Feasibility, accuracy, and safety of 3-dimensional electroanatomic mapping without fluoroscopy in patients with congenital heart defects

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BACKGROUND Use of nonfluoroscopic 3-dimensional electroanatomic mapping (NF-3DEAM) in patients with congenital heart defects (CHDs) is not well reported.

OBJECTIVE The purpose of this study was to evaluate the feasibility, accuracy, and safety of NF-3DEAM in patients with CHDs.

METHODS Retrospective review of electrophysiologic study (EPS) in patients with CHD from 2009 to 2013 was conducted. Patients undergoing EPS with NF-3DEAM using the EnSite NavX system (St. Jude Medical) were included and those with fluoroscopy were excluded. Cardiac angiography performed in close proximity was matched with 3DEAM by proper aspect ratio using manual alignment by overlay images and comparing distances between cardiac landmarks using Pearson correlation coefficient and intraclass correlation. Success and complications were reviewed.

RESULTS Three-dimensional electroanatomic mapping and angiograms were compared in 48 EPS (45 patients); 13 patients with intracardiac leads, quiescent chambers indicating significant scarring, and who required transseptal puncture were excluded. Indications for EPS included documented tachyarrhythmia and preoperative mapping. Mean age was 25.3 ± 9.8 years. Simple CHDs (isolated shunt lesions or valvular lesions) were identified in 13 studies (27%) and complex CHDs (others) were identified in 35 studies (73%). Ablations were performed in 25 studies (52%). Average time to obtain right atrial geometry was 25.3 minutes (range 14–47 minutes) and right ventricular geometry was 22.8 minutes (range 12–35 minutes). Pearson correlation coefficient and intraclass correlation of cardiac landmarks were 0.90 and 0.80, respectively. Anatomic landmarks, mapping, and ablation were accurate in all 3DEAMs. No complications were recorded.

CONCLUSION NF-3DEAM is feasible, safe, and accurate in CHD patients without extensive scarring, intracardiac leads, and need for transseptal puncture.

KEYWORDS Three-dimensional electroanatomic mapping; Congenital heart defect; Feasibility; Safety; accuracy

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Introduction

Advances in 3-dimensional electroanatomic mapping (3DEAM) have reduced radiation exposure during electrophysiologic study (EPS) in addition to the main utilities, including activation mapping, voltage mapping, catheter position, and ablation for defining lesions. The principle of 3DEAM involves generating a magnetic field, creating a virtual 3-dimensional image, and recording voltage and impedance using a mapping and reference catheter. Three-dimensional electroanatomic mapping is traditionally performed with fluoroscopic guidance and has been used for pediatric supraventricular tachycardia mapping and ablation with documented success without compromise in results or safety.[1–6] Previous studies also reported successful reduction or elimination of fluoroscopy in pediatric patients with normal cardiac anatomy.[3,5–7] A few case reports on the success of 3DEAM in patients with congenital heart defects (CHDs) have been reported.[8–10] To date, no studies on the utility of nonfluoroscopic 3DEAM (NF-3DEAM) in CHD patients have been conducted. The purpose of this study was to evaluate the accuracy, feasibility, and safety of NF-3DEAM in the CHD population.

Methods

Study design and patient selection

A retrospective single institutional review of patients with repaired and unrepaired CHDs who underwent EPS using NF-3DEAM from July 2009 to July 2013 for mapping and ablation was performed. The study was approved by the Institutional Review Board. Only patients who had undergone angiography for hemodynamic or interventional cardiac catheterization within 9 months of EPS were selected to aid in comparing accuracy. No patient underwent angiography to help with navigation of 3DEAM. Patients with

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hemodynamically insignificant valvular heart disease, such as bicuspid aortic valve without aortic insufficiency, mitral valve prolapse, and patent ductus arteriosus, were excluded. CHD patients who underwent fluoroscopy by the transseptal approach only were also excluded from our review. Demographic data including age, weight, and height, type of congenital heart lesions, indication for EPS, tachycardia mechanism, and follow-up status were reviewed. EPS details included time taken to obtain right atrial (RA) and right ventricular (RV) geometries (if performed), complications that occurred during or immediately after the procedure, and success rates.

