the RIPV (205 ms), the LSPV (215 ms), and the longest was in the LIPV (248 ms). The same distances were measured during pacing from the proximal CS bipoles. Similarly, the shortest distance was observed in the RSPV (132 ms), followed by the RIPV (184 ms), the LSPV (187 ms), and the LIPV (205 ms). The first signal on the Lasso, when inserted into the RSPV, was on the poles close to the anterior superior aspect of the vein, where the next gap was suspected. The Lasso catheter was left in the RSPV during proximal CS stimulation. A single RF application near the RSPV anterior roof led to the disappearance of signals on the Lasso catheter, as it is shown on Fig. 3.

The Lasso catheter was inserted into all other PVs and isolation of all PVs was confirmed. The completeness of the posterior box was then verified using a LA voltage remap during sinus rhythm.

## Discussion

The PVI-only approach in patients with persistent or even long-lasting persistent AF seems to be inadequate [2,3]. Using a stepwise approach is associated with acceptable success rates, but the procedure can be time consuming and often requires two attempts [1]. The hybrid surgical thoracoscopic/catheter procedure for ablation of persistent or long-lasting persistent atrial fibrillation is a relatively recent

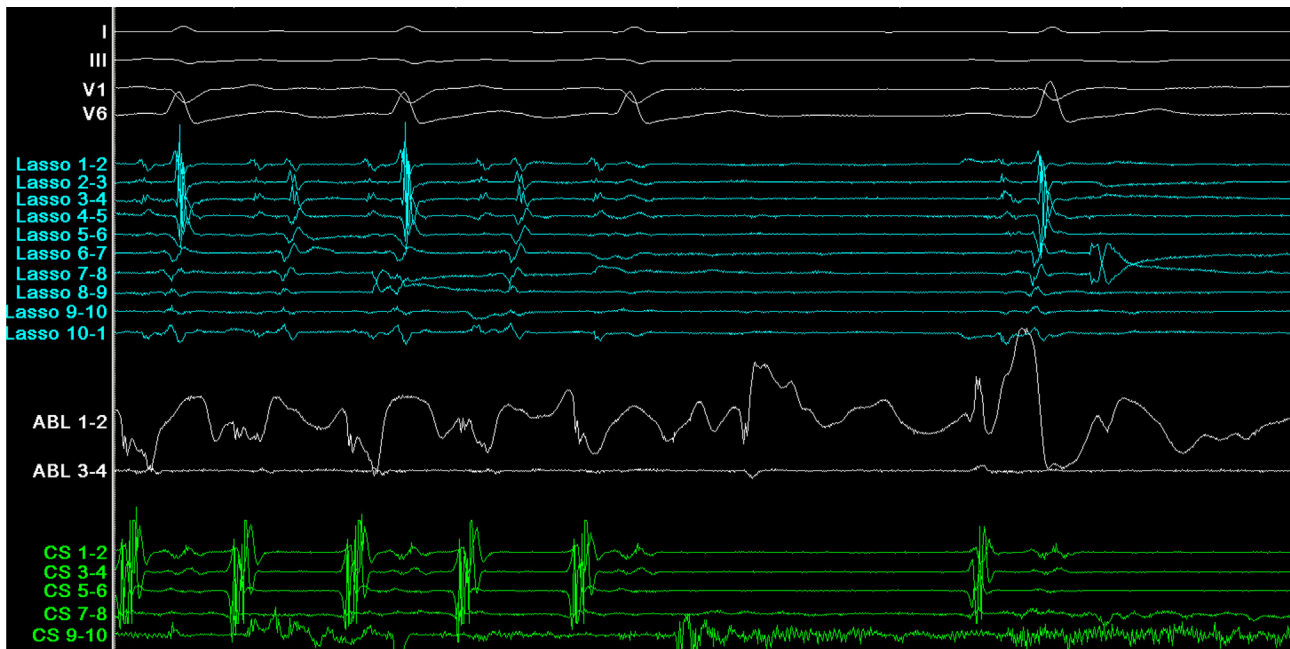
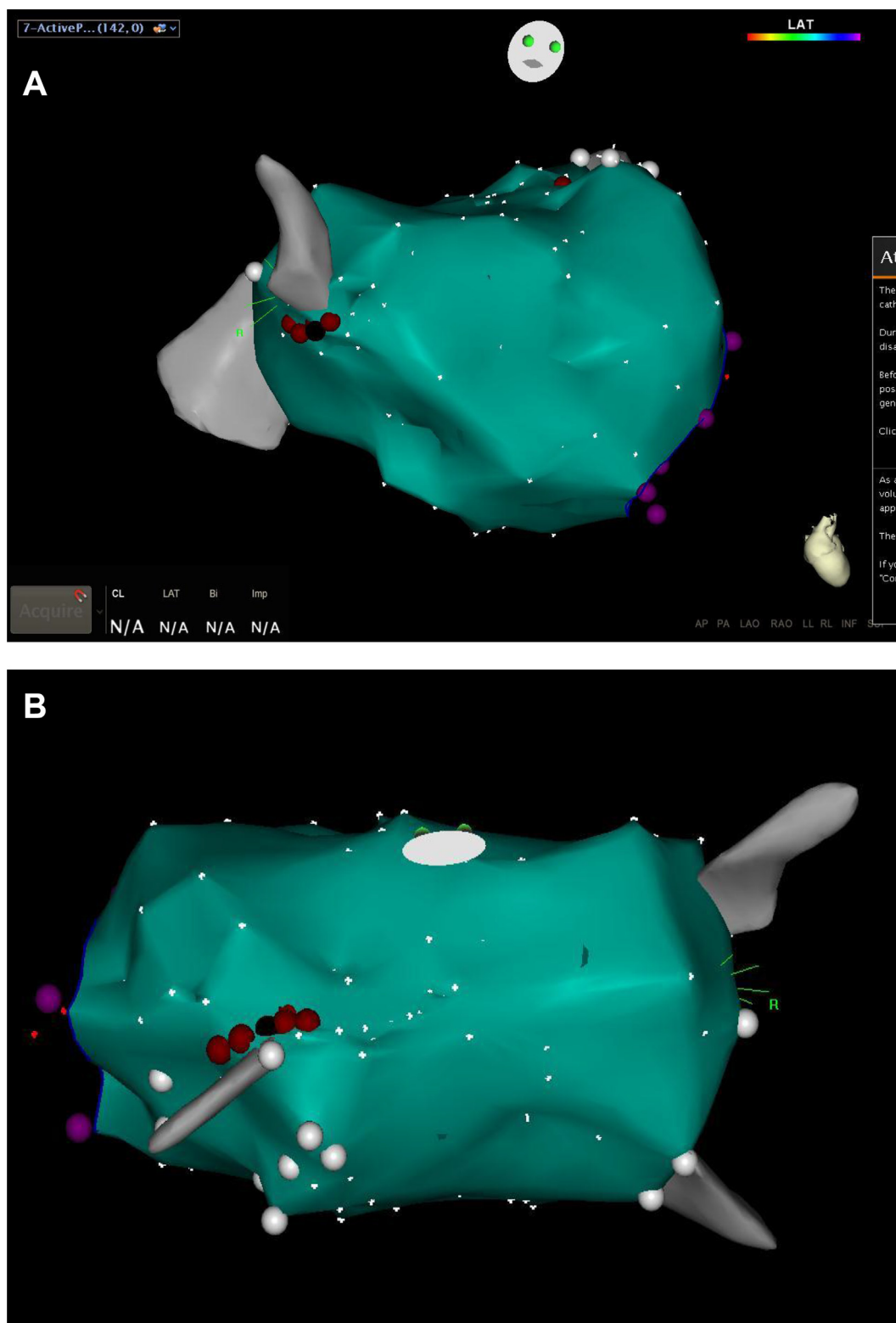


