

## Video-assisted thoracoscopic pacemaker lead placement in children with atrioventricular block

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### ABSTRACT

- Background** : The pacemaker lead placement is presented as one of the most appropriate procedures in children with a complete atrioventricular block (AVB). Despite the fact that video-assisted thoracic surgery (VATS) for epicardial lead placement has demonstrated positive results as to the feasibility, safety, and efficacy in adults, its role in pacemaker implantation in children remains unclear.
- Aim** : This study sought to assess the intermediate-term outcomes of video-assisted thoracoscopic pacemaker lead placement in children with complete AVB
- Materials and Methods** : From May 2017 to November 2019, five children with complete AVB underwent minimally invasive left ventricular (LV) lead placements via thoracoscopic video assistance approach. The procedure was performed under complex intratracheal anesthesia with single-lung ventilation, all pacing parameters were evaluated in perioperative and follow-up periods.
- Results** : The median age of children at implantation was 3 years (range: 2 to 4 years), the median weight was 13 kg (range: 12–15 kg). All procedures were completed successfully, pacing thresholds for the active lead measured 0.3–1.1V, with R-wave amplitude of 8–18 mV and impedance of 560–1478 Ohm.
- Conclusion** : Thoracoscopic pacemaker lead placement may provide a potential alternative to the transthoracic approach of epicardial lead placement in children with AVB.
- Keywords** : Atrioventricular block, children and adolescents, epicardial lead placement, minimally invasive approach, pacemaker implantation

### INTRODUCTION

Congenital atrioventricular block (AVB) is a rare disorder with a prevalence rate of approximately 1/15000–1/20000 live-born infants.<sup>[1–3]</sup> Despite the major advance in surgical techniques and human experience in these recent times, making treatment decisions in children with AVB can vary widely by institution, and it depends on multiple factors.<sup>[4,5–8]</sup>

Permanent pacing has been proved to enhance long-term survival, quality of life, and exercise tolerance, as well as to decrease hospital admission rate.<sup>[2,5,7]</sup> It is currently accepted that epicardial pacing is more justified than the endocardial one in children weighing <15 kg.<sup>[5–10]</sup> However, implantation of an epicardial pacemaker

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traditionally requires thoracotomy or partial sternotomy and is associated with a high degree of surgical injury.<sup>[9-11]</sup>

Over the past decade, video-assisted thoracic surgery (VATS) in adults has become more popular by being less traumatic. Lead placement through the VATS approach reduces scarring and is a durable procedure in adults, who have failed transvenous lead placement.<sup>[12,13]</sup> Even though VATS for epicardial lead placement has demonstrated positive results as to the feasibility, safety, and efficacy in adults, its role in pacemaker implantation in children remains unclear.

The present study aims to analyze the intermediate-term outcomes of video-assisted thoracic pacing in children with congenital complete AVB.

## METHODS

The present study was approved by the Ethics Committee of Veltischev Research and Clinical Institute for Pediatrics of the Pirogov Russian National Research Medical University. Between May 2017 and November 2019, a total of five children underwent minimally invasive epicardial pacemaker implantation through video-assisted thoracoscopic surgery. The median age of children was 3 years (ranging from 2 to 4 years); the median weight was 13 kg (ranging from 12 to 15 kg); there were 1 male and 4 female. Demographic and clinical details are shown in Table 1. All patients had congenital AVB. Lupus antibodies were absent in all patients and in their close relatives. In one child, the patent foramen ovale was diagnosed by echocardiography. During hospital admission, standard diagnostic workup was performed, including routine biochemistry, ECG, echocardiography, and 24-h ECG Holter monitoring (HM). Bradycardia and atrioventricular regurgitation were observed in all patients. QTc prolongation was observed in two of five patients. The maximal duration of heart rate (HR) pauses on HM was 4420 ms. Atrioventricular (both mitral and tricuspid) regurgitation has been observed in all patients by echocardiography. Furthermore, an increase of left ventricular end-diastolic diameter has been detected in all patients, which indicated the development of arrhythmogenic myocardial dysfunction. All patients were asymptomatic.

