ESOPHAGEAL SIGNALS AS REFERENCE GUIDE FOR ABLATIONS IN CONGENITAL HEART DISEASES

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Abstract

The quadripolar catheters used for the transesophageal electrophysiological study is an alternative in such cases due to limitations of vascular access and size of the pediatric patients, additional catheter for intracardiac electrograms cannot be placed in atria stable position.To aim of this article is to report the effectiveness of transesophageal electrode as a reference catheter in patients with limited vascular access and complex congenital heart disease during ablation procedures. Transesophageal catheters can be used as an alternative to the reference catheter in the electrophysiology laboratory for provoking or terminating arrhythmias, understanding mechanism of arrhythmias or as an aid in mapping

Figure legends:

Figure 1 . Catheter positions and ablation point of patient, esophageal catheter and its relation with atria is seen on fluoroscopic images.

Figure 2 . a) Ablation of left posteroseptal accessory pathway in ccTGA patient, reference esophageal catheter is red. Esophageal signals can be seen on the right side. b) Mapping with Advisor TM, HD grid mapping catheter on electro anatomical anatomy of right atria, arrow indicates signals received from posteriorly located esophageal catheter displayed green.

Figure 3 . Arrows pointing esophageal signals during mapping of atrial tachycardia.

Table legends:

Table 1 . Demographic and clinical features of the patients

Table 2 . Mechanism and management of the arrhythmias of the patients

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Despite technological advances in the field of catheter ablation and mapping system, there can be some limitations and challenges especially in congenital heart disease due to complexity of anatomy. In complex cardiac anatomy such as heterotaxia syndromes, chambers of heart, great vessels and structures such as coronary sinus may pose problems as they are not located where they used to be [1]. Vascular access is another challenge beside this complex anatomy, and arrhythmia mechanisms. During electrophysiological studies and ablation procedures reference signal keeps its importance in respect to recent developments of technology of mapping systems. A stable reference signal is mandatory in all cases. In such cases due to limitations of vascular access and size of the pediatric patients, additional catheter for intracardiac electrograms cannot be placed in atria stable position. Due to stability and gaining both atrium and

ventricular signals, coronary sinus is the most convenient place for reference catheters. The quadripolar catheters used for the transesophageal electrophysiological study is an alternative in such cases. Since the esophagus is in an anatomical position close to the left atrium, signals acquired from esophagus have both atrial and ventricular signals. In addition to acquiring stable signals from atria and ventricle, it can also be used to stimulate the atria [2, 3].

To aim of this article is to report the effectiveness of transesophageal electrode as a reference catheter in patients with limited vascular access and complex congenital heart disease during ablation procedures.

Case 1

A 25-year-old girl with left atrial isomerism, mitral atresia, moderate regurgitation of tricuspid valve, non-restrictive ventricular septal defect, non-restrictive atrial septal defect, severe subpulmonary stenosis with a systolic gradient of 60 mmHg and both great arteries were arising from right ventricle presented with high ventricular responded atrial tachycardia. Echocardiography showed no intracardiac thrombus, signs of systolic dysfunction or heart failure. Conversion to sinus rhythm could not be achieved with cardioversion. She underwent ablation procedure after one month of palpitation symptoms. CARTO 3 systems (Biosense Webster, Inc., Diamond Bar, CA, USA) is used for the three-dimensional mapping with Thermocool Smarttouch SF catheter. Reference catheter could not be inserted due to absence of hepatic portion of IVC. Ablation catheter inserted through right subclavian vein with a The Agilis NxT Steerable Introducer. A quadripolar catheter (Esolo FIAB, Italy) was inserted into esophagus as a reference catheter (figure 1). The tachycardia cycle length was measured as 280 ms with 2:1 AV conduction. The activation and propagation mapping revealed that the early-meets-late line was in the cavotricuspid isthmus region. In the voltage mapping, a widespread and patchy-style scar area was detected in the both atria. Cavotricuspid isthmus ablation was performed and sinus rhythm was achieved. There was no complication related to procedure.