Three-dimensional electroanatomic mapping

Three-dimensional electroanatomic mapping was performed using the EnSite NavX system (St. Jude Medical, St. Paul, MN). EP-Workmate (St. Jude Medical) was used for stimulation and recording in all cases. Cardiac magnetic resonance imaging, computed tomography, and intracardiac echocardiography were not used during EPS. All EPS was performed under general anesthesia by 1 pediatric electrophysiologist experienced in routinely performing EPS using NF-3DEAM. Femoral venous access was the preferred route. The EnSite NavX surface electrodes were placed per protocol but were trimmed for smaller patients per the manufacturer's recommendations (Figure 1). Venous anatomy was obtained as a steerable catheter was advanced from the venous access site. RA geometry was created from the point of obtaining the first atrial electrogram and marked as the inferior vena cava (IVC)–RA junction. The catheter was then guided into the superior vena cava (SVC), and the point of the SVC–RA junction where the atrial electrogram disappeared was located. The catheter was then maneuvered into the rest of the RA, the valvular points were marked, the location of His potentials was marked, and the catheter was positioned in the coronary sinus (CS) (when feasible). The tricuspid annular points where the atrial and ventricular electrogram signals were equal were marked. RV geometry was obtained in patients who underwent ventricular tachycardia (VT) study. A similar method was used to obtain RV geometry. From the tricuspid annular point, the steerable catheter was gently advanced to the RV apex and maneuvered in the RV cavity with constant rhythm monitoring. The pulmonary annular point was located when the ventricular signals disappeared. In contrast to RA geometry, RV geometry usually was obtained to identify important landmarks and sites having potential as the arrhythmia substrate, rather than for complete geometry. In patients with unique anatomy, lesion-specific landmarks were used. In patients with an RV-to-pulmonary artery conduit, the base or proximal part of the conduit landmark was defined. For patients with D-transposition of the great arteries who had undergone an atrial switch operation, the SVC, superior mitral annulus, and left atrial appendage tip were used. Voltage mapping was performed simultaneously to map scar tissue in all CHD patients. EPS was performed using standard protocols, with catheters placed in the high RA, across the tricuspid valve into the RV septum for monitoring His-bundle signals, in the CS (if feasible), in the RV apex, and in the RV outflow tract.

Angiography and fluoroscopy from recent cardiac catheterizations

Biplane angiographic images and fluoroscopy obtained from recent cardiac catheterizations, performed for either diagnostic or interventional purposes within 9 months, were used for correlation and comparison of the electroanatomic shell created. When more than one angiogram or fluoroscopy was available, the study closest to the date of EPS was chosen for comparison. In patients who underwent congenital heart surgery after EPS, only preoperative cardiac catheterization was selected for comparison. The angiographic and fluoroscopic images were reviewed by an interventional cardiologist. The measurements were performed online using the Syngo system (Siemens Healthcare, Germany), and the maximum dimension measured was used for comparison.

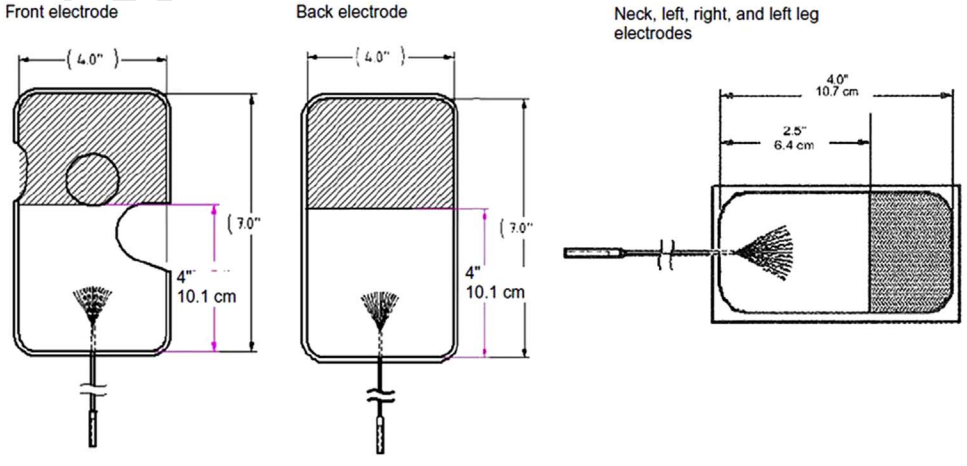

Figure 1 EnSite NavX surface electrodes. Trimmable portion is shaded. (Adapted from EnSite System Model EE3000, Version 8.0, Instructions for Use. U.S. Edition 54-06154-001, 2008, Chapter 3, p 40.)