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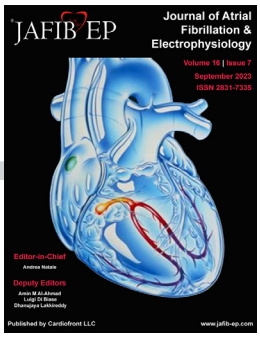

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Radiofrequency Catheter Ablation via the Superior Vena Cava Using the Robotic Magnetic Navigation (RMN) System in a Patient with Atrial Flutter and Iliac Vein Compression Syndrome

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Abstract

Radiofrequency catheter ablation of atrial flutter is commonly performed via the femoral vein. There are special cases such as iliac vein compression syndrome and congenital anatomical abnormalities in the femoral vasculature that make approaching the isthmus from the femoral vein difficult. Of course, in the congenital absence of an inferior vena cava, approaching the isthmus from the femoral vein is impossible. In this case report, a patient with atrial flutter and iliac vein syndrome was treated with radiofrequency ablation via the subclavian vein using a robotic magnetic navigation (RMN) system.

Introduction

Catheter radiofrequency ablation of atrial flutter is commonly performed via the femoral vein. There are special cases such as iliac vein compression syndrome and congenital anatomical abnormalities in the femoral vasculature that make approaching the isthmus from the femoral vein difficult. Of course, in the congenital absence of an inferior vena cava, approaching the isthmus from the femoral vein is impossible. A less common approach is to introduce a catheter through the subclavian vein. In this case report, we introduced an ablation catheter from the subclavian vein to perform radiofrequency ablation of atrial flutter in a patient with iliac vein compression syndrome.

Case Report

A 51-year-old female was hospitalized with symptomatic atrial flutter. The patient had previously failed treatment with external direct current cardioversion and metoprolol, as well as antiarrhythmic drugs. At the time of admission, the patient had 100% oxygen saturation, blood pressure of 120/70mmHg and a regular heart rate of 75 beats per minute. Physical examination revealed a 1/6 systolic murmur in the left sternal border. Lab work showed that hemoglobin, BNP, white blood cell count, and thyroid function were within normal ranges. Her ECG during palpitation (**Figure 1**) was suggestive of clockwise atrial flutter. Her transthoracic echocardiography revealed a left ventricular ejection fraction of 65%, a left atrium diameter of 39 mm, and mild tricuspid regurgitation.

The electrophysiology procedure was performed without general anesthesia. First, the left femoral vein was punctured under local anesthesia (1% lidocaine) and a short straight 8F sheath was inserted. The delivery of the deflectable 10-pole catheter to the IVC proved difficult, so a long wire was inserted into the sheath to aid navigation, but we were still unsuccessful in reaching the IVC. Subsequently, we

Key Words

radiofrequency ablation; iliac vein compression; subclavian access; robotic magnetic navigation system

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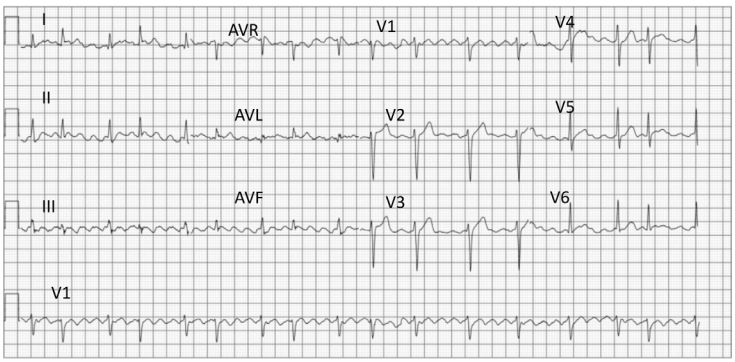


Figure 1: ECG after hospital admission.