Children were selected for device implantation based on standard criteria such as symptomatic complete AVB or asymptomatic complete AVB in association with LV dysfunction, or QTc prolongation, or presence of wide ectopic ventricular rhythm, average awake ventricular rates of 50 bpm or slower, presence of rhythm's pauses more than 3 R-R intervals measured on the base rate.<sup>[14]</sup>

## Technic

We routinely use right lateral decubitus position for comfortable access to the left pleural cavity and

**Table 1: Clinical and demographic patient details**

Patients	Sex	Age (years) at PM implantation	Weight (kg)	Percentile for weight	Height (cm)	Percentile for height	Heart rate (bpm)	The longest QTc pause on 24-h Holter monitoring (ms)	Ventricular ectopy with exercise	Left ventricular end-diastolic diameter (mm)	Atrioventricular regurgitation	Cardiac defect	Syncope	PM indication
1	Female	3	13	≤3 <sup>th</sup>	101	75 <sup>th</sup>	57	2658	No	39	1.5+	No	No	Bradycardia, ventricular dysfunction
2	Female	4	13	≤3 <sup>th</sup>	98	25 <sup>th</sup>	50	2623	No	39	1.5+	No	No	Bradycardia, ventricular dysfunction
3	Female	2	13,5	25 <sup>th</sup>	93	50 <sup>th</sup>	56	3230	Yes	37	1+	No	No	Bradycardia, ventricular dysfunction, ventricular ectopy with exercise
4	Female	3	12	≤3 <sup>th</sup>	92	25 <sup>th</sup>	44	2456	No	38	1+	PFO	No	Bradycardia, ventricular dysfunction, QTc prolongation
5	Male	2	15	75 <sup>th</sup>	98	95 <sup>th</sup>	44	4420	Yes	38	1+	No	No	Bradycardia, ventricular dysfunction, QTc prolongation

PFO: Patent foramen ovale, PM: Pacemaker

pericardium. Single-lumen endotracheal intubation with carbon dioxide insufflation for the lung isolation is the anesthetic technique for such procedures.

We perform three skin incisions through the sixth intercostal space in the middle axillary line, and through the fourth and ninth intercostal space in the anterior axillary line [Figure 1]. A 4 cm - long longitudinal pericardium incision is made parallel and anterior to the left phrenic nerve, gaining appropriate access to the LV. A unipolar (Medtronic 5071 screw-in) or bipolar (Medtronic 4968 CapSure Epi) epicardial electrode is inserted into the pleural cavity through the trocar. The lead is fixed in the avascular area on the anterolateral surface of the LV. The anterior area of the LV was chosen for a more physiological position. We believe that placing the lead in anterior area of LV provides the best preservation of LV function due to a more physiological approach and a favorable choice for electrode placement is the nearest one to the interventricular septum. We attach primary importance to anatomical landmarks in deciding final lead position. We use a standard Medtronic delivery system in case of the 5071 screw-in lead, and we use polyester suture 4-0 Ethibond exel for fixing Medtronic 4968 CapSure Epi. Closure of the pericardium is performed

with three stitches with enough in-between space for hemopericardium prophylaxis [Figure 2].

The next step is making a midline 4 cm incision in the epigastric region. The pacemaker pocket is formed under the left rectus abdominal muscle. The connector part of the electrode is passed to the pocket under visual control. The lead is tunneled to the abdominal generator subcutaneously. Although subcutaneous tunneling predisposes patients to potential traumatic damage, there are no cases in our practice associated with such complications.

Routine tests of impedance, threshold, and R-wave amplitude are performed. Connector part of the electrode is connected to the pacemaker, and the pacemaker is implanted into the pocket.

Percutaneous pleural and pericardial active drainage is provided before suturing the incisions.

