Transvenous endocardial pacemaker pacing in thoracoscopic cardiac surgery

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Abstract

Background: Temporary cardiac pacing is frequently required during heart surgery due to life-threatening complications of arrhythmias. The conventional method of epicardial pacing could have risks such as bleeding and myocardial tears. Transvenous endocardial pacing provides another option. The efficiency of transvenous epicardial and endocardial pacing were compared in this study. Methods: We performed a retrospective study and reviewed medical records in patients who received either thoracoscopic cardiac surgery with transvenous endocardial pacing or median sternotomy with transvenous epicardial pacing between June 2019 and January 2021. Patients were assigned into two groups depending on the surgical type and pacing method. Preoperative patient characteristics and perioperative outcomes were collected. The efficiencies of endocardial and epicardial pacing were compared and analyzed in SPSS. Results: A total of 68 patients were included. Thirty-five (51.5%) patients were in the thoracoscopic cardiac surgery group with transvenous endocardial pacing. Thirty-three (48.5%) patients were in the median sternotomy group with transvenous epicardial pacing. Intensive care unit (ICU) time ($p = 0.014$), in-hospital duration ($p = 0.036$), operation time ($p = 0.005$), and the 24-h drainage volume ($p < 0.001$) showed significant differences between the two groups. There was no significant difference between the pre- and post-operative heart rate and rhythm compared between two groups. Conclusions: Compared with transvenous epicardial pacing, transvenous endocardial pacing showed no significant differences in heart rate and arrhythmia during the perioperative period. Transvenous endocardial pacing was also associated with better operative measurements.

Ethics and integrity policies statements

The study protocol was approved by the First Affiliated Hospital of Jinan University Ethics Committee NO.2019002. All patients provided written informed consent.

Conflict of interests

The authors declare that there are no conflict of interests.

Data availability statements

All data generated or used during the study appear in the submitted article.

Funding statement

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Author contributions

Xiangnian Li was responsible for interpretation of results, and manuscript writing. Wu Zhang was responsible for study design, recruiting, and clinical diagnosis. Shengjie Liao performed some data sorting and worked on the manuscript's revision. Xiaoshen Zhang contributed to results interpretation, and in revising process for the final draft. All authors read and approved the final manuscript.

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Methods: We performed a retrospective study and reviewed medical records in patients who received either thoracoscopic cardiac surgery with transvenous endocardial pacing or median sternotomy with transvenous epicardial pacing between June 2019 and January 2021. Patients were assigned into two groups depending on the surgical type and pacing method. Preoperative patient characteristics and perioperative outcomes were collected. The efficiencies of endocardial and epicardial pacing were compared and analyzed in SPSS.

Results: A total of 68 patients were included. Thirty-five (51.5%) patients were in the thoracoscopic cardiac surgery group with transvenous endocardial pacing. Thirty-three (48.5%) patients were in the median sternotomy group with transvenous epicardial pacing. Intensive care unit (ICU) time ($p = 0.014$), in-hospital duration ($p = 0.036$), operation time ($p = 0.005$), and the 24-h drainage volume ($p < 0.001$) showed significant differences between the two groups. There was no significant difference between the pre- and post-operative heart rate and rhythm compared between two groups.

Conclusions: Compared with transvenous epicardial pacing, transvenous endocardial pacing showed no significant differences in heart rate and arrhythmia during the perioperative period. Transvenous endocardial pacing was also associated with better operative measurements.

Keywords: cardiac surgery; transvenous pacing; epicardial pacing; endocardial pacing, arrhythmia

Introduction:

Arrhythmias are life-threatening complicated diseases after cardiac surgery, with estimated incidences of 5% and 12% after mitral valve replacement (MVR) and aortic valve replacement (AVR) surgery, respectively [1]. Throughout cardiac surgery, incisions, stitches, and ischemia-reperfusion can cause damage to the myocardium. Arrhythmias primarily occur during the myocardium repair process. Patients with postoperative arrhythmias require intensive medical management and additional antiarrhythmic medications.