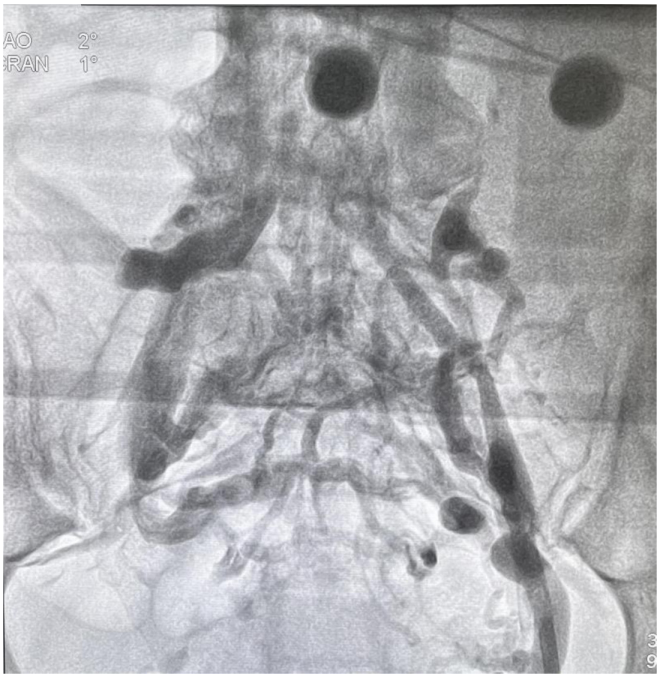


Figure 2: The iliac vein is compressed, along with extensive collateral formation.

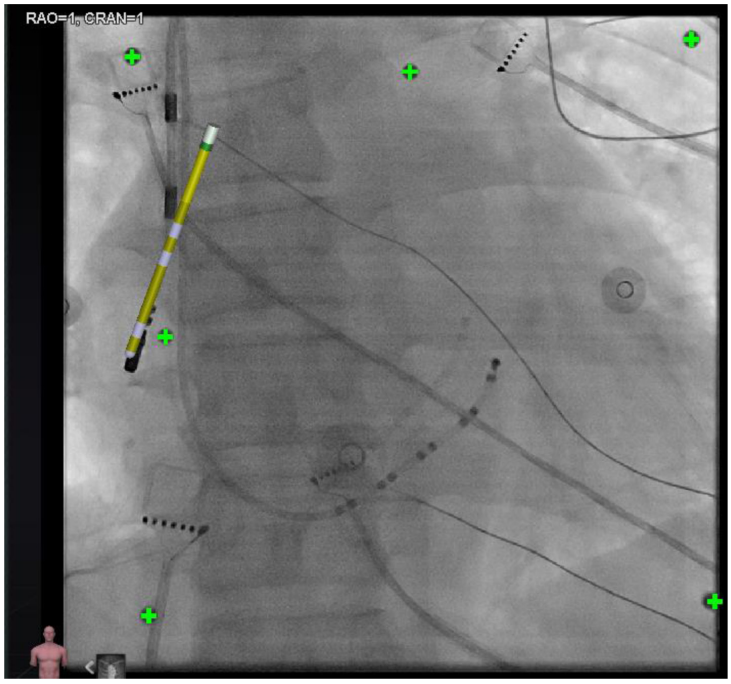


Figure 3: Ablation catheter in right atria via the left subclavian vein; a 10-electrode catheter in CS via the right internal jugular.

performed femoral vein and iliac venography from the sheath and found that the left iliac vein showed reticular development (**Figure 2**). We attempted access from the right femoral vein, and the catheter could not pass through the right iliac vein either.

According to the patient's medical history, we found that prior to her hysterectomy two years ago, the patient had a history of uterine fibroids, which caused bladder pressure and frequent urination. This may be related to her iliac compression syndrome.

Because of the inability to gain access via the IVC, we chose to perform the procedure via a superior vena cava (SVC) approach. For this procedure, the Niobe® Robotic Magnetic Navigation system (Stereotaxis, Inc., St. Louis, USA) was used to direct a Navistar Thermocool RMT magnetic ablation catheter (Biosense Webster, Diamond Bar, CA). Unlike conventional pull-wire catheters, this magnetic ablation catheter is extremely flexible and soft, and the RMN system's magnetic field provides direct control of the catheter tip.

