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Atrial flutter cardioversion in pediatric patients by postoperative transesophageal pacing

Pediatrik hastalarda ameliyat sonrası transözofageal pacing ile atriyal flutter kardiyoversiyonu

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ABSTRACT

Background: This study aims to evaluate the efficacy and safety of transesophageal atrial pacing for the restoration of sinus rhythm in the intraatrial reentrant tachycardia treatment.

Methods: A total of 16 patients (8 males, 8 females; mean age 8.3 years; range 6 days to 19 years) who underwent transesophageal atrial pacing for cardioversion of atrial flutter were included in the study. Atrial pacing was instituted at a cycle length equal to that of the atrial flutter and continued for a period of 30 seconds to one minute with 10 milliseconds decrements until a paced cycle length of 120 milliseconds was achieved or the flutter was terminated. If sustained atrial fibrillation was induced or the sinus rhythm could not be restored despite maximal transesophageal atrial pacing, direct current cardioversion was performed.

Results: Sinus rhythm was achieved in 11 of 18 episodes (61%). The median tachycardia cycle length was 210 milliseconds (range 190 to 300 milliseconds). Overdrive transeophageal atrial burst stimulation was performed at a cycle length of 280-120 milliseconds. Direct current cardioversion was performed in six patients (33%). Overdrive pacing was successful in all patients under oral antiarrhythmic therapy. Median follow-up was 3.15 years (1-6 years).

Conclusion: Transesophageal atrial pacing is a safe and effective treatment modality for atrial flutter, especially in patients with a compromised cardiovascular reserve. It should be preferred as first line treatment before direct current cardioversion for sinus rhythm achievement especially in pediatric patients and patients who were performed open heart surgery.

Keywords: Atrial flutter; cardioversion; pediatric; transesophageal pacing.

ÖZ

Amaç: Bu çalışmada intraatriyal reentrant taşikardi tedavisinde sinus ritminin restorasyonu için transözofageal atriyal uyarımın etkinliği ve güvenilirliği değerlendirildi.

Çalışma planı: Çalışmaya atriyal flutter kardiyoversiyonu için transözofageal atriyal pacing uygulanan 16 hasta (8 erkek, 8 kız; ort. yaş 8.3 yıl; dağılım 6 gün-19 yıl) dahil edildi. Atriyal pacing atrial flutter döngü hızına eşit hızda başlanıp 10 milisaniye azaltımlarla 30 saniye ila bir dakikalık süreyle 120 milisaniyelik döngü hızına ulaşılıncaya veya çarpıntı sonlanana kadar uygulandı. Maksimum transözofageal atriyal pacing'e rağmen sürekli atriyal fibrilasyonun geliştiği veya sinüs ritminin sağlanamadığı durumlarda doğru akım kardiyoversiyon uygulandı.

Bulgular: Sinüs ritmi 18 epizodun 11'inde sağlandı (%61). Ortanca taşikardi döngü hızı 210 milisaniye (dağılım 190-300 milisaniye) idi. Overdrive transözofageal atriyal burst stimülasyon 280-120 milisaniyelik döngü hızında uygulandı. Doğru akım kardiyoversiyon altı hastada (%33) uygulandı. Overdrive pacing oral antiaritmik tedavi gören hastaların tümünde başarılı idi. Ortanca takip süresi 3.15 yıl (1-6 yıl) idi.

Sonuç: Transözofageal atriyal pacing özellikle kardiyovasküler rezervi sınırda olan hastalarda atriyal flutter için etkili ve güvenilir bir tedavi yöntemidir. Sinüs ritminin sağlanmasında özellikle pediatrik ve açık kalp cerrahisi uygulanmış hastalarda doğru akım kardiyoversiyon öncesinde birinci basamak tedavi olarak tercih edilmelidir.

Anahtar sözcükler: Atriyal flutter; kardioversiyon; pediatrik; transözofageal pacing.

