USING NON-STEERABLE DIAGNOSTIC CATHETERS FOR ZERO-FLUOROSCOPY MAPPING OF RIGHT VENTRICULAR OUTFLOW TRACT ARRHYTHMIAS VIA SUPERIOR VENA CAVA: A TECHNICAL REPORT

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Summary

Background: Techniques for zero-fluoroscopy mapping of right ventricular outflow tract (RVOT) arrhythmias are increasingly implemented and usually use deflectable catheters such as steerable diagnostic catheter or ablation catheter via inferior vena cava. These catheters can cause mechanical trauma and be more expensive than the non-steerable ones, especially in developing countries. We have introduced the technique of using non-steerable diagnostic catheters to replace the deflectable catheters for a fluoroless RVOT approach (FRVOTA). ***Subjects and methods:*** In this report, we introduced a fluoroless RVOT approach and mapping using non-steerable diagnostic catheters. We conducted on 41 patients undergoing catheter ablation for RVOT VAs from May 2020 to November 2021 at the Cardiovascular Center of E Hospital. ***Results:*** The mean time of procedural and ablation were 74.4 ± 27.3 min and 588.9 ± 344.3 seconds, respectively. Acute procedural success was achieved in all patients and the success rate was 90.2% (37/41) at a mean follow-up of 2 ± 0.5 months. No complication was noted. ***Conclusion:*** Techniques for zero-fluoroscopy mapping of right ventricular outflow tract (RVOT) arrhythmias is feasible, safe, and cost-effective to map RVOT arrhythmias.

** Keywords: Right ventricular outflow tract arrhythmias; Non-steerable diagnostic catheter; Zero-fluoroscopy approach.*

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INTRODUCTION

Catheter ablation for right ventricular outflow tract (RVOT) arrhythmias is normally performed under fluoroscopy guidance and the risks of radiation exposure for patients and catheterization lab personnel have been demonstrated in several articles with complex and/or lengthy electrophysiology studies [1, 3]. Minimizing or even eliminating the need for fluoroscopy and radiation exposure is desirable to prevent harm to the patient and healthcare workers.

The increasingly common electroanatomic mapping (EAM) systems have allowed operators to significantly reduce radiation exposure [4], even to achieve zero-fluoroscopy level. In the fluoroless RVOT mapping procedure, deflectable catheters are normally manipulated to approach and map the tract [5, 6] and are typically monitored under the guidance of EAM system and ICE (intracardiac echocardiography) [7]. The combination of deflectable catheters, ICE, and EAM systems is shown to be safe and feasible in fluoroless catheter ablation of idiopathic RVOT arrhythmias [5,7]. However, using deflectable catheters to map RVOT arrhythmias can sometimes cause mechanical trauma and generate pseudo elimination of arrhythmias with junior electrophysiologists. Furthermore, ICE may be unavailable in many developing countries including Vietnam.

Therefore, we have introduced the technique of using non-steerable diagnostic catheters to evaluate the safety and feasibility for a fluoroless RVOT approach (FRVOTA), which can simplify the mapping of idiopathic RVOT arrhythmias particularly and right heart arrhythmias generally. Moreover, using non-steerable diagnostic catheters for patients is more cost-effective when compared with the combination of steerable diagnostic catheters and ICE.

SUBJECTS AND METHODS

1. Subjects

The study enrolled 41 consecutive patients undergoing catheter ablation for RVOT VAs with electrocardiographic features of typical left bundle branch block, inferior axis QRS morphology, and a precordial transition $\geq$ V3 from

May 2020 to November 2021 at the Cardiovascular Center of E Hospital. Techniques for zero-fluoroscopy mapping of right ventricular outflow tract (RVOT) arrhythmias were accepted by the Ethics Committee of Hanoi E hospital.

2. Methods

** Study design:*

This is a prospective study.

