ORIGINAL ARTICLE

Midterm Follow-up and Outcome of Pacemakers in Children: A Single Center Experience

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Abstract

Background: Pacemaker implantation is an effective life-long treatment in patients with atrioventricular block to generate a reliable heartbeat. Choosing between epicardial and endocardial (trans-venous) techniques in children is based on the cardiac center experience and each technique has some benefits and risks.

Methods: In this observational cross-sectional study, we reviewed file-records of 186 under 18- year-old patients who underwent cardiac pacemaker implantation due to atrioventricular block. All of endocardial implantations had been performed by experienced pediatric cardiologists and all epicardial pacemakers by experienced cardiac surgeon from 2006 to 2018 in Namazi and Faghihi hospitals in Shiraz, Iran.

Results: One hundred and five patients had epicardial pacemaker and 81 patients had endocardial pacemaker**.** One hundred and seventy-eight patients had postoperative complete heart block after correction of congenital cardiac abnormality due to the destruction of conductive pathway. Eight patients were born with complete heart block**.** Four (2.15%) patients in the endocardial group developed pacemaker related infection**.** Two (1%) patients had sudden cardiac death after pacemaker insertion in the follow-up; Medtronic single chamber pacemaker was inserted for one patient who had complete heart block after surgical ventricular septal defect closure. However, a month later she expired due to sudden cardiac arrest during exercise and one patient after correction of complete atrio-ventricular septal defect had pacemaker insertion and sudden death, 3 months after pace insertion (1.12%); none of them had history of palpitation, syncope, arrhythmia in their post-operation electrocardiography, or tachycardia in their pacemaker analysis**.**

Conclusion: In Conclusion, epicardial pacemaker has a noticeable battery longevity in comparison to endocardial pacemakers and fewer valvular complications and endocarditis cases. Also, it appears that increasing size and vessel stiffness followed by aging can prime better vascular access and less lead malfunction in older pediatrics in endocardial approach; however, the site of ventricular pacing is still a puzzle because of the effect of pacing site on left ventricle synchrony and ejection fraction.

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Introduction

Pacemaker implantation is an effective life-long treatment in patients with atrioventricular block to generate a reliable heartbeat. Choosing between epicardial and endocardial (trans-venous) techniques in children is based on the cardiac center experience and each technique has some benefits and risks.[1] Some studies support endocardial technique because of more battery longevity and lower risk of lead fracture.[2] On the other side, the risk of venous thrombosis, perforation, and tricuspid regurgitation in this approach has made epicardial technique as an alternative.[3] However, increasing stimulation threshold, significant incidence of sensing and capture failure leads to shorter battery longevity in epicardial devices. It should be noticed that models to predict complications, especially venous thrombosis, using various variables i.e. patient's age, weight, vessel size, and lead cross-sectional area, did not yield a convincing result.[4] Hence, in the field of pediatric cardiology, since they are dependent on pacemaker for a long time, one may choose a technique which is less invasive and more effective as the so-called optimum technique. In the present study, we reviewed our 13-year experience in pediatrics pacemaker implantation in Southern Iran to acknowledge the outcomes of the two pacing methods.

Methods

In this observational cross-sectional study, we reviewed file records of 186 patients under 18 years of age who underwent cardiac pacemaker implantation due to atrioventricular block. All of the endocardial implantations had been performed by experienced pediatric cardiologists and all epicardial pacemakers by experienced cardiac surgeon from 2006 to 2018 in Namazi and Faghihi hospitals in Shiraz, Iran.

We divided these patients into two groups according to the site of pacemaker implantation, epicardial versus endocardial. In epicardial technique, the pacemaker leads were directly attached to the epicardium under general anesthesia in operation room, sternotomy, or subxiphoid incision. Trans-venous pacing was achieved by threading a pacing electrode through a vein into the right ventricle under fluoroscopic and electrocardiographic guidance.

Single chamber pacemakers (114 of Medtronic and 72 of ST-Jude cardiac devices) had been chosen for insertion. Stimulation mode of the pacemaker had been programmed on VVIR to generate a reliable heartbeat.

All medical information including age, weight, date of performing procedure, history of previous cardiac surgery, and the indication of pacemaker implantation was extracted from medical records. Also, the type of generator and primary programming data such as lead impedance, battery impedance, sensing and pacing threshold, pacing amplitude, and pulse width were collected and added to demographic variables. Battery longevity and the need for second generator based on battery half-life, as well as infection of the pacing system site and valvular endocarditis as the complications which led to reintervention were the variables extracted from medical record during the follow-up.