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Atrial flutter is uncommon in children with structurally and functionally normal hearts, but it is encountered more often after surgery for congenital heart diseases. The term "intraatrial reentrant tachycardia" (IART) is often used interchangeably with atrial flutter. An abnormal atrial tissue caused by atrial distention or a conduction delay is often present.[1] Although atrial flutter is uncommon in children with structurally normal hearts, it is associated with 30% of fetal tachycardia cases. Clinical outcome for newborns with atrial flutter without a structural heart defect is excellent once the termination of tachycardia is achieved.[2] Intraatrial reentrant tachycardia is an important source of mortality and morbidity after complex congenital heart operations, especially after surgeries involving extensive atrial remodeling such as Fontan operation, Senning or Mustard procedures.[3]

Treatment options for IART involve pharmacologic therapy, direct current (DC) cardioversion or rapid atrial pacing. The clinical status of the patient determines the choice of treatment option. Antiarrhythmic drugs may enhance the efficacy of DC cardioversion or rapid atrial pacing and prevent recurrence once sinus rhythm is restored.[1] Thromboembolic events may develope in patients with atrial flutter after restoration of sinus rhythm. Patients who have thrombi identified on transesophageal echocardiography or have a history of chronic atrial flutter (two weeks duration) should be treated with a period of anticoagulation (three days-four weeks), if hemodynamically and symptomatically tolerated, before undergoing DC cardioversion or other conversion of their rhythm.

The transesophageal route provides an easy way for atrial pacing especially in pediatric patients; patients feel less discomfort under sedation and it can be as effective as DC cardioversion in virtually all kinds of paroxysmal supraventricular tachycardia types, and in about 71% cases of atrial reentry.[4] It presents a good therapeutic alternative for patients in whom DC cardioversion is contraindicated or repeated cardioversions are required. A serious complication has not been reported with transesophageal atrial pacing but it must be kept in mind that atrial fibrillation may be induced in some patients. The induced atrial fibrillation might resolve spontaneously in a short period of time; however, cardioversion is required in patients in whom sustained atrial fibrillation is induced.[1]

In this study, we aimed to evaluate the efficacy and safety of transesophageal atrial pacing for the restoration of sinus rhythm for the IART treatment.

PATIENTS AND METHODS

Consecutive 16 patients with IART who underwent transesophageal overdrive pacing for conversion of sinus rhythm between May 2003 and May 2012 were retrospectively reviewed. Of these, 16 patients (8 males, 8 females; mean age 8.3 years; range 6 days to 19 years) with 18 different IART episodes were enrolled. The median weight of the patients was 31 kg (range 3.5 to 86). All of the patients had previous cardiac surgeries including ventricular septal defect closure in seven, Fontan procedure for tricuspid atresia in three, Senning procedure for transposition of great arteries in three, partial anomalous pulmonary venous drainage repair in one, cortriatriatum repair in one, and atrioventricular septal defect repair in one. Intraatrial reentrant tachycardia was observed during early postoperative period in only one patient who underwent surgery for partial anomalous pulmonary venous drainage. The patient did not have temporary atrial pacing wires; therefore, atrial pacing was performed via transesophageal route. Patient characteristics are shown in Table 1. All patients underwent a detailed transthoracic echocardiographic evaluation prior to the electrophysiological study. A transesophageal electrophysiological study was performed in the fasting state in the electrophysiology laboratory. Informed consent was obtained from the patients and/or parents. Moderate sedation was performed with midazolam by nasal route or through a venous line in required cases. After placement of standard 12-lead surface electrodes, a 5 or 6F quadripolar electrode (Esokid 4, Fiab SpA, Florence, Italy) with electrodes spaced at 10 mm was inserted transnasally into the esophagus. The quadripolar electrode was placed at the esophageal level where optimal atrial signals were obtained. Atrial stimulation was conducted with a programmable stimulator (Fiab Programmable Cardiac Stimulator 8,817) with a pulse width and amplitude capacity between five milliseconds and 20 milliseconds and five mA and 45 mA, respectively. A standard electrocardiography machine was used for recording. After confirmation of the diagnosis of IART by transesophageal electrophysiologic study, tachycardia cycle length was measured. Pacing was instituted at a cycle length equal to that of the IART and continued for a period of 30 seconds to one minute with 10 milliseconds decrements until a paced cycle length of 120 milliseconds was achieved or the flutter was terminated. If overdrive pacing failed to produce sinus rhythm, the entire sequence was repeated at output amplitude of 15-20 mA. Atrial capture was determined when the morphology of the atrial flutter waves changed on the surface electrocardiogram or by