In recent years, thoracoscopic cardiac surgery has developed rapidly in many medical centers in China. More cardiac surgeries have been performed in high-risk patients, including patients with poor baseline conditions, older age, and severe adhesions due to primary cardiac operations.

Temporary pacing (TP) can be used during the postoperative period to adjust the heart rhythm and rate, stabilize the hemodynamics, and optimize the cardiac function [2,3]. Once the heart rhythm remains to a unstable rate after implanting TP, a permanent pacemaker is required to replace the TP.

The first pacemaker was applied in the clinic in 1958 and the transvenous cardiac pacemaker was utilized in 1976 [6]. Currently, TP is installed in patients after cardiac surgery to maintain a stable heart rate and cardiac output (CO). In addition, TP can reduce the total amount of vasoactive drugs and ultimately improve perioperative safety [7]. There are several types of TP placement methods: epicardial, endocardial, and transesophageal auricle pacing. The transvenous endocardial pacing (TEP) lead is implanted through the catheter in the internal jugular vein and the superior vena cava into the right atrium with the assistance of an experienced anesthetist. During tricuspid valve surgery, after the pacing lead is exposed to the surgical field, the surgeon can place it into the right ventricle under direct visualization. In single mitral valve surgery, the location of the pacing leads can be monitored by trans-esophageal echocardiography (TEE) and post-pacing electrocardiograph (ECG). The EP lead has been conventionally implanted in valve surgery for years [4]. However, due to complex procedures in thoracoscopic cardiac surgery, the implantation of the EP lead may cause bleeding and tears in the myocardium [5]. With advances in lead and pacemaker technologies, especially the development of transvenous endocardial leads, new therapeutical and surgical opportunities have been continuously introduced into clinical practice.

In the present study, we reviewed our experience in epicardial and transvenous pacing based on operative and postoperative data in our hospital, with the purpose to compare the efficiency between the TEP lead and the EP lead in patients after cardiac surgery.

Materials and Methods

Study design and participants

We performed a retrospective study in patients who had cardiac surgery with pacing at the Department of Cardiovascular Surgery and the Surgery Intensive Care Unit (SICU) of the First Affiliated Hospital of Jinan University between June 2019 and January 2021. The study protocol was approved by the First Affiliated Hospital of Jinan University Ethics Committee. This study demonstrated that the TENP lead was a viable option when the implantation of a TEPP lead was risky.

Patient inclusion criteria were: 1), age between 14 and 79 old; 2), received either thoracoscopic cardiac surgery with transvenous endocardial pacing or median sternotomy with epicardial pacing. Patients with incomplete medical records or existing permanent pacemakers were excluded.

Study protocol

General anesthesia was performed through a combination of intravenous and inhalation approaches. A double-lumen tracheal cannula was inserted in the left lung for single-lung ventilation. The endocardial TP lead catheter was routinely implanted before the operation and started during the induction of anesthesia. The central venous catheter (CVC) and the temporary bipolar pacing catheter were placed into the right internal jugular vein. The exposed temporary bipolar pacing catheter was protected using a sterile protective sheath. For epicardial pacing (EP) leads, the negative pole lead is stitched into the myocardium to avoid the coronary artery in the right atrium surface. The positive pole lead is fixed in the skin surface, which is commonly located near the 4th intercostal space at the left anterior axillary line, approximately 1.5 cm right of the negative pole lead.Systemic heparinization of cardiopulmonary bypass was performed through femoral artery, femoral vein and superior vena cava (SVC) cannulation. Peripheral cardiopulmonary bypass (CPB) was established.