Case 2

A 11-year-old boy with Ebstein anomaly, who underwent tricuspid valve replacement using a 27 mm St Jude prothesis when he was nine, underwent ablation due to drug resistant atrial flutter. ECG revealed an atrial rate of 250 ms and 4:1 AV conduction. Echocardiography revealed no paravalvular regurgitation from prosthetic valve, thrombosis nor increase in transvalvular mean doppler gradient of the prosthetic valve, with a normal ventricular systolic function. He had history of several CV under medical treatment of amiodarone and propranolol. Since decapolar reference catheter could not be inserted into the coronary sinus, a quadripolar catheter (Esolo FIAB, Italy) was inserted into esophagus as a reference catheter. The EnSite NavX Precision system (St. Jude Medical St. Paul, MN, USA) is used as three dimensional mapping system and Tacticath ^{TM} Quartz Contact Force (St. Jude Medical St. Paul, MN, USA) for mapping and ablation procedure. Widespread scar areas were detected in the posterolateral region of right atrium. The patient had three distinctive type of tachycardia with different cycle lengths, two reentries detected involving scar areas in right atrium posterior and superior region. Ablation lines were applied on that region in low voltage scar areas forming isthmuses for the reentries. Since ablation of myocardium under mechanical valve could not be performed due to loss of contact of catheter. CTI dependent flutter could not be accomplished even though ablation line extended beyond mechanical valve. Even though, CTI ablation could not be accomplished, sinus rhythm achieved under medical treatment of flecainide and propranolol and remained for two years after ablation procedure.

Case 3

A 15-year-old boy with a history of Rastelli procedure using a Hancock valve conduit for congenitally corrected transposition of great arteries, ventricular septal defect and pulmonary atresia underwent ablation for the complaint of palpitations for the last 6 months. The EnSite NavX Precision system (St. Jude Medical St. Paul, MN, USA) is used as three dimensional mapping system and Tacticath^{TM} Quartz Contact Force (St. Jude Medical St. Paul, MN, USA) with Agilis NxT Steerable Introducer for mapping and ablation procedure. Selective coronary angiography was performed as catheter could not be positioned into the coronary sinus despite multiple attempts which revealed that coronary veins were opened separately without

confluence of the coronary sinus. The Duodecapolar Steerable catheter (Medtronic, USA) was placed in the right atrium. Since the stable atrium potential could not be obtained, the transesophageal electrode (Esolo FIAB, Italy) was advanced into the esophagus towards the left atrium neighborhood via the nasal route. The tachycardia with 1:1 VA relationship was induced by single extra stimulus and catheter manipulation in the patient. Tachycardia was interrupted with entrainment mapping, and tachycardia was terminated by administration of adenosine. Activation and voltage mapping were performed during tachycardia in order to evaluate the scar areas in the atrium (figure 2a). Diagnostic maneuvers revealed AVRT with earliest atrial activity during tachycardia localized left posteroseptal region. Catheter was advanced into left atrium via patent foramen ovale, and then early atrial activity of the left atrium was mapped during tachycardia, -35 ms atrial activation was obtained in the left posterior region. Ablation was performed successfully without any complications.

Case 4

A 2-month-old girl with 6 kg of body weight was referred to our clinic with the diagnosis of tachycardia-induced cardiomyopathy. Electrocardiogram revealed long RP tachycardia with deep inverted P waves inferior leads. Echocardiography revealed a global dilatation of left ventricle (left ventricle end diastolic dimension of 36 mm, z score +4,3) with severe dysfunction of left ventricle (ejection fraction of 37%). A quadripolar catheter (Esolo FIAB, Italy) was inserted into esophagus as a reference catheter. Right atrial anatomy was mapped with Marinr ^{TM} CS Steerable Decapolar catheter (Medtronic, Inc., Minneapolis, MN, USA). During the procedure, long RP tachycardia was observed in the patient with negative P waves in the inferior leads. Pacing maneuvers revealed tachycardia mechanism as atypical AVNRT. Upon this, the activation mapping was obtained from earliest atrial activations during tachycardia, and ablation was performed in the posterior region of the right atrium near the entry of the coronary sinus with power of 30 W and 50°C temperature for 110 seconds. Tachycardia was terminated with accelerated junctional rhythm. On follow-up echocardiography, left ventricular systolic function has been improved. She is symptom-free for 2 years.

