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Original article

Limited fluoroscopy catheter ablation of accessory pathways in children

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ABSTRACT

Background: Limited fluoroscopy ablation using 3D electro-anatomical system (3DS) has been used for arrhythmias in children, however it is not a common practice. We aimed to facilitate a fluoroscopy limited approach for ablation of accessory pathways (AP) in children.
Methods: Following electrophysiologic (EP) catheter placement a single dual-plane fluoroscopic image (right anterior oblique-30° and left anterior oblique-60° views) was acquired and the 3DS views were rotated to be a perfect match to the fluoroscopy. Ninety-four consecutive pediatric patients [mean age 11.8 ± 4.1 (4.2–18) years, 61.7% males] with Wolf–Parkinson–White syndrome underwent ablation of an AP. Fifty-seven had manifest AP, 54 had left-sided AP (LSAP) and 40 had right-sided AP (RSAP).
Results: The acute success rate was 95.7% (90/94), with a recurrence rate of 1.1% (1/90) at a mean follow-up of 13 ± 5.5 (4.4–22.9) months. Mean procedure and fluoroscopy times were 144 ± 45 (55–262) min and 1.8 ± 1.4 (0.1–5.6) min, respectively. Comparison of the first 20 procedures to the next 74 procedures demonstrated an extended procedure time (171 ± 53 min vs 135 ± 38 min, $p < 0.005$), however the fluoroscopy time, the number of long applications, the time to effect, and the acute success rate were similar. There were no permanent ablation-related complications.
Conclusions: A limited fluoroscopy approach for ablation of AP in children using 3DS is easily acquired, adapted, reduces the fluoroscopy time, and has an excellent efficacy and safety profile.

Introduction

Catheter ablation of atrioventricular (AV) accessory pathways (APs) has become the established therapy for the treatment of pediatric supraventricular tachycardia (SVT) [1]. Ablation procedures are typically of long duration and the reported fluoroscopy time ranges from 16 to 38 min, with a fifth of the procedures requiring more than 50 min [2]. Although the consequences of X-ray exposure during catheter ablation are not yet fully known, it is well established that radiation exposure is associated with increased incidence of dermatitis, genetic defects, cataracts, and malignancy [3,4], especially in children [5]. It has been shown that 3D electro-anatomic mapping systems (3DS) can significantly reduce and even eliminate fluoroscopy exposure during catheter ablation in children, with comparable safety and efficacy [6–14]. Although the advantages of this approach are well established, it is not yet a common practice [15]. We hypothesize that one of the important obstacles to overcome is the operator's familiarity with the fluoroscopy-based approach and views. We suggest combining the use of 3DS with limited fluoroscopy in a methodology that resembles the more familiar fluoroscopy approach. The aim of this study is to show that using 3DS with limited fluoroscopy is not associated with a prolonged procedure time, is safe, effective, and can be adopted easily.

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Patients and methods

This prospective study was conducted at The Schneider Children's Medical Center of Israel, Cardiology Institute, Petach Tiqva, Israel. Patient records were reviewed with the approval of the institutional review board at the Schneider Children's Hospital of Israel.

Patients

From December 2013 to May 2015, 94 consecutive children with overt ($n = 57$) and concealed ($n = 37$) accessory pathways underwent radiofrequency ablation or cryoablation guided by an electro-anatomic mapping system (EnSiteNavX^{TM}, St. Jude Medical, St Paul, MN, USA) and limited fluoroscopy. The inclusion criteria were patients with atrioventricular reciprocating tachycardia (AVRT) due to an overt or concealed AP and patients with asymptomatic Wolf–Parkinson–White syndrome with high-risk criteria or inducible AVRT. The demographic and clinical data collected included the patient's age, gender, ethnicity, height, weight, body surface area, medical history, and clinical manifestations.

Electrophysiological study

Electrophysiological (EP) study has been described in detail previously [16]. An electro-anatomic mapping system (EnSite-NavX^{TM}) was used to define anatomical and electrical landmarks and to reduce fluoroscopy time. An EP study was performed for risk stratification and to test for AVRT induction in each patient. In patients with overt pre-excitation, atrial fibrillation was induced to determine the short pre-excited RR interval (SPRRI) during atrial fibrillation. Children with induction of AVRT or with high-risk criteria for sudden death underwent ablation of the AP.