** Techniques:*

FRVOTA is performed under the assistance of the Ensite Velocity 3D EAM system using non-steerable diagnostic catheters (a decapolar catheter 5F, 2/8/2 mm and a quadripolar catheter 5F, 5/5/5 mm, St. Jude Medical Company, Irvine, CA, USA). These catheters are reshaped to form new curves with the decapolar and quadripolar catheters in semicircular and moderate deflection shapes respectively (*Figure 1A*). We use two geometric projections (left anterior oblique [LAO] and right anterior oblique [RAO]) to make referential navigation for the whole procedure while the external skin patch was used as the initial reference.

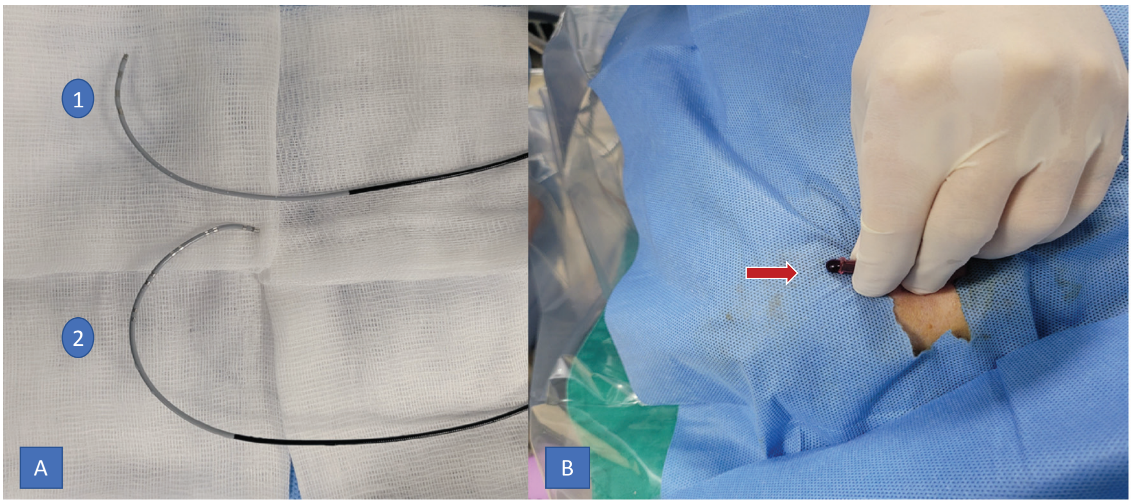

Figure 1: A, Reshaping the grey tip in the form of moderate deflection with the quadripolar catheter (1) and in the form of a semicircle with the decapolar catheter (2)(a decapolar catheter 5F, 2/8/2 mm and a quadripolar catheter 5F, 5/5/5 mm, St. Jude Medical Company, Irvine, CA, USA). B, Confirmation of the venous blood color and the pressure (red arrow).

Step 1: Manipulation of the non-steerable decapolar diagnostic catheter via SVC (Figure 2)

After the left subclavian or right jugular vein puncture is confirmed by the venous blood color and the pressure measurement (*Figure 1B*), a 6F sheath is inserted and fixed. The decapolar catheter, which is reshaped, is connected to the EAM system and advanced firstly into the right atrium (RA) through the sheath. The 3D geometry of superior vena cava (SVC) and RA is partly constructed by the advancement of the catheter and is confirmed by the obtained intracardiac electrograms. As the catheter contacts the tricuspid annulus (TA), the atrial and ventricular signals are recorded by the catheter and become a milestone to locate and mark the His bundle. From His bundle site, the catheter is slightly pushed through the TA until only ventricular intracardiac electrogram is shown, then signal amplitude decreases and disappears. The tip of catheter is kept perpendicularly and cranially upward in LAO view. The ventricular signal changes when the catheter moves to the RVOT and goes up to the pulmonary artery. The border of abrupt amplitude change indicates the pulmonary valve. We continue to manipulate the decapolar catheter in RVOT to map all its 3D anatomy structures and nearby regions. After completion of voltage and activation mapping, the catheter is pulled back until its distal pair of electrodes is at the TA level. The decapoplar catheter is rotated clockwise, directed perpendicularly to the interatrial septum under the guidance of both LAO and RAO views. The manipulation of the catheter is continued until it is inside the coronary vein and the atrioventricular electrograms of the mitral valvular annulus are recorded. The positioned CS decapolar catheter can be set as an intracardiac reference for mapping confirmation by ablation catheter.