For access, a 7F sheath was placed through the right internal jugular vein. Through the 7F sheath, we inserted a decapolar catheter in the coronary sinus (CS). Following left axillary angiography, the magnetic ablation catheter was placed via an 8F sheath in the subclavian vein (**Figure 3**). A FAM was created (**Figure 4**) and rapid atrial pacing induced atrial flutter. The activation and propagation map were suggestive of clockwise atrial flutter (**Figure 5**). At this stage, spot radiofrequency (RF) lesions were delivered on the IVC-TA isthmus, and then linear lesions were delivered at 30W, for 120–240 s resulted in the termination of atrial flutter and restoration of normal sinus rhythm (**Figure 6**). Following ablation, no arrhythmias were induced using a vigorous stimulation protocol and administration of isoprenaline. Bidirectional block was confirmed by pacing from CS 9/10 and ablation catheters. At the 16-month follow-up, no more symptoms were observed.

Discussion

Catheter ablation for cardiac arrhythmias is routinely performed via femoral vein access. However, congenital anatomical abnormalities or adjacent structural abnormalities of the femoral vein, iliac vein, or inferior vena cava, characterized by narrow vessel, vein bifurcation, excessive bending and tortuosity, interruption or hypoplasia, may lead to difficulty or inability in placing the ablation catheter via the femoral vein.[1] Studies indicate that obstruction above the iliac vein has the greatest incidence among middle-aged women and suggests that compression of the iliac vein is not uncommon on CTs from asymptomatic people.[2] In these cases, superior vena cava access may either be beneficial or required, and this approach is enhanced with the use of RMN.

Narikawa et al.[3] also reported an approach from the internal jugular vein for PVI in a patient with AF and an IVC filter. The patient described in our case report was in a similar situation, suffering from iliac vein compression syndrome and formulation of collateral circulation in the iliac vein, which precluded IVC access.

Congenital or acquired abnormalities of IVC create technical challenges in introducing ablation catheters. Alternative approaches via the internal jugular vein, subclavian vein, and transhepatic approach[4,5] have been used for ablation of atrioventricular nodal reentrant tachycardia,[6] accessory pathways,[7] and atrial fibrillation[5] via superior approach in patients with IVC anomalies. There are also reports of atrial flutter ablation via an azygos vein approach.[8] In these reports,

