

# A new method of superior vena cava isolation without phrenic nerve injury by longitudinal ablation parallel to the phrenic nerve: A case report

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## Abstract

Superior vena cava (SVC) isolation improves outcomes in patients with atrial fibrillation (AF). However, right phrenic nerve (PN) injury is a major complication of this procedure. Repeated SVC isolation was performed due to recurrence of SVC-triggered AF. The right atrium (RA)-SVC activation map revealed that the propagation broke through the gap at the PN site from the RA to the SVC. To avoid PN injury, the SVC was isolated by making longitudinal lines on both sides of the PN in a cranial direction. This novel approach of SVC isolation may be an effective therapeutic option to prevent PN injury.

## Introduction

The superior vena cava (SVC) isolation has improved outcomes of paroxysmal AF originating from the SVC<sup>1,2</sup>. However, right phrenic nerve (PN) injury is one of the major complications associated with the SVC isolation procedure, and 13% of the SVC isolation procedures could not be performed because of the risk of injury to the PN<sup>1</sup>. The PN passes through the posterolateral aspect of the SVC and the right atrium (RA). Therefore, in cases where the RA-SVC conduction site is near the PN, tremendous care is required to prevent PN injury.

Here, we report a novel method of SVC isolation without PN injury by longitudinal ablation parallel to the PN in a cranial direction in cases where the PN is located on the ablation site.

## Case report

A 65-year-old man complained of palpitation, prompting a visit to our hospital. He had a history of pulmonary vein isolation (PVI) for paroxysmal AF and underwent additional SVC isolation procedures for AF arising from the SVC. He experienced AF recurrence 7 months after the first procedure and underwent the second procedure. The reconnection between the SVC and the RA along the path of the PN and SVC firing was detected. Point-by-point radio frequency (RF) applications were performed at 15 W/30 seconds on the PN and SVC isolation was achieved. However, he had AF recurrence again 5 months following the second procedure. Written informed consent was obtained from the patient. He underwent the third procedure for recurrent paroxysmal AF.

The SVC-RA map during sinus rhythm using a three-dimensional (3D) mapping system (CARTO 3 system version 6; Biosense Webster, Diamond Bar, CA, USA) and a 20-electrode mapping catheter (Pentaray; Biosense Webster) revealed the reconnection between the SVC and the RA (Figure 1, Supplement 1). The PN site was identified by pacing at 20 mA/2.0 ms and 5 mA/2.0 ms using the contact force-sensing irrigated

ablation catheter (Thermo-Cool Smart touch SF, Biosense Webster). The circumferential conduction block line was detected by the lower threshold function in the CARTO 3 system version 6 (lower threshold at 20%, total local activation time of 155 ms) except for the course of the PN. Therefore, we attempted SVC isolation by making longitudinal lines on both sides of the course of PN(RF applications; 30W/30 seconds). The course of the PN identified at high output pacing (20 mA/2.0 ms) was wide, so we performed catheter ablation along the path of the PN site except for where low-output pacing (5 mA/2.0 ms) captured (Figure 1). We performed PN pacing at the right subclavian vein and confirmed compound muscle action potential (CMAP) to detect PN injury. Eventually, the SVC was successfully isolated without PN injury by making longitudinal lines on both sides of the PN in a cranial direction (Figures 1, 2). We confirmed the bi-directional block with SVC using isoproterenol infusion and adenosine triphosphate (40 mg). Postoperatively, the patient maintained sinus rhythm without antiarrhythmic drugs during a 14-month follow-up period.

## Discussion

In this case, insufficient low-output ablation to the PN site caused the reconnection of the SVC and subsequent AF recurrence. In this session, the course of the PN was effectively identified by high and low-output pacing.

We adjusted the output to precisely detect the course of the PN. In addition, when catheter ablation was performed near the PN where high out-put pacing captured, we performed CMAP to monitor for the occurrence of PN injury<sup>3</sup>. A previous study reported that , to avoid PN injury, the ablation line was directed parallel to the PN in a caudal direction. However, this method posed the risk of sinus node injury if the PN extended near to the sinus node and could not be performed in case the PN has continuous proximity from the SVC to the RA<sup>4</sup>. Our case describes a new approach to prevent PN injury by making longitudinal lines on both sides of the PN in a cranial direction. This method could facilitate safe and effective isolation of NPVF in the SVC with the conventional system, including the cases with AF foci located on the course of the PN.

