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Minimally invasive technique of placing a dual chamber permanent pacemaker in children

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INNOVATION ARTICLE

Minimally invasive technique of placing a dual chamber permanent pacemaker in children

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Abstract

Objective: To share the experience of a minimally invasive technique in the implantation of a dual chamber permanent pacemaker in paediatric population.

Methods: The retrospective study was conducted at Aga Khan University Hospital, Karachi, and comprised data of patients aged up to 16 years who underwent epicardial dual chamber permanent pacemaker insertion via xiphisternal incision between April 2011 and August 2016. Demographic data included age, weight and gender of the patient. Indications for pacemaker insertion, electrocardiography findings, concomitant cardiac procedures and procedural complications were reviewed. Pacemaker thresholds and impedance at the time of implantation and throughout the course of follow-up were extracted from the clinical data.

Results: Of the 10 patients, 5(50%) were males and 5(50%)were females. The overall mean age was 3.4±3.8 years (range: 1 month - 13 years). The mean weight at the time of operation was 11.4±6.8 kg (range: 4.3-27kg). Indications for permanent pacemaker insertion included postoperative advanced or complete atrioventricular block in 7(70%) and complete congenital heart block in 3(30%). There was no reported morbidity.

Conclusion: Dual chamber permanent pacemaker insertion via xiphisternal incision was found to be of benefit to the patients and the surgeons alike.

Keywords: Permanent pacemaker, Complete heart block, Congenital heart disease. (JPMA 69: 1119; 2019)

Introduction

Atrioventricular (AV) block is intermittent transmission of impulses from the atria to the ventricles that result due to anatomical and functional impairment in the conduction system.[1] Congenital heart block is a rare but potentially lethal disease entity with prevalence ranging from 1 in 15,000 to 1 in 22,000 live births.[2] Management of heart block includes temporary or permanent methods. Temporary treatment includes the use of transcutaneous or transvenous pacing, while a permanent solution of complete heart block is to combine single or dual chamber device with an epicardial or transvenous pacing lead.[3]

Dual chamber pacing has many theoretical and practical advantages. It maintains synchrony of atrial and ventricular contraction and dominance of sinoatrial (SA) node as opposed to asynchronous ventricular stimulation. It also reduces the subsequent risk of atrial fibrillation, stroke and death along with prevention of pacemaker syndrome.[3-6] The most common indications for permanent pacemaker implantation in congenital heart disease include bradycardia associated with poor cardiac output, congestive heart failure, poor exercise tolerance and ventricular dysfunction.[6,7] Permanent pacing in paediatric population can be demanding due to several paediatric issues such as body growth, patient's size, lifestyle, presence of coexisting congenital heart disease and intracardiac shunts.[3,6]

A dual chamber pacemaker has two leads: one is implanted on the right atrium and other on the right ventricle, hence mimicking normal physiological cardiac conduction.[6] The advent of steroid eluting leads have led to improved stimulation thresholds and performance.[3,8,9] The pacing leads can be implanted via transvenous (endocardial) or surgical (epicardial) route. The choice of route depends upon the anatomy, size of the patient and the surgical procedures performed. Epicardial implantation is the route of choice in children weighing less than 15 kilograms,[8] in those with intracardiac shunts and univentricular anatomy. Endocardial implantation has lower complication rates but requires special attention in children due to their high rate of somatic growth, increased incidence of venous obstruction, thromboembolism and loss of AV valve integrity.[5,10]

Epicardial pacemaker can be implanted using median sternotomy, lateral thoracotomy, left subcostal or xiphoid approach. The advantages and disadvantages of different surgical techniques are well defined in literature on

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adults. However, minimal evidence exists in paediatric literature. A study demonstrated that the type of surgical approach utilised is the key factor for determining lead survival.[10] A median sternotomy is preferred as it provides excellent visualisation and relative ease of implantation of pacemaker leads. However, patients with congenital heart disease undergoing multiple surgeries have extensive scar tissue which complicates the procedure.

The current study was planned to share our experience with the xiphisternal approach with successful implantation of both atrial and ventricular leads.