Statistical analysis was carried out using statistical package for social sciences (SPSS) (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.). Quantitative variables were described by mean±standard deviation (SD) or median [IQR (interquartile range)]. For group comparison, we used independent *t*-test. Wilcoxon rank-sum test was an alternative when data was not normally distributed. $P \leq 0.05$ was considered statistically significant.

Results

One hundred and five patients had epicardial pacemaker, and 81 patients had endocardial pacemaker. One hundred and seventy-eight patients had postoperative complete heart block after correction of congenital cardiac abnormality due to destruction of conductive pathway. Eight patients were born with complete heart block. From 8 patients with congenital complete heart block, six patients had positive maternal anti-ribosomal antibodies and two patients with unknown reason of atrioventricular block.

The most common surgery that leads to heart block was ventricular septal defect closure (43%) followed by tetralogy of Fallot (36%) and complete atrioventricular septal defect (15%), and 4% had other complex cardiac surgery. Four (2%) patients had complete heart block after interventional ventricular septal defect closure and atrial septal defect closure.

Four (2.15%) patients in the endocardial group developed pacemaker-related infection. Two of them had pocket infection that required pacemaker driving out at 3 and 6 months after pacemaker insertion; then, the pacemaker was replaced in the opposite side. One patient developed endocarditis five months after insertion, so the pacemaker was driven out and after successful treatment of the underlying disease, it was replaced again. The other one developed fungal endocarditis following Rastelli surgery; the homograph and pacemaker were removed, and the epicardial pacemaker was inserted. In surgically inserted epicardial pacemaker, 3 (1.6%) patients had pocket infection resolved by debridement and oral antibiotic therapy.

Two (1%) patients had sudden cardiac death after pacemaker insertion in the follow-up; Medtronic single chamber pacemaker was inserted for one patient who

Table 1: Comparison between endocardial and epicardial pacemakers

Variable	Type of pacemaker		P
	Epicardial	Endocardial	
Age (year)	8.50±3.85	10.01±2.44	0.042
Weight (Kg)	19.10±14.4	28.75±10.84	0.019
Follow up duration (year)	4.55±1.96	3.84±1.30	0.660
Voltage (mV)	2.72±0.03	2.72±0.11	0.968
Lead impedance (ohm)	344.55±197.45	597.71±294.86	0.040
Pacing threshold	3.91±1.25	4.25±1.64	0. 048
Pulse width	0.63±0.56	1.01±0.90	0.032
Battery impedance (ohm)	1200.35±537.25	718.52±442	0.754
Battery longevity (year)	5.65±3.36	7.61±3.13	0.060

had complete heart block after surgical ventricular septal defect closure. However, a month later she expired due to sudden cardiac arrest during exercise, and one patient had pacemaker insertion and sudden death three month after pace insertion and correction of complete atrio-ventricular septal defect (1.12%). None of them had a history of palpitation, syncope, arrythmia in their post-operation electrocardiography, or tachycardia in their pacemaker analysis.

One patient with corrected transportation of great artery needed lead reposition after endocardial pace insertion and another patient with heart block after ventricular septal defect closure had lead malfunction after endocardial lead insertion. Two patients with surgical epicardial pacemaker insertion had lead malfunction, so the lead was changed (2.15%).

During the follow-up echocardiography, 2 (1%) patients had severe tricuspid regurgitation, 6 (3.2%) patients had moderate regurgitation, and the other patients had mid or trivial tricuspid regurgitation. Table 1 shows group comparison regarding various variables, comprising lead and battery parameters. Endocardial technique patients were significantly older (epicardial: 5.5 [2.65] years vs. endocardial: 9.5 [5.5] years; P=0.042) and of greater weight (epicardial: 17 [8] kg vs. endocardial: 27.5 [21.5] kg; P=0.019). The median voltage was not statistically different (epicardial: 2.72 [0.07] mV vs. endocardial: 2.73 [0.23] mV; P=0.968). Lead impedance was statistically lower in epicardial pacemakers (epicardial: 361.5 [203.75] ohm vs. endocardial: 442 [399.25] ohm; P=0.04). Amplitude (Pacing threshold) was not different between the groups (epicardial: 3.75 [2.41] mV vs. endocardial: 2.62 [0.76] mV; P=0.208). Endocardial pacemakers had a higher mean battery longevity compared to pericardial pacemakers, but that was not statistically significant (epicardial: 7.65±3.36 years vs. endocardial: 6.61±3.13 years; P=0.66). Finally, there was no difference regarding remaining battery longevity (epicardial: 4 [3.5] years vs. endocardial: 5.85 [3.08] years; P=0.192).