Step 2: Manipulation of the non-steerable quadripolar diagnostic catheter via inferior vena cava (Figure 2)

The quadripolar catheter is used to reconstruct a 3D geometry roadmap of the inferior vena cava (IVC) through a 6F sheath, which is inserted into the right femoral vein. The catheter is connected to the monitoring system before inserting through the sheath and its movement and location are observed using recorded intracardiac electrogram signals on the monitor.

The quadripolar catheter is often slightly pushed forward towards the head until it shows the atrial electrogram signal. The initial presence of atrial electrograms is a mark of the junction between the IVC and RA. The catheter tip movement is controlled during the whole process of 3D IVC geometric contours reconstruction, pulling back a little and changing the direction in case the tip goes diagonally or stuck, and always making sure its manipulation is smooth. The 3D IVC geometry is created by a non-steerable catheter to allow fluoroless approach of the ablation catheter to RVOT over the built roadmap. When it reaches the TA, the catheter is advanced ahead corresponding to the 12 o'clock position in the LAO view.

The manipulation during the procedure must be gentle and follows a rule: Pushing a short distance and holding slightly, heading towards the heart chambers.

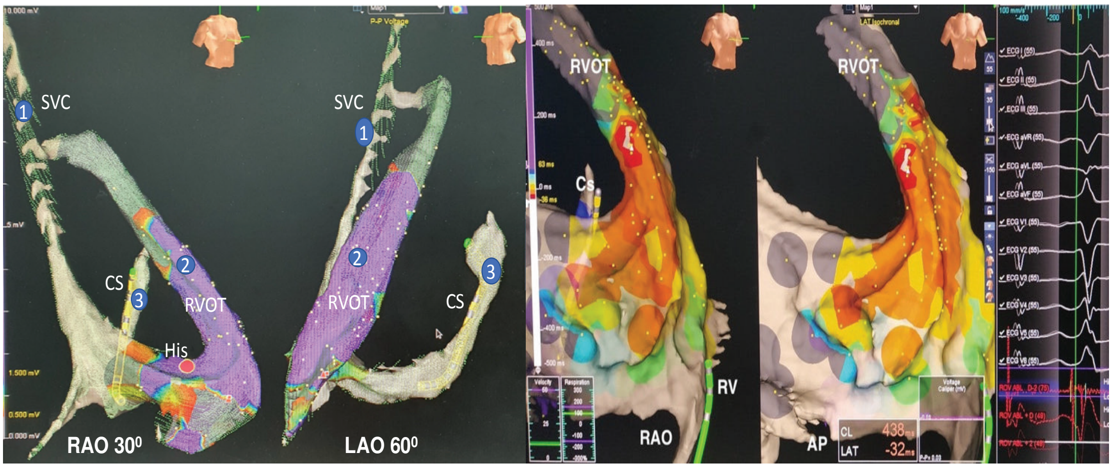

Figure 2: Using a non-steerable decapolar catheter to map RVOT and locating inside CS as an intracardiac reference. The reconstructing steps start from SVC to RVOT, and finally CS. The non-steerable decapolar catheter is used for the voltage map (left) and activation map (right).