Patients and Methods

The retrospective study was conducted at Aga Khan University Hospital, Karachi, and comprised data of patients aged up to 16 years who underwent epicardial dual chamber permanent pacemaker insertion via xiphisternal incision between April 2011 and August 2016. Approval was obtained from the institutional review committee. Patients over 16 year of age, those with placement of permanent pacemaker by any other surgical approach, replacement of permanent pacemaker, emergent pacemaker placement and insertion of single chamber pacemaker were excluded.

Medical records of all patients were retrieved and reviewed. Demographic data was collected and included age, weight and gender of the patient. The indications for pacemaker insertion, electrocardiography (ECG) findings, concomitant cardiac procedures and procedural complications were reviewed. Pacemaker thresholds and impedance at the time of implantation and throughout the course of follow-up were extracted from the clinical data.

Statistical analysis was done using Microsoft Excel. Proportions were compared using Chi-square test and means were compared using 2 sample independent T tests.

As for the operative procedure, all patients were operated under general anaesthesia. The patient was placed in a supine position. Either a 5cm vertical midline incision was made over the xiphoid process or in patients with reoperation the lower portion of the median sternotomy scar was reopened. The lower one centimetre of the sternum was divided along with the xiphisternum. A pericardial well was created. Exposure was facilitated by placement of a self-retaining retractor and two Langenbeck retractors: one lifting the sternum upwards and the other retracting the diaphragmatic pericardium downwards. After maintenance of optimal exposure, Babcock forceps were used to hold and retract the right atrium into the wound for placement of right atrial leads. The atrial leads were placed on the mid portion of the body of right atrium to avoid stimulation of the phrenic nerve. The atrial lead buttons were sutured using two interrupted 5/0 polypropylene sutures each. Babcock forceps were removed to release the right atrium. The right ventricle was exposed by gentle downward traction on the diaphragm using either a suction cannula or a Langenbeck retractor. The ventricular pacing lead buttons were sutured to the diaphragmatic portion of the right ventricle using two interrupted 5/0 polypropylene sutures each (Figure).

For placement of pacemaker generator, a transverse paraumblical incision was made in the left lumbar region. The size of the incision was approximated to the size of the pacemaker generator. Subcutaneous flaps were created. A vertical incision was made to create rectus sheath flaps. The rectus abdominis muscle was retracted anteriorly to create a pocket large enough to house the pacemaker generator and pacemaker leads. The pacemaker generator was placed just posterior to the rectus abdominis muscle, and the leads were tunnelled to the pacemaker pocket via a subcutaneous tunnel. Steroid eluting bipolar epicardial leads were used. The electrodes were connected to the pacemaker generator in the usual manner. After maintenance of a satisfactory pacing threshold by an electrophysiologist, the anterior rectus sheath, subcutaneous tissue and skin were closed. The pericardium was left open and the xiphoid incision was closed in layers. No drains were left in place.

Results

Of the 10 patients, 5(50%) were males and 5(50%)were females. The overall mean age was 3.4±3.8 years (range: 1 month - 13 years). The mean weight at the time of operation was 11.4±6.8 kg (range: 4.3-27kg). Indications for permanent pacemaker insertion included postoperative advanced or complete atrioventricular block in 7(70%) and complete congenital heart block in 3(30%). Of the 10 patients, 7(70%) had structurally abnormal hearts and had undergone surgical repair of complex cardiac malformations via median sternotomy.

The pacemaker implantation via xiphisternal incision was successful in all 10(100%) patients. There were no intraoperative complications. The mean duration of surgery was 2±0.16 hours (range: 110-140 minutes). The mean length of stay in the hospital was 5.8±5.4 days (range 1-20 days). There were no early lead failures, wound complications or device infections. None of the patients required blood transfusion after pacemaker implantation. One (10%) patient suffered from right

Table-1: Pacemaker threshold for atria and ventricle.