Table 1. Patient characteristics

Patients	Age	Cardiac pathology	Overdrive success	Drug	Ablation	Under medication
1	6 days	PAPVD repair	Successful	None		
2	5 years	VSD repair	Successful	Propafenone		
3	10 years	VSD repair	Successful	Amiodarone + Propranolol		Yes
4	17 years	VSD repair	Successful	Amiodarone		
5	11 years	Senning for TGA	Successful	Amiodarone	Transcatheter	Yes
6	17 years	Fontan repair for TA	Successful	Amiodarone		
7	11 years	VSD repair	Successful	Propafenone		
8	17 years	Fontan repair for TA	Successful	Propafenone		Yes
9	2 years	Cortriatriatum repair	Unsuccessful	Propafenone + propranolol		
10	9 months	VSD, ASD repair	Unsuccessful	Amiodarone		
11	14 years	Senning for TGA	Unsuccessful	Propafenone		
12	19 years	Fontan repair for TA	Unsuccessful	Propafenone	Surgical	
13	18 years	VSD repair	Unsuccessful	Propofenone		
14	11 years	ASD repair	Unsuccessful	Amiodarone		
15	3 years	VSD repair	Unsuccessful in first attack, successful under medication	Amiodarone	Transcatheter	Yes
16	10 years	Senning for TGA	Unsuccessful in first attack, successful under medication	Amiodarone		Yes

PAPVD: Partial pulmonary venous return; VSD: Ventricular septal defect; TGA: Transposition of great arteries; TA: Tricuspid atresia; ASD: Atrial septal defect.

a change in ventricular response during pacing. The pacing period was 30 seconds in first three patients and the pacing sequence was not repeated for a total of five times. If sustained atrial fibrillation was induced or the sinus rhythm could not be restored despite maximal transesophageal pacing, DC cardioversion was performed. Anticoagulation was not applied prior to procedure.

RESULTS

The median tachycardia cycle length was 210 milliseconds (range 190 to 300 milliseconds). Atrioventricular conduction was 2:1 in 70% of patients, one patient had complete atrioventricular block that developed during the postoperative period and the remaining patients had varying degrees of atrioventricular block. Transeophageal atrial burst stimulation at a cycle length of 280-120 milliseconds was performed for 30 seconds to one minute. The pacing sequence was repeated for a median number of three (range 1 to 5). Direct current cardioversion was performed in six patients (33%); the reason for cardioversion was resistance of IART to overdrive pacing in four and development of sustained atrial fibrillation in two patients.

Conversion to sinus rhythm was achieved in 11 of 18 episodes (61%) by transesophageal atrial pacing. All unsuccessful attempts were observed during late postoperative period. Pacing period was short (30 seconds) and the pacing sequence was not repeated for a total of five times in the three of unsuccessful patients. Beside atrial fibrillation that was observed in two patients, no complications such as bleeding or esophageal erosion occurred.

Five patients (27%) included in the study were under oral antiarrhythmic therapy (three amiodarone, two propafenone) during the procedure and overdrive pacing was successful in all. Two patients who had undergone unsuccessful atrial pacing previously without using antiarrhythmic therapy responded to atrial overdrive pacing under medical therapy.

After termination of IART, antiarrhythmic therapy was started in all patients except the patient in the early postoperative period. Of the patients, arrhythmia recurrence was not observed with amiodarone in seven (46%), propafenone in six (37.5%), a combination of propafenone and propranolol in one, and a combination of amiodarone and propranolol in one patient. Beside antiarrhythmic medication and longer duration of pacing, there was no factor detected effecting success

of the atrial pacing including age, types of congenital heart disease or surgery.

Median follow-up was 3.15 years (range 1 to 6 years) and three patients were lost to follow-up. During follow-up, surgical Maze procedure was performed in one and radiofrequency catheter ablation was performed in two postoperative patients who had IART recurrences despite medical therapy. One of the patients who had radiofrequency ablation had ventricular septal defect repair and the other had Senning procedure for transposition of great arteries. Ablation was successful in both patients. One patient underwent surgical Maze procedure due to resistant tachycardia and repair of a failing Fontan circulation.

DISCUSSION

Atrial flutter is uncommon in pediatric age especially in patients with structurally normal hearts. As reported in the literature, majority of patients (83%) enrolled in our study developed atrial flutter in the postoperative period.[5] Impact of postoperative tachycardia on mortality and morbidity is high in patients.[6] After conversion to sinus rhythm, medical therapy should be started immediately upon diagnosis to enhance the success rate of electrical intervention and to prevent recurrences.