Fig. 2 – The intracardiac recording at the termination of macro reentrant tachycardia during ablation close to the left superior pulmonary vein.



**Fig. 3 – CARTO images with ablation points at the site where arrhythmia was terminated near the LSPV (A) and at the site where the gap of the box was closed near the RSPV and the completeness of the box lesion was achieved (B).**

development [5,8]. The hybrid approach consists of surgical thoracoscopic ablation followed by an EP study to check the lesion for completeness. Two different sets of thoracoscopic instrument approaches have been developed. One approach

uses the COBRA Fusion instrument set (Estech, Atricure, Inc.), which needs only a unilateral thoracotomy. The approach is from the right side, and the left atrium is encircled (above the superior PVs and below the inferior PVs) by a single flexible

ablation catheter and all 4 PVs are isolated with a single box lesion. The other instrument set uses a radiofrequency bipolar clamp (AtriCure Isolator Transpolar Clamp, AtriCure Inc.), and both left and right sided thoracotomy is needed. All 4 PV are isolated separately at the ostia. Additionally, the superior and inferior PVs are connected by separate lines using a radiofrequency pen (AtriCure Isolator Bipolar Pen, AtriCure Inc.). Despite the differences in techniques, the goal of both surgical procedures is similar, i.e. the creation of a box lesion surrounding the 4 pulmonary veins. Both techniques have their own advantages and disadvantages. The disadvantage of the Atricure system is the need for a bilateral thoracotomy. The advantage is that, it allows for isolation and verification of isolation of each PV to be done separately. A big plus for the COBRA system is that it is less invasive, since only a right thoracotomy is needed, A negative however, is that a single in the box lesion, created using COBRA, means that none of the PVs are isolated.

According to the recent reports, the hybrid approach seems to offer very good success rates with few complications [5,8]. However, procedure-specific complications, such as macro-reentrant arrhythmias, can occur.

Satomi et al. described macro-reentrant tachycardia caused by two gaps in the common circuit used for ipsilateral pulmonary vein isolation [9]. This atrial tachycardia was of CL approximately 290 ms. The associated mechanism was macro reentry caused by two gaps in the PV circuit. He noticed, that macro reentrant tachycardia was possible, when the gaps were further than 2 cm apart. A situation was found in our patient. The mechanism was also reentry, but it was caused by two gaps in the superior (roofline) section of a box lesion created during surgical thoracoscopic AF ablation. Pison et al. observed that the most common gap locations following surgical ablations are sites close to the upper pulmonary veins [8]; our findings are in agreement with Pison's observations. A combination of activation and entrainment mapping is necessary to assess the arrhythmia mechanism, however,

once determined, the ablation can be quiet easy with very good success rates.

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