Patient	Atrial threshold at implant (V/0.4ms)	Ventricular threshold at implant (V/0.4ms)	Atrial threshold at follow-up (V/0.4ms)	Ventricular threshold at follow-up (V/0.4ms)
1.	0.75	1.0	1.0	1.25
2	5.0	1.25	0.5	0.5
3.	0.5	0.5	0.5	0.75
4.	0.75	1.0	0.5	0.5
5.	0.5	0.5	0.75	0.5
6.	0.5	5.0	0.5	1.0
7.	0.5	0.5	Expired	Expired
8.	0.5	1.0	Expired	Expired
9.	1.0	0.75	Lost to follow-up	Lost to follow-up
10.	0.5	1.0	Lost to follow-up	Lost to follow-up
Range	0.5 - 5.0	0.5 - 5.0	0.5 - 1	0.5 - 1.25
Median	0.5	1.0	0.5	0.5
Mean	1.05±1.40	1.25±1.34	0.625±0.21	0.75±0.32

Table-2: Pacemaker impedance for atria and ventricles.

Patient	Atrial impedance at implant (ohms)	Ventricular impedance at implant (ohms)	Atrial impedance at follow-up (ohms)	Ventricular impedance at follow-up (ohms)
1.	586	1080	659	829
2.	712	989	592	891
3.	542	787	549	764
4.	480	676	532	644
5.	489	1000	522	622
6.	501	747	668	744
7.	668	998	Expired	Expired
8.	650	1000	Expired	Expired
9.	460	1150	Lost to follow-up	Lost to follow-up
10.	501	525	Lost to follow-up	Lost to follow-up
Range	489-712	525 - 1150	522 - 668	622-891
Median	668	989	549	744
Mean	559±90	895.2±199.8	587±64	749±104

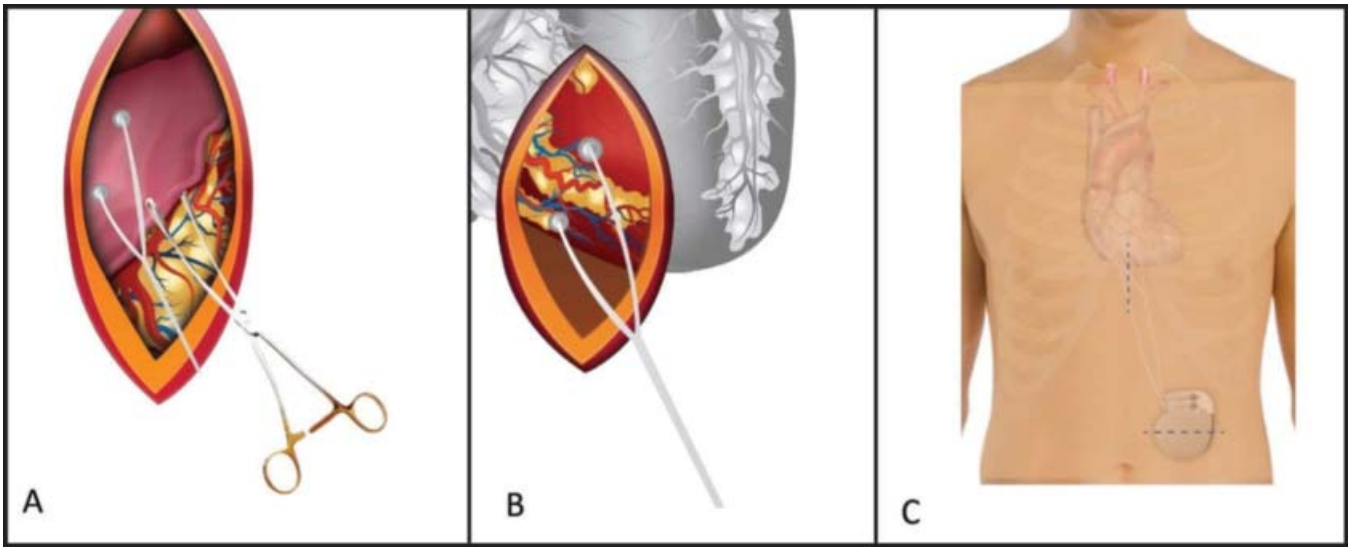

Figure: Operative details. A) Babcock forceps are shown holding the right atrium, with dual chamber PPM electrodes in place. B) Dual chamber PPM electrodes are attached to the right ventricle. C) Site of incisions for electrode placement (xiphisternal) and PPM generator location (transverse paraumbilical) are represented by the blue dotted lines.

hemiplegia following stroke. No postoperative complications were seen in the other 9(90%) patients.