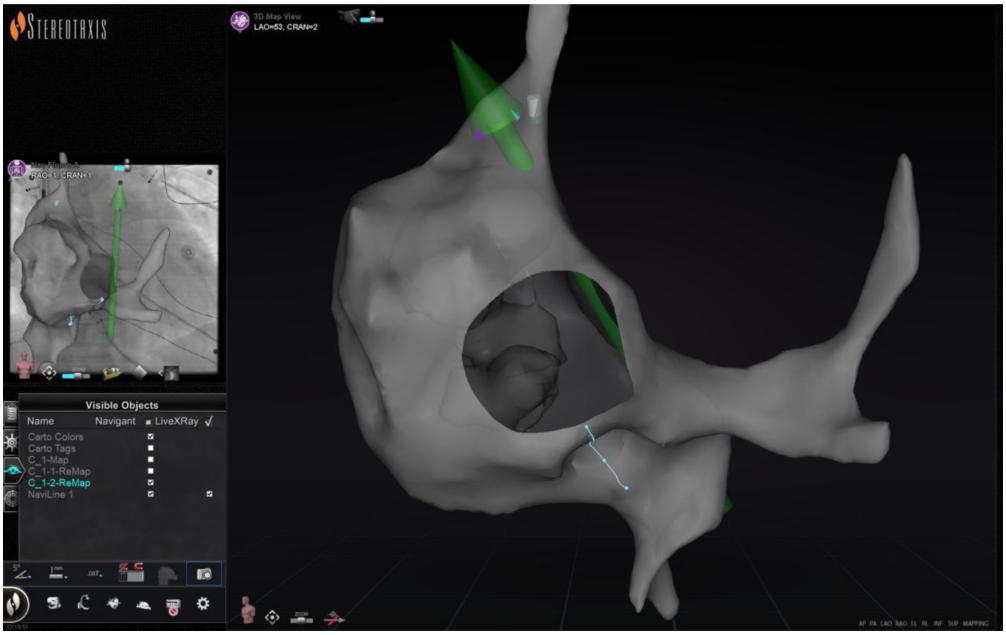
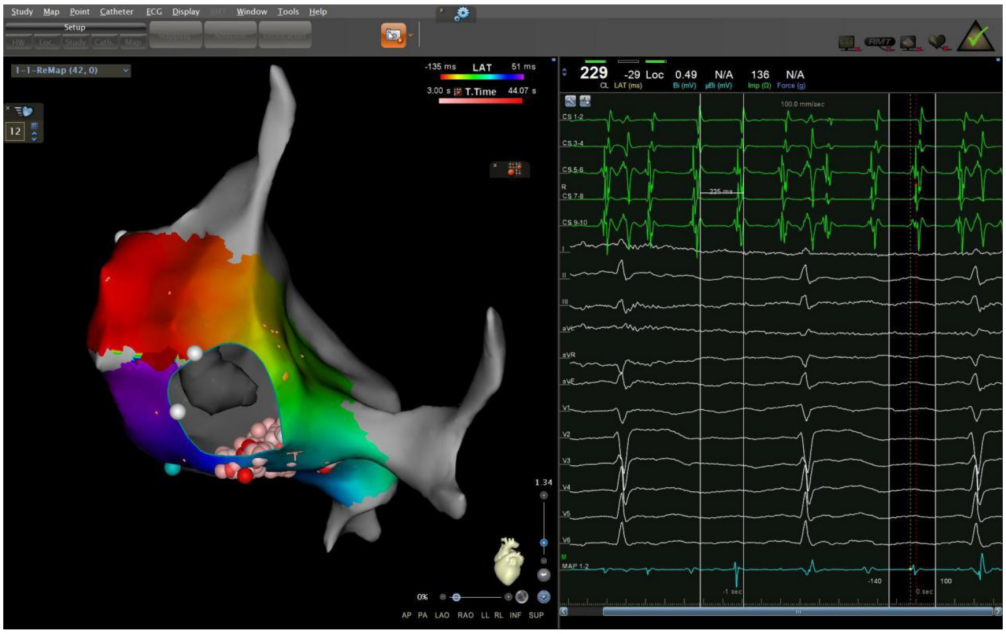


Figure 4: Right atrium and tricuspid annulus were mapped.



AT cycle length 200ms

Figure 5: Activation mapping of atrial flutter.

manual approaches were used and operators experienced several navigation challenges, such as difficulties of catheter manipulation, unstable catheter contacts, and increased radiation exposure.

Differences between RMN and manual catheters

Most manual ablation catheters are designed for inferior vena cava access. The length of the catheter is optimized for this approach, with most of the length supported by the patient's vasculature. Catheter bowing is minimized, and the tortuosity of the blood vessels aids torque transmission. Catheter deflection can occur from relatively stable locations.

When employing the same manual catheter in a superior approach, more of the catheter shaft is outside the body, thereby changing the catheters handling characteristics noticeably. This shift, when combined with the unfamiliarity of the approach, requires additional effort and time as physicians need to understand and estimate the catheter motion and learn innovative maneuvers to access the desired site for ablation