RESULTS

The procedure was completed successfully in all patients. Median operation time was 180 min (ranging from 120 to 240 min). All patients received a VVI® permanent pacemaker system. Surgical data are presented in Table 2. Pacing parameters measurements were obtained in the perioperative period. Pacing thresholds were below 1.3 V in all children. Pacing lead impedances were between 560 and 1478 Ω, and R-wave amplitudes were ranged from 8 to 18 mV. The standard length of the hospital stay was 7 days. No complications were observed whether in early or late postoperative periods. The mean follow-up period was 23 months. All children had more than two ambulatory follow-up visits per year. In particular, regular electrocardiographic, echocardiographic, X-ray assessment and pacemaker device checks were made at 3, 6, and 12 months in the postoperative period [Figure 3].

During the follow-up, high pacing threshold was obtained in one of the patients in the 3<sup>rd</sup> month after pacemaker implantation. The pacing threshold of the left ventricle was 3.5–4.0 V at 0.4 ms and 2.9 V at 1.0 ms. The presence of a subacute inflammatory process was assumed. In this

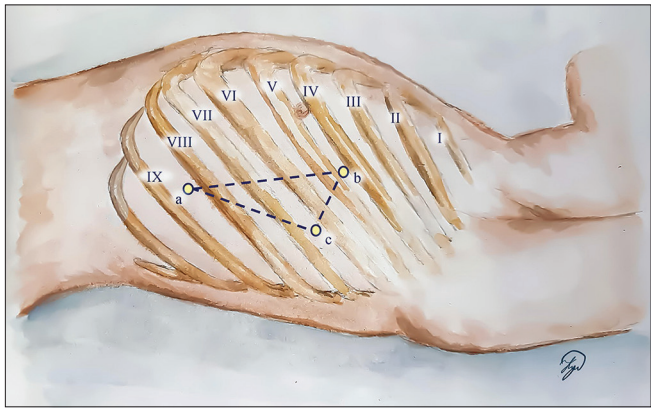


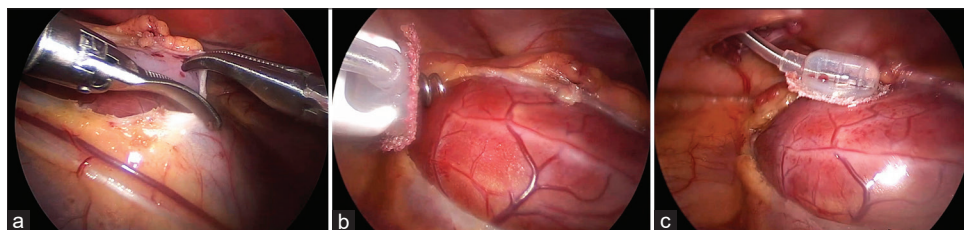
Figure 1: The scheme of thoracoscopic instrumentation location, incisions in points “a” and “c” are needed for trocars, and “b” – for camera placement

Table 2: Perioperative data

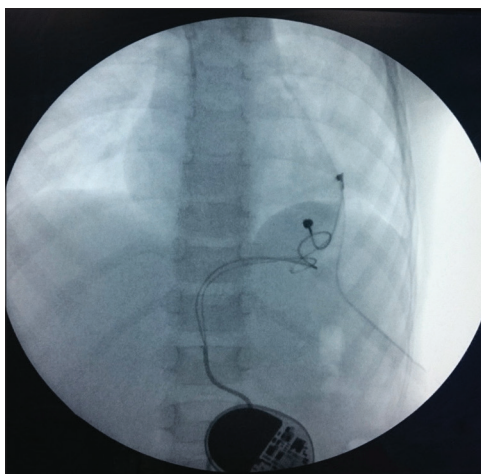
Patients	Operation time (min)	Stimulation mode	Ventricular lead	Use of electrode with active fixation	Device	Pulse rate (bpm)	Pacing threshold (V)	Impedance (Ohm)	Amplitude (mV)
1	220	VVIR	Bipolar CAPSURE EPI 4968-25	N	Adapta ADSR01	70	0.5	1478	>15.6
2	120	VVIR	Medtronic 5071-35	Y	Adapta ADSR01	70	1.1.	760	>9.4
3	150	VVI	Medtronic 5071-35	Y	Adapta ADSR01	70	0.5	743	>15
4	240	VVIR	Medtronic 5071-35	Y	Adapta ADSR01	75	0.5	767	>8
5	180	VVIR	Medtronic 5071-35	Y	BS Proponent MRI SR	75	0.3	560	18