Case 5

A 21-year-old boy with a history of atriopulmonary anastomosis at the age of two for tricuspid atresia and severe pulmonary stenosis underwent ablation procedure for the atrial tachycardia documented in 24 hours Holter ECG recordings. The EnSite NavX Precision system (St. Jude Medical St. Paul, MN, USA) is used as three dimensional mapping system and Advisor TM, HD grid mapping catheter and Tacticath^{TM} Quartz Contact Force (St. Jude Medical St. Paul, MN, USA) with Agilis NxT Steerable Introducer for mapping and ablation procedure. Confluence of coronary veins was absent and they drained to atria separately. Reference quadripolar esophageal (Esolo FIAB, Italy) catheter inserted to esophagus with close relation to left atria. During sinus rhythm voltage mapping, and tachycardia activation and propagation mapping was performed with high definition catheter by reference atrial signals receiving from esophageal recordings (figure 2b). Although atrial-sensing signals received perfectly, atrial capture could not be achieved from esophagus due to dextrocardia (figure 3). Therefore decapolar catheter was inserted to high atria for induction of tachycardia. Focal atrial tachycardia originating from free wall of right atria was detected and ablated successfully. Atrial activity was 130 ms earlier on target point when compared to esophageal signal.

Discussion :

Survival of complex congenital heart disease has improved dramatically over the last two decades. Improved survival leads to facing different types of arrhythmias developing due to hemodynamic effects of underlying disease or corrective surgery. Radiofrequency catheter ablation (RFCA) is an important therapeutic option for these arrhythmias. Accessing to the heart in cases with complex congenital heart defects may become a real obstacle for operators. Abnormalities of vascular structures (absence of hepatic part of inferior vena cava, coronary sinus anomalies, double superior vena cava without intercaval communication, left superior vena cava), surgical boundaries, and obstructed femoral veins are real challenges for electrophysiologists. Besides different electrical properties of complex congenital heart diseases altered myocardium acts as a substrate

for atrial and ventricular arrhythmia. In complex congenital hearts reentries involving atria and ventricle scar areas are common with changing proportion to underlying disease or surgery as well as atrio-ventricular or nodal reentries or ectopic tachycardia. [4]

3D-electroanatomical mapping is recommended as class I for atrial and ventricular tachycardia in congenital heart diseases [5] which is reported to facilitate RFCA procedures for different types of arrhythmia mechanisms. All the mapping systems based on reference signal, and mapping catheter for electro anatomical mapping procedures. A stable positioned reference catheter is mandatory for performing such complex cases. Reference signal is generally acquired from intracardiac structures such as high right atria or coronary sinus, the latter is preferred mostly due to receiving signals both from atria, ventricle and extends to other side of atrioventricular groove. In cases with limited access resulting from congenital anomaly or size of the patient's signals acquired from esophagus are very good alternative for intracardiac electrograms. Signals from esophagus have both atrial and ventricular potentials; additionally, close relation with left atria provides information about left sided structures.

Esophageal catheters are generally used for semi invasive electrophysiological studies in our center, which provides us useful information about palpitation complaints during pediatric age group, or overdrive pacing protocols for control of arrhythmia. A quadripolar catheter (Esolo FIAB, Italy) which is compatible with both Carto and EnSite NavX Precision system (St. Jude Medical St. Paul, MN, USA) with stimulation/sensing electrodes was inserted through the nares, and positioned, where the best atrial signals were received, approximately one cm above the cardiac portion of the stomach. The same protocol was applied during RFCA and mapping procedures successfully providing reference signals and pacing atria form left side. The demographic and clinical characteristics of patients are listed in Table 1, and mechanism and management of the arrhythmias are summarized in Table 2. Only in one patient atrial capture could not achieved due to dextroposition of heart. No complications associated with esophageal catheter were observed among our patients.