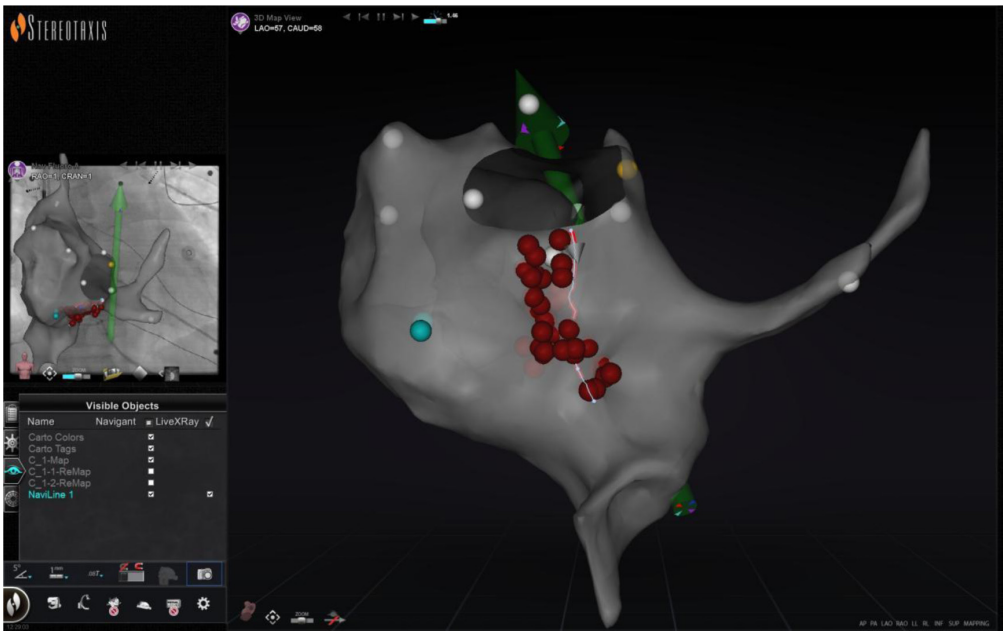


Figure 6: **Linear ablation of tricuspid isthmus.**

while maintaining stability. Navigating the tricuspid isthmus from SVC access requires a higher level of skill in catheter manipulation, because the movement does not follow the inferior access technique of dragging the catheter back to the IVC. Operating the catheter through the superior vena cava proved challenging and could result in complications, especially during ablation in the vicinity of the His bundle region. In addition, the operator may experience greater radiation exposure compared to the femoral approach, due in part to the increased fluoroscopy time, but also due to the operator's closer proximity to the X-ray tube. Finally, patient discomfort can be a problem. In China, most radiofrequency ablation procedures are performed under local anesthesia, and patients may feel anxious and discomfortable when manipulating catheters in the neck and shoulder region, inciting patient movement that could cause map shifts and procedure failure.[9]

Employing Stereotaxis Niobe® robotic magnetic navigation system in such patients may help to overcome the manual catheter challenges above. The magnetic catheter is less likely to cause mechanical perforations due to its flexible shaft and limited maximal force, increasing operator comfort when maneuvering the catheter with minimal fluoroscopy. Robotic magnetic navigation is emerging as one of the most promising technologies for the treatment of arrhythmias and the only option for some abnormal patient conditions. RMN has been demonstrated in prior studies to accurately navigate catheters to target locations with exceptional precision while maintaining stable focal contact. When compared to conventional manipulation for catheter ablation, numerous studies have shown that RMN can improve mapping efficiency, ablation time, and navigation to difficult sites.[10] In this case report, we performed linear ablation of the tricuspid isthmus via subclavian venous access using RMN without complications.

Conclusions

Isthmus dependent flutter ablation can be performed safely via the superior approach in patients with venous anomalies. Application of robotic magnetic navigation technology may be the preferred option in such special cases.

Key teaching points

- Iliac vein compression syndrome, congenital inferior vena cava agenesis or malformation can block a patient's inferior vena cava.
- Catheter ablation from the superior vena cava can be challenging using conventional catheters that are designed for access via the IVC.
- Magnetic navigation catheters can overcome this operational difficulty. It may be helpful for special access situations.

Funding

None

Conflict of interest

None

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