Complications and Risk Assessment of 25 Years in Pediatric Pacing

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Background. **Children who require cardiac pacemaker implantation have presented a small patient subpopulation since the breakthrough of this technology in the 1950s and 1960s. Their small bodies result in a technical challenge for the operating surgeon and put the patient at risk for a series of specific complications. Our study aims to analyze complications and to identify risk factors of endocardial and epicardial pacemaker systems in children.**

Methods. **All pacemaker-related operations in pediatric patients up to the age of 18 years from 1985 through 2010 were retrospectively evaluated. Demographic data including age, height, and weight were recorded. Idiopathic and postoperative dysrhythmias were analyzed separately.**

Results. **A total of 149 pacemaker operations were performed in 73 patients. Thirty-two patients did not have a previous cardiac operation. Indications for revision included box exchange, lead-related problems, pacemaker pocket complications, impaired left ventricular function, and pectoral muscle stimulation. Increased pacing thresholds occurred in 17.2% of the patients with epicardial leads compared with 2.9% in the endocardial group. Aside from threshold-related revision, lead problems are more common in the endocardial group (30.4% vs 17.2%). Venous thrombosis occurred in 13.7% of the patients (only endocardial), preferentially (25%) in the weight group less than 15 kg and in idiopathic patients (15.6% vs 10.5% with prior cardiac surgery).**

Conclusions. **Cardiac pacing is particularly challenging in the pediatric patient population facing a large number of reoperations during their lifetime. The lack of clear superiority of either epicardial or endocardial pacing systems requires an individual concept.**

(Ann Thorac Surg 2015;100:147–53)

In 1957 Dr Clarence Walton Lillehei (University of Minnesota) placed the first pediatric pacemaker. At the end of a surgical procedure for structural heart disease, he used epicardial pacing leads and attached them to the cardiac surface [1, 2]. Two years later Dr Seymour Furman was able to use a transvenous technique to place the pacemaker leads endocardially [3, 4].

Children represent less than 1% of all pacemaker patients and can have pacemaker systems placed with either method. The endocardial method is preferred in older children and adults. However, in children smaller than 10 to 15 kg many centers have advocated the use of epicardial pacemaker systems. Specific concerns with the endocardial approach in this population include venous occlusion, growth-related lead problems, the need for future lead extractions or replacements, and skin erosions at the pectoral generator site. Smaller generators and the use of various techniques such as looping the pacemaker lead in the right atrium to allow for future growth have lessened, but not eradicated, some of these concerns. Venous occlusion, in particular, remains a major concern in children smaller than 15 kg. For this reason, epicardial systems have been preferred in these children. On the other hand, there has been a global trend in using endocardial pacemaker systems in younger and smaller patients including those weighing less than 10 to 15 kg [5–10].

This retrospective study seeks to analyze complications of pediatric pacemaker systems and to identify relevant risk factors. In addition, we add our experience using endocardial pacemaker systems in small children weighing less than 15 kg to the small body of the current literature. In order to gain greater knowledge about the incidence of pacemaker-related complications in pediatric patients, we compare the existing literature to our findings.

Material and Methods

Patients

We analyzed all pacemaker implantations performed on patients between birth and the age of 18 years at the University Hospital of Düsseldorf between 1985 and 2010. All children with endocardial and epicardial pacemaker

Accepted for publication Dec 23, 2014.

Presented at the Poster Session of the Fifty-first Annual Meeting of The Society of Thoracic Surgeons, San Diego, CA, Jan 24–28, 2015.

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0003-4975/$36.00
http://dx.doi.org/10.1016/j.athoracsur.2014.12.098

systems were included. Operative reports and patient charts were analyzed. Demographic information such as age, gender, height, and weight as well as medical and surgical history was obtained. Data reviewed included type of pacemaker system (epicardial versus endocardial), operative time, generator and lead information, and pacemaker mode. A retrospective analysis of perioperative complications and indications for pacemaker revision was conducted.