Placement of EP electrodes

After inserting three right femoral venous sheaths and a left subclavian vein (LSCV) sheath, the four EP catheters (2 quadri-polar, 1 deca-polar, and 1 ablation) were connected to the EP recording system and to the mapping system (EnSiteNavX^{TM}). The catheters were registered and calibrated by the mapping system (validation process). Optimization of the catheters' signals was achieved and respiration compensation was applied. The catheters were advanced to their positions using the 3DS exclusively.

Combined approach: combined uses of 3DS and limited fluoroscopy in a method that precisely resembles the familiar fluoroscopy approach

In all cases, the EnSiteNavX^{TM} electro-anatomic system (3DS) was used with NavX^{TM} skin patches. Six patch electrodes (NavX) were placed on the body to create three orthogonally intersecting axes, with the heart at the center. Accurate patch placement is essential and it is very difficult to maintain uniform standard patch placements, especially in the relatively small body of a child. For this reason there is a wide variability of the views acquired using 3DS. As seen in Fig. 1A and B, the frequently used views for catheter ablation, right anterior oblique (RAO) 30° and left anterior oblique (LAO) 60°, demonstrate the relative position of the catheters, quite different on the EnSiteNavX^{TM} mapping system from the same angled views using traditional fluoroscopy (Fig. 1B). These differences may make it difficult for the operator to navigate freely and precisely with the non-familiar 3DS views.

To overcome this we developed a simple method so that the 3DS views will resemble those of fluoroscopy. Once the EP catheters are placed in the desired locations, a single dual-plane fluoroscopic image (in RAO 30° and LAO 60° views) is acquired (Fig. 1B), and the 3DS views are rotated and scrolled to perfectly match the fluoroscopic views (Fig. 1C) and once this is achieved the 3DS is used almost exclusively for catheter movement and navigation. The ablation catheter is maneuvered similarly for further mapping using local activation time. Each ablation application is marked within the 3DS acquired anatomy of the heart. Once successful ablation is achieved, "insurance" applications are made in close proximity to the successful site using the 3DS.

Use of fluoroscopy was limited exclusively to: (1) contrast injection for imaging of the LSCV (for sheath insertion); (2) any difficulty in advancing a catheter through the inserted sheaths; (3) trans-septal puncture in the case of left-sided accessory pathways (LSAPs); (4) a single dual-plane fluoroscopic image (in RAO 30° and LAO 60° views) acquired once the electrodes were positioned; (5) navigating the ablation catheter during the mapping period, necessary only in rare cases. In addition, fluoroscopy, when performed, was adjusted at 15 frames per second (fps), single-shot pediatric low exposure at lowest radiation intensity (2.5 μR/s) to minimize the radiation exposure.

Definitions

High-risk APs were so defined if the AP effective refractory period (ERP) was <240 ms and/or SPRRI during atrial fibrillation was <250 ms. Acute ablation success was defined as the elimination of all AP conduction in direct response to RF ablation or cryoablation. Short RF applications were up to 10 s, long RF applications were usually for 60 s. The time to effect for cryoablation was defined as the duration of time from reaching −30 °C to the disappearance of the AP during the cryo-mapping phase. All patients were observed for at least 30 min following the apparently successful ablation. A repeat EP study with and without isoproterenol was performed post-ablation in order to ensure an inability to re-induce AVRT or any conduction via the AP.

Follow-up

All patients were left overnight for in-hospital observation and a repeat 12-lead electrocardiogram was recorded before discharge. Out-patient follow-up visits were arranged for 1 and 12 months post ablation. Recurrence was defined as the return of clinical symptoms, documented SVT, or the return of ventricular pre-excitation.

Statistics

All data were reported as median and range or mean and standard deviations for continuous variables and frequency for categorical variables. Independent Samples T test and one way ANOVA with Bonferroni's correction were used as needed for continuous variables. Comparisons of categorical data were performed using a χ^2 (Fisher's exact test for cell counts <5). Statistical analysis was performed using the SPSS version 17.0 statistical package (Chicago, IL, USA). A p-value < 0.05 was considered significant.

Results

Ninety-four pediatric patients, 56 males and 38 females, with a mean age of 11.8 ± 4.1 years, underwent RF ablation and/or cryoablation guided by the electro-anatomic mapping system (EnSiteNavX^{TM}). All but two children (one with Ebstein's anomaly and one with an atrial septal defect) had a structurally normal heart. Fifty-seven had a manifest AP and 37 had a concealed AP, 54 had a LSAP and 40 had a right-sided AP (RSAP), among them 7 with para-Hisian AP and one with Mahaim fiber. Four children had two APs and two children had both an AP and AVNRT. All but one of these six children was successfully ablated. The patient with Ebstein's anomaly