Conclusion:

Transesophageal catheters can be used as an alternative to the reference catheter in the electrophysiology laboratory for provoking or terminating arrhythmias, understanding mechanism of arrhythmias or as an aid in mapping. To best our knowledge, it is the only case series in the literature where the transesophageal electrode is used as a reference catheter.

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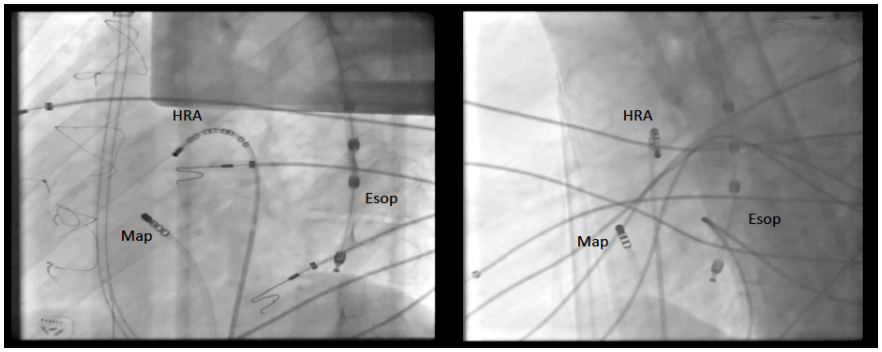

Figure 1 - Catheter positions and ablation point of patient, esophageal catheter and its relation with atria is seen on fluoroscopic images