**Table 3: Follow-up data**

Patient	Follow-up (months)	Complications	Medication use	Syncope	Atrioventricular regurgitation	Left ventricular end-diastolic diameter (mm)	Reprogramming of a pulse rate
1	33	N	N	N	N	N	N
2	26	N	N	N	N	N	N
3	26	N	N	N	N	N	N
4	15	N	N	N	N	N	N
5	15	Increase of pacing threshold	Nimesulide	N	N	N	75 → 65 (bpm)



**Figure 2: Pacemaker implantation through thoracoscopic video assistance. (a) A longitudinal pericardium incision is made parallel and anterior to the left phrenic nerve. (b) A unipolar epicardial electrode is inserted into the pleural cavity through the trocar. (c) The lead is fixed in the avascular area on the anterolateral surface of the left ventricular**



**Figure 3: Postoperative chest X-ray from anteroposterior projection after epicardial left ventricular pacing lead implantation via thoracoscopic video assistance**



**Figure 4: Postoperative photographs, which demonstrate a cosmetic effect**

regard, anti-inflammatory therapy was used (nimesulid). The purpose of the anti-inflammatory therapy, in this case, is to stop the increase in thresholds and subsequently, to prevent the need for reimplantation. The benefit cannot be attributed to anti-inflammatory therapy with any certainty owing to the lack of international clinical studies. Due to the absence of the pacing threshold increase in the dynamic observation, re-operation was not indicated.

At the latest follow-up, all device parameters remained the same, without changes in pacing threshold, lead impedance, or R-wave amplitude. Follow-up data are described in Table 3. Regression of atrioventricular regurgitation was observed. Left ventricular sizes returned to normal in all children. All patients reported clinical benefit, in particular, adequate body weight and height gains during the follow-up, and evidenced satisfactory compensation of bradycardia with permanent pacing.

## DISCUSSION

Permanent pacing is the cornerstone of treatment for children with complete AVB regardless of the etiology of the disease.<sup>[2,5,7]</sup> Numerous age-specific factors may contribute to the difficulties of pacemaker implantation in pediatric patients such as small vessel size, the effects of growth on the leads, the requirement of revisions throughout a patient's lifetime, and so forth.<sup>[9-11]</sup> Despite the development of permanent pacing technology and surgical strategies, the use of cardiac pacing in the young population is still an area of significant controversy.



Conventionally, epicardial pacing is more preferable than the endocardial one for patients weighing up to 15 kg, mainly for venous access preservation and lower risks of procedure-related complications.<sup>[5-10]</sup> Transthoracic implantation of pacing lead is the most common technique of lead placement for pacemaker implantation in the smallest children. As a general consensus, pulse generator is placed in the abdominal wall for small body size instead of chest wall placement. However, the transthoracic approach is associated with a high level of tissue injury regardless of pulse generator placement. Minimally invasive techniques such as VATS have demonstrated some advantages over open surgery in adults, including fewer complications, shorter length of stay, and improved quality of life.<sup>[12-13]</sup> Nevertheless, to our knowledge, there are no studies describing VATS for permanent pacing in children to date.

In our study, satisfactory device parameters were obtained in all patients in the latest follow-up period. It should also be taken into account that all operations were performed by the same two surgeons; we assume that distinctions in the experience of different hospitals may influence the results. No procedural complications such as pocket hematomas, device infections, or lead dislocations have been observed. The operative scars are very small compared to open thoracotomy and demonstrate a good cosmetic effect [Figure 4]. Reduction of heart dysfunction was obtained in all patients. The clinical benefit is evidenced by adequate weight gaining during the follow-up.

## CONCLUSION

We believe that VATS is truly the least invasive approach for epicardial pacing and may provide a potential alternative to the transthoracic technique of epicardial lead placement in children with AVB.

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## Conflicts of interest

There are no conflicts of interest.

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