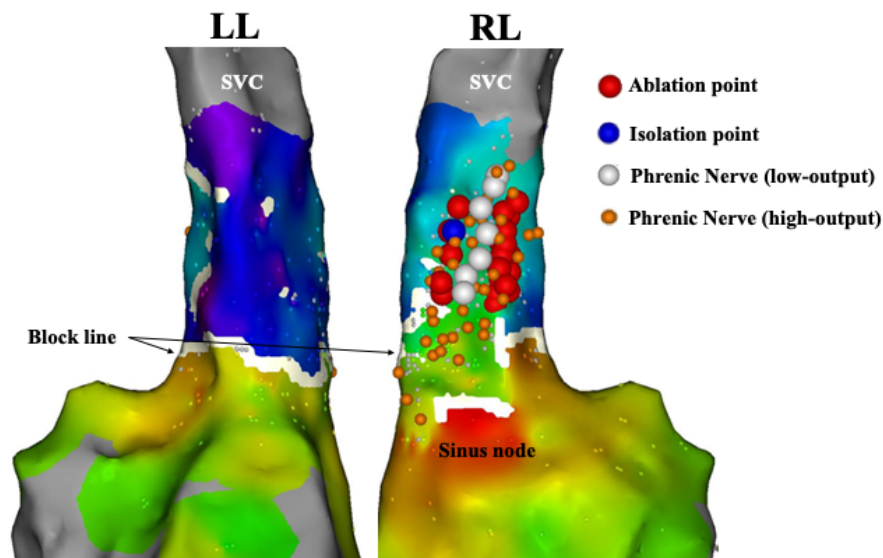
In conclusion, longitudinal linear ablation on both sides of the PN may be a therapeutic option to isolate the SVC and avoid PN injury.

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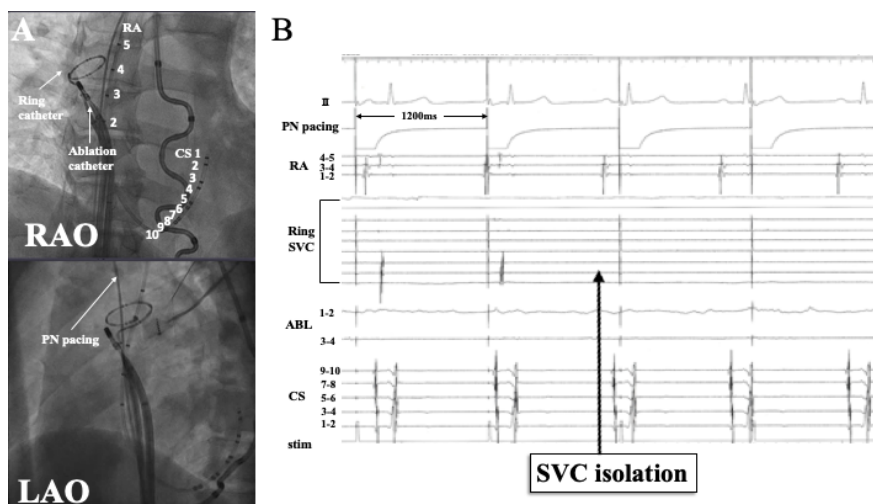
## Figure legends

### Figure 1



Superior vena cava-right atrium (SVC-RA) activation map during sinus rhythm show the reconduction of the SVC. The circumferential conduction block line was detected by lower threshold function at 20% with total local activation time of 155 ms (white line). The propagation broke through the gap at phrenic nerve (PN) site from the RA to the SVC. The PN sites were identified by high and low-output pacing (white points and orange points). We performed the longitudinal linear ablation from the RA to the SVC in a cranial direction (red points).

**Figure 2**



A) The longitudinal linear ablation in a cranial direction was performed with the mapping catheter positioned in the superior vena cava (SVC), pacing the phrenic nerve (PN) for confirming compound muscle action potential. B) SVC isolation was performed during the PN pacing with 1200-ms interval. The intracardiac electrogram shows SVC isolation from the 3<sup>rd</sup> beat.

**Supplement 1** The activation map during sinus rhythm shows the reconduction between the superior vena cava (SVC) and right atrium (RA) using Coherent map<sup>TM</sup> in CARTO 3 system.