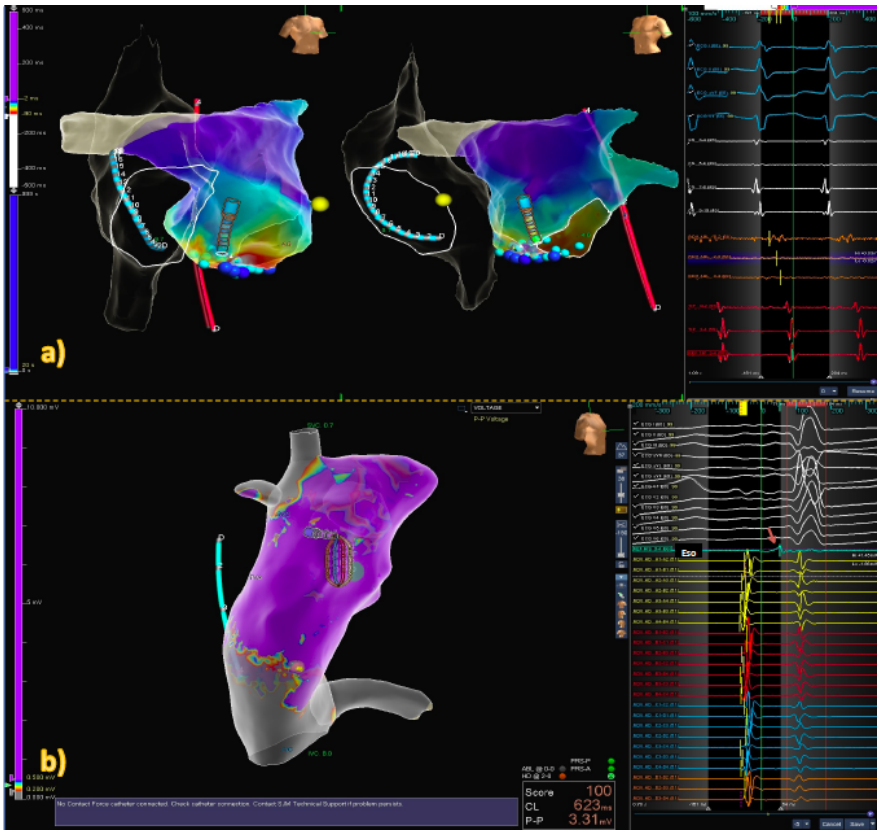

Figure 2 – a) Ablation of left posteroseptal accessory pathway in cc-TGA patient, reference esophageal catheter is red. Esophageal signals can be seen on the right side. b) Mapping with Advisor TM, HD grid mapping catheter on electro anatomical anatomy of right atria, arrow indicates signals from posteriorly located esophageal catheter displayed green.

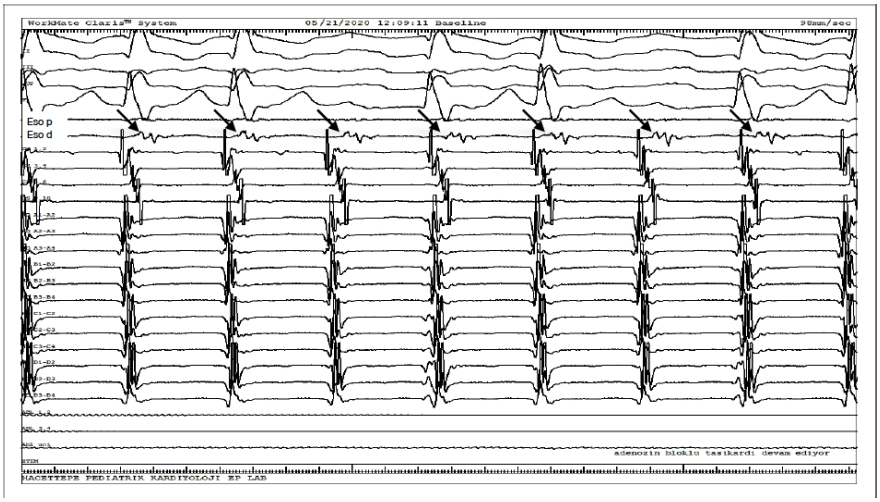

Figure 3 - Arrows pointing esophageal signals during mapping of atrial tachycardia

Table 1 - Demographic and clinical features of the patients

Pt	Age	BW	Diagnosis	Surgery
1	25 y	48	DORV, mitral atresia, LAI, PS, VSD, ASD	-
2	11 y	26	Ebstein anomaly	TVR
3	15 y	68	cc-TGA, VSD, pulmonary atresia	Rastelli procedure
4	2 m	6	Tachycardia-induced cardiomyopathy	-
5	21 y	64	Dextrocardia, Tricuspid atresia, PS	Fontan Procedure (Atriopulmonary anastomosis)

y- year, m- month, BW- body weight, DORV- double outlet right ventricle, LAI- left atrial isomerism, PS- pulmonary stenosis, VSD- ventricular septal defect, ASD- atrial septal defect, TVR- tricuspid valve replacement, cc-TGA- congenitally corrected transposition of the great arteries

Table 2 – Mechanism and management of the arrhythmias of the patients

Pt	Arrhythmia	Indication of transesophageal electrode	Ablation site
1	Atrial tachycardia	Absence of hepatic portion of IVC	CTI
2	Atrial Flutter	Complex cardiac anatomy	Scar area of posterior and superior region of RA, C
3	AVRT	Non-confluence of coronary veins	Posteroseptal region of LA
4	Atypical AVNRT	Low body weight	Posterior region of the RA
5	Focal atrial tachycardia	Non-confluence of coronary veins	Free wall of RA

AVNRT- atrioventricular nodal reentrant tachycardia, AVRT- atrioventricular reciprocating tachycardia, IVC- inferior vena cava, CTI – cavotricuspid isthmus, RA- right atrium, LA- left atrium