The mean follow-up interval was 22±21.7 months (range: 0.1-50months). Two (20%) patients were lost to follow-up owing to their death during the follow-up period and that were unrelated to pacemaker implantation. One (50%) death was due to end-stage heart failure and the cause of the other death was unknown.

At the last follow-up, all patients remained in dual chamber demand pacemaking (DDD) mode with AV synchrony.

Successful AV synchrony was established in all the 10(100%) patients. The pacing threshold and impedance at the time of implantation and follow-up was noted (Tables-1-2).

Discussion

Since the implantation of first cardiac pacemaker in 1958 in Sweden,[11] the advancement in technology has made the use of cardiac pacemakers very effective and reliable. Virtually all pacemakers used today have state-of-the-art biocompatible material and long battery life; they are inhibited in the presence of spontaneous cardiac activity and are multi-programmable. The development of steroid eluting leads was another leap in technology which led to decreased risk of exit block and intervention-free survival of pacemaker leads in the majority of patients.[8,10,12]

Dual chamber cardiac pacing maintains AV synchrony, consequently reducing the risk of pacemaker syndrome, but they are more expensive, and more difficult to implant, programme, and followup.[3,4,9] Despite the advantages of dual chamber pacing over ventricular pacing, the incidence of implantation remains low due to the financial constraints of the device, as well as lack of comparative data from large randomised clinical trials (RCTs) comparing the morbidity and mortality of dual chambered pacing with ventricular pacing.[5] Reports of dual chamber cardiac pacing in children have been infrequent due to complications arising from the discrepancy in the size of children and the size of the pacemaker, relative difficulty in implantation and high incidence of atrial lead complications.[11,13]

Various techniques for the implantation of epicardial permanent pacemaker have been described in the literature.[6,9,14-18] A retrospective review of 1239 paediatric patients speculated that the surgical approach used for pacemaker lead implantation plays a key role in lead survival.[10] It reported the results of 4 atrial and 25 ventricular epicardial pacing leads implanted via xiphisternal approach. In this study, lead placement via xiphisternal approach was compared with lateral thoracotomy and median sternotomy. In comparison with other surgical approaches, the xiphisternal approach showed excellent results with 100% freedom from lead failure.[10] To date minimal evidence exists for the use of xiphisternal approach for placement of dual chamber pacemaker. Arguments against the use of xiphisternal approach include inadequate exposure and inability to implant atrial leads.[10,18] Our experience and other reports.[10,17] clearly demonstrate the technical feasibility of this surgical technique.

In our experience, pacemaker implantation via xiphisternal approach gave excellent outcomes and minimal morbidity. All our patients had insertion of bipolar steroid eluting leads. We had no incidence of lead fracture, early lead failure or device malfunction. We attained satisfactory pacing thresholds with pacing impedance. Furthermore, all patients remained in DDD mode with AV synchrony at the last follow-up.

Our initial experience with xiphisternal approach has been gratifying. The exposure is adequate for suturing of bipolar steroid eluting lead electrodes. Compared with thoracotomy and median sternotomy, this surgical technique is associated with marked improvement in cosmetic appearance, minimal pain, morbidity, next-day discharge and relative ease in pacemaker electrodes or module replacement. This minimally invasive surgical technique is easily reproducible by surgeons in training.

In terms of limitations, the study is a single-centre, retrospective study with a small sample size. Besides, there may well be institutional bias in the choice of pacemaker manufacturer. The follow-up time was brief, as some patients were lost to follow-up. Pacing parameters, especially sensing values, were not always recorded and documented.

Conclusion

Technical feasibility for implantation of dual chamber permanent pacemaker in paediatric population was found to be positive. Compared to other surgical techniques, it is associated with minimal surgical trauma and hence can be considered a minimally invasive procedure.

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Conflict of Interest: None.

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