RESULTS

Our technique was performed in 41 patients (11 males) with RVOT originated VPC/VT from May 2020 to November 2021. All procedures were performed without fluoroscopy in RVOT reconstruction and mapping. The mean age of patients was 53.6 ± 13.5 years (range 23 - 83 years). Used mapping methods for RVOT VPC/VT were voltage map and activation map with only the non-steerable decapolar catheter. Of the 41 patients who underwent RF catheter ablation, limited fluoroscopy was used in four patients to confirm target sites during the ablation stage due to insufficient 3D geometry. The remaining patients were completely treated with fluoroless approach, including mapping and RF ablation stages. The mean time of procedural and ablation were 74.4 ± 27.3 min and 588.9 ± 344.3 seconds, respectively. Acute procedural success was achieved in all patients and the success rate was 90.2% (37/41) at a mean follow-up of 2 ± 0.5 months. No complication was noted in any patients (table 1).

Table 1: Procedural outcomes.

Procedural results	Values (n = 41)
Total procedure time (minutes) ($\overline{X}$ ± SD)	74.4 ± 27.3
Total RF ablation time (seconds) ($\overline{X}$ ± SD)	588.9 ± 344.3
Acute success (n, %)	41 (100%)
Long-term success (n, %)	37 (90.2%)
Major complication (n, %)	0 (%)

DISCUSSION

The first two EAM techniques allow operators to localize catheters in the heart chambers over a magnetic field (CARTO 3 system, Biosense-Webster, Inc., Diamond Bar, CA) or sensing impedance changes (Ensite Velocity 3D EAM system). Ensite Velocity 3D EAM system works on electrical impedances, allowing operators to observe the broad field of view and create the geometry in body regions remote from the chest. By producing the three orthogonal electrical fields, it can detect a catheter electrode in the patient's body [8], which allows operators to be able to access veins and reconstruct IVC 3D geometric contours via the femoral venous approach without ICE assistance. Moreover, we use the Ensite Velocity 3D EAM system because it can be compatible with available catheters, including both diagnostic and ablation catheters (irrigated and non-irrigated) [3, 8]. In some previous studies of fluoroless RVOT arrhythmias catheter ablation, Wang et al. [6] and Isa Ozyilmaz et al. [5] also used the Ensite NavX system for mapping in 163 and 9 patients, respectively and all reported the technique to be safe and effective. Another study also focused on zero-fluoroscopy during RVOT arrhythmias ablation procedures but the authors used a combination of the CARTO 3 system and ICE [7].

The development of steerable catheters has delivered the effects of the dynamic cardiac environment. Steerable diagnostic catheter technology that has been employed to ease contact to target sites is commonly used for geometry creation and mapping in cardiac electrophysiology. By the steering ability with various shaped curves, it can approach conveniently to cardiac anatomic structures [9]. The steerable catheter is favored for coronary sinus (CS) placement via femoral vein access. However, the operator occasionally needs to reshape the curve of the CS catheter to enlarge the curve size due to the wide space from the CS ostium to IVC and insufficient length of the catheter to reach the orifice [3].

One of the major challenges known during RVOT arrhythmias mapping is the frequency and inducibility of VPC (Ventricular Premature Complexes)/VT (Ventricular Tachycardia). Using a catheter with a soft tip is preferable to mitigate the risk of mechanical trauma. Most previous studies for the performance of RVOT arrhythmias mapping use deflectable catheters such as steerable diagnostic catheters or an ablation catheter for the first step of mapping [3, 5, 7]. Meanwhile, nearly all deflectable catheters have a harder tip than non-steerable ones. In our protocol, we can use only a non-steerable decapolar catheter for both RVOT arrhythmias mapping and CS placement with good efficacy and safety in a series of cases diagnosed with RVOT VPC/VT. Moreover, the cost of the procedure is significantly reduced as a non-steerable catheter is three times cheaper than deflectable catheters, as well as the need for ICE is avoided. We believe this is a feasible choice that is cost-effective and could still minimize the risk of radiation exposure and mechanical trauma for patients in institutes where ICE is not available.

CONCLUSION

Fluoroless RVOT approach and arrhythmias mapping can be performed safely and feasibly using a non-steerable diagnostic catheter. This technique also reduces radiation exposure for patients, operators, and other cath lab staff.

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