Materials

Pacemaker lead models were documented. Specific features including polarity, insulation material, and lead-tip configuration are illustrated in Table 1.

Operative Technique

EPICARDIAL PACEMAKER SYSTEMS. Various methods of epicardial pacemaker placement are available. Implantation of epicardial pacemaker systems can be done by left thoracotomy, sternotomy, or a subxiphoid approach. The generator can be placed in various locations. In our study, pacemaker pocket placement for epicardial systems was either under the rectus abdominis sheath or subpectoral. Other techniques that have been described include subxiphoid and subcostal placement [11].

ENDOCARDIAL PACEMAKER SYSTEMS. Placement of our endocardial pacemaker systems were performed through an incision in the clavicular-pectoral groove. Venous access was established by cannulation of the cephalic vein. If the diameter of the cephalic vein was not sufficient, we used the sheath dilatation technique as previously described by Ong and colleagues [12]. In order to allow for the child's growth, the pacemaker electrode was looped in the right atrium under fluoroscopy.

Groups

Our study included children with postoperative and non-postoperative symptomatic bradycardias, most commonly complete atrioventricular blocks (grade III). The non-postoperative group was subdivided into congenital and non-postoperatively acquired conduction abnormalities. Data were analyzed separately for patients with epicardial versus endocardial pacemaker systems.

There were 19 out of 73 patients who had previous pacemaker operations at other institutions. For the analysis of the total number of revisions these patients were included. The remaining 54 patients, whose first pacemaker operations were done in the study period of 1985 and 2010, were analyzed separately because not all the demographic data were available prior to 1985.

Statistical Methods

All applicable data were written into a spreadsheet. Descriptive statistical analysis was done using Microsoft Excel 2010 and SPSS for Windows, version 18.0.

Results

Patients

During the study period of 1985 to 2010, a total of 73 patients underwent 149 pacemaker operations. Nineteen patients had at least 1 previous pacemaker operation at other facilities. Twenty-seven patients were female (37%) and 46 patients were male (63%). The average clinical follow-up period was 7.9 years. The average age during the initial pacemaker implantation was 6.7 years; for

Table 1. List of Pacemaker Leads

Manufacturer	No.	Model	Lead-Tip	Polarity	Steroid-Eluting	Insulation
Medtronic	4033	CapSure-Z	Passive	Unipolar	Yes	Polyurethane
Medtronic	4023	CapSure-SP	Passive	Unipolar	Yes	Polyurethane
Medtronic	4003	CapSure	Passive	Unipolar	Yes	Polyurethane
Medtronic	4011	TargetTip	Passive	Unipolar	No	Polyurethane
Medtronic	2151	SP	Passive	Unipolar		
Medtronic	4081	TargetTip	Passive	Unipolar	No	Polyurethane
Medtronic	5076	CapSureFix-Novus	Active	Bipolar	Yes	Silicone
Medtronic	4067	CapSureFix	Active	Unipolar	Yes	Polyurethane
Medtronic	4057	Screw-In	Active	Unipolar	No	Polyurethane
Medtronic	4057M	Screw-In	Active	Unipolar	No	Polyurethane
Medtronic	6957	Spectraflex	Active	Unipolar	No	Polyurethane
Medtronic	4068	CapSureFix	Active	Bipolar	Yes	Polyurethane
Medtronic	4951	Spectraflex	Epicardial	Unipolar	No	Polyurethane
Medtronic	4968	CapSure-EPI	Epicardial	Bipolar	Yes	Silicone
Medtronic	4965	CapSure-EPI	Epicardial	Unipolar	Yes	Silicone
Boston-Scientific	NA	Endotak-Reliance-SG-Single-Coil	Active	Bipolar	Yes	Silicone
Boston-Scientific	NA	Acuity-Steerable	J-shaped	Bipolar	Yes	Silicone + ETFE
Boston-Scientific	NA	Acuity-Spiral	Helical-shaped	Unipolar	Yes	Polyurethane

ETFE = ethylene tetrafluoroethylene.