Discussion

An optimized selection between epicardial versus endocardial (trans venous) pacemaker implantation techniques has still remained a puzzle. Some pediatric centers revealed that endocardial technique might be preferred in infants regardless of small body size and small vessels, supported by good short-term outcome.[2, 5-7] Robledo-Nolasco et al.[3] (2009), showed that endocardial pacemaker implantation was safe and practical, even in children weighing <10 kg with small size vessels. They concluded that improvement in generators and leads and implantation technique and progressive dilation of the entry site could decrease the vascular complication in endocardial approach.

Vos et al.[4] (2017), in a retrospective cohort study, mentioned that endocardial pacemaker amongst infants (<10 kg) is associated with higher incidence of vascular complication such as vascular thrombosis, occlusion, and valvular regurgitation during long term follow-up. They showed that epicardial approach was more suitable in this group of patients. They acknowledged that data on long term follow up was lacking which might mislead to the safety of endocardial approach in small children. Furthermore, prediction of thrombosis based on the patients' age, body size, vessel size, and lead characteristics such as the lead cross-sectional area is still unclear. For example, Bar-Cohen et al.[8] (2006) showed that none of them clearly predicted venous occlusion. Based on these arguments, we decided to insert endocardial pacemaker in older infants with greater weight in our centers to reduce vascular complications in small infants.

Some studies mentioned that attachment of leads to the epicardium caused higher pacing thresholds and higher incidence of sensing and capture failure in epicardial approach. Hence, it can cause shorter battery longevity and more reintervention.[2, 3] As tendency toward generator exhaustion in pediatrics is an issue of concern, due to more rapid heart rate compared to adults, it is crucial to choose a technique with acceptable battery longevity.[8] However, our study did not show a statistically difference in battery longevity between the two groups. The same results were achieved by Kwak et al.[9] (2012). They showed that battery longevity in epicardial technique was sufficient and acceptable in long term follow-up in spite of higher pacing thresholds.

As a matter of fact, generator and lead reintervention and replacement due to generator exhaustion, vascular complication or lead malfunction in pediatrics is inevitable, but it should be minimized for better pacemaker performance in this group of patients who have life-long dependency to pacemaker. On the other hand, some recent studies have shown that the site of ventricular pacing has a major effect on the left ventricle synchrony and ejection fraction. They showed that left ventricle apex and lateral wall pacing preserved the left ventricle systolic and diastolic functions rather than right ventricular pacing.[5, 6]

As a result, it appears that we could preserve vascular access, valvular function and left ventricular systolic and diastolic function in infants by choosing epicardial technique regardless of age, weight, and vessel size of the patients for the first pacemaker implantation. As we just mentioned that epicardial pacemakers had a competitive battery longevity and generator exhaustion compared to the epicardial ones, while epicardial pacemakers had fewer vascular and valvular complications as well as better preserved left ventricular function due to left ventricle apex pacing.

In our study, we experienced 4 cases with complication in cases with endocardial route; one case developed pocket abscess and the generator was removed and put in the other side; after 2 weeks of intravenous antibiotic therapy, the patient was discharged with good condition. The other case developed wound infection in the side of pocket which improved with intravenous antibiotics.

We had also two cases with infective endocarditis, one of whom improved with intravenous antibiotics and also changing the pacemaker wire, but the other case was a female with down syndrome who developed infective endocarditis and also pocket abscess; he was prescribed intravenous antibiotics and the generator, and the wire was changed. After 6 weeks, he was discharged in good condition but again referred to hospital with fever and also infective endocarditis, so we decided to change the endocardial pacemaker to epicardial pacemaker and again after 6 weeks of intravenous antibiotics; then, the patient was discharged in good condition.

In a study conducted by Michael Brunner in 2004, the rate of infection was only one case and also they determined that endocardial pacemaker had a longer survival than epicardial pacemakers; in our study, there was no significant difference between epicardial and endocardial pacemakers in the survival rate; however, their study included both children and adults.[10, 11]

Conclusion

In conclusion, epicardial pacemakers had a noticeable battery longevity in comparison to endocardial pacemakers and fewer valvar complications and endocarditis cases. Also, it appears that increasing size and vessel stiffness followed by aging can prime better vascular access and fewer lead malfunction in older pediatric cases in endocardial approach; however, the site of ventricular pacing is still a puzzle because of the effect of pacing site on the left ventricle synchrony and ejection fraction.

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Ethical Approval

All procedures performed in this study were in accordance with the ethical standards of the national research committee with the ethical code of IR.sums.med.rec.1398.307

Conflicts of interest*:* None declared.

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