Success of rapid transesophageal atrial pacing to achieve cardioversion of flutter is reported to be between 53% and 94%.[7,8] Success rate in our study was 61% which is in accordance with the previous studies. As reported by two separate studies, patients under antiarrhythmic medication and those with longer pacing periods respond better to overdrive pacing.[9,10] Overdrive pacing was unsuccessful in eight procedures. Analyzing our results retrospectively, we think that failure to achieve cardioversion of the flutter was the result of inadequate pacing which could be attributed to the learning period; the pacing period was 30 seconds and the pacing sequence was not repeated for a total of five times in the first three patients. All these patients responded to external DC cardioversion. Although longer periods of pacing protocols were applied to the remaining five patients, these patients did not respond to overdrive pacing. The sinus rhythm was restored in two of these five patients under medication (amiodarone) by overdrive pacing. Different atrial pacing protocols might have increased the success in patients with atrial flutter. As Hii et al.[11] reported, delivering extrastimuli following a rapid pacing train may be more efficacious than overdrive atrial pacing at the same pacing cycle length in terminating atrial flutter.

Success of overdrive atrial pacing may be enhanced by the use of antiarrhythmic medications such as propafenone and amiodarone and longer pacing periods. A study performed in 30 adult patients with atrial flutter showed that the efficacy of pacing increased from 53% to 87% two hours after 600 mg oral propafenone treatment.[9] In another study by the same group,[10] which included 80 adult patients, it was shown that success of overdrive pacing increased from 20% to 85% with the combined use of a longer pacing period and propafenone treatment. Shorter periods of pacing applied in first three patients brought failure as stated previously. Therefore, longer duration of pacing and antiarrhythmic medication should be applied if normal sinus rhythm cannot be established. In our study, five patients (25%) underwent atrial pacing under antiarrhythmic therapy and overdrive pacing was successful in all of them. Two of these patients had undergone unsuccessful atrial pacing and required DC cardioversion in their previous flutter attacks during which they did not use antiarrhythmic therapy.

As stated earlier, conversion to sinus rhythm can be achieved by DC or by medical cardioversion; a minimal invasive treatment that is immediately effective is especially desirable for pediatric patients. Atrial pacing can be performed by using these atrial pacing leads inserted during surgery. Implantation of these leads enable both diagnosis and treatment of arrhythmias developing after the surgery. However, atrial pacing lead was not inserted after the surgery in our patients; therefore, the procedure was performed via transesophageal route. Transesophageal atrial pacing is a semi-invasive and quickly effective treatment modality that can be performed on an outpatient basis.

External DC cardioversion is the treatment of choice for hemodynamically instable and resistant tachycardia. Nevertheless, although generally well tolerated, it is not without complications. Even though most complications are self-limiting or relatively benign, potential life-threatening complications such as arrhythmias, thromboembolism, myocardial necrosis, and dysfunction or pulmonary edema may be encountered. Painful skin burns may develop as a result of the shocks. Especially in cases with resistant atrial flutter that require repeated cardioversion episodes, further damage to the myocardium might be observed.[12] This damage might be well tolerated in patients with a normal intra cardiac anatomy; however, its effect in patients with already compromised cardiovascular reserve might be detrimental (i.e. patients with single ventricle physiology or patients

with right ventricle as the systemic ventricle). Particularly for patients with a compromised cardiovascular reserve, we think that overdrive atrial pacing is a safer and feasible alternative to external cardioversion for the acute restoration of sinus rhythm. In our study, three patients had systemic right ventricle and three patients had single ventricle physiology. Therefore, rapid atrial pacing was a good alternative for these patients. Cardioversion may provoke other arrhythmias or disturbances of impulse conduction.[12] Sinus arrest or severe sinus bradycardia that causes a significantly decreased heart rate may develop following cardioversion in some patients. Transesophageal pacing may be used for acute control of bradycardia in such patients and eliminate the need for transvenous pacing.

Long-term treatment of recurrent atrial flutter in the pediatric population includes electrophysiologic intervention for abnormal atrial tissue. New insights from invasive electrophysiologic studies and mapping techniques will help patients with ablation of flutter and prevent recurrences for recurrent and resistant cases.[13] Radiofrequency catheter ablation was performed successfully in two patients and surgical Maze procedure was performed in one with failing Fontan circulation; all three patients had recurrent flutter attacks despite antiarrhythmic therapy.

In conclusion, we think that transesophageal atrial pacing is a safe and effective treatment modality in atrial flutter. As it is a minimally invasive method, it can be applied as an outpatient procedure and does not require general anesthesia. Also, in the event of a prolonged pause observed after termination of flutter, esophageal pacing provides the option of atrial escape pacing. The myocardial damage that occurs during direct current cardioversion might not be well tolerated in patients with a complex intra cardiac anatomy. Overdrive atrial pacing should be preferred as first line treatment before external direct current cardioversion for the restoration of intraatrial reentrant tachycardia especially in pediatric and postoperative patients.

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