During thoracoscopic cardiac surgery, all the procedures were performed via three or four incisions made in the right hemithorax. A primary operating point (3–5 cm) was chosen in the 3rd or 4th intercostal space at the right midclavicular line to insert the surgical instruments. An assist operating point (2–3 cm) in the 2nd or 3rd intercostal space at the right anterior axillary line was chosen to pass the cardioplegia cannula, aortic clamp, and the drainage tube for the SVC and right superior pulmonary vein. In addition, a camera port (1.5–2 cm), via an incision in the 5th or 6th intercostal space at the anterior axillary line, was used to operate the inferior vena cava snare and thoracoscope. All thoracoscope cardiac surgeries, including mitral surgery, tricuspid surgery, and the combined mitral-tricuspid surgery or excision of intracardiac myxomas, were performed under thoracoscopy via three one-inch incisions made in the right chest wall by soft tissue retractors.

In patients who received median sternotomy, an incision was made down the midline of the entire sternum. In our center, all aortic valve diseases, including aortic valve surgeries with or without artificial vascular replacement, were performed using a median sternotomy.

The TP was established by an anesthetist default to the VVI(paces and senses the ventricle and is suppressed by a sensed ventricular event) standard. The sensitivity was 0.8 mV with an output of 7 mV. The range of the pacing rate was from 80 to 100, depending on different conditions.

Once the patient returns to the ward from the operating room, a bedside chest X-ray will be taken to determine whether the pacemaker and thoracic drainage tube are satisfactory during the operation.

The TP leads were removed after the spontaneous heart rhythm in the patient was stable with no third-degree atrioventricular block or supraventricular tachycardia even if the pacemaker was off. In most patients, TP was removed five days postoperatively.

Outcome measurements

Patients were assigned into two groups: a group with thoracoscopic cardiac surgery and transvenous endocardial pacing and another group with median sternotomy and transvenous epicardial pacing.

Patient baseline demographic information, weight, height, NYHA classification, EuroSCORE, serum pro-BNP, LVEF, and PASP were recorded. Perioperative measurements, including operation time, CPB time, ACC time, and 24-h drain volume, were documented. ICU time and in-hospital duration were also noted. Preoperative and postoperative cardiac monitoring were performed. Any secondary surgery or life-threatening infection was also documented.

Statistical analysis

Statistical analysis was performed in SPSS 23.0 (SAS Institute, Cary, NC, USA). The data are presented as means ± standard deviations or percentages. Differences between two groups were compared using a two independent simples t -test, a Chi-square test, and Fisher exact tests, when appropriate. A $p < 0.05$ was considered statistically significant.

Results

A total of 68 patients were included in the present study. Thirty-five (51.5%) patients were in the thoracoscopic cardiac surgery group who had transvenous endocardial pacing lead implantations. Thirty-three (48.5%) patients were in the median sternotomy group who had epicardial pacing lead implantations. None of the included patients underwent unplanned secondary surgeries or had severe life-threatening infections.

The preoperative characteristics of the patients are summarized in Table 1. Patients with transvenous endocardial pacing had lower PASP(pulmonary arterial systolic pressure)($p = 0.031$) and were more likely to have lower NYHA (New York Heart Association) functional classifications than those with epicardial pacing.

The intraoperative conditions, ICU times, and in-hospital durations are summarized in Table 2. The ICU stay time ($p = 0.014$), in-hospital duration ($p = 0.036$), operation time ($p = 0.005$), ACC(aortic cross-clamp) time ($p = 0.017$), and the 24-h drainage ($p = 0.00$) all showed significant differences between the two groups. The CPB(Cardiopulmonary bypass) time ($p = 0.905$) showed no significant difference. The efficiencies of the transvenous endocardial pacing and epicardial pacing, reflected by the heart rate and rhythm preoperatively and postoperatively, are summarized in Table 3. The postoperative heart rate was obtained after adjusting the vasoactive agent through different medications and dosagesand prior to removing the TCP lead. There were no significant differences in the preoperative and postoperative heart rates and rhythms between patients with the transvenous endocardial pacing lead and the epicardial pacing lead.

One patient (1.5%) had secondary cardiac surgery performed. Six patients (8.8%) returned to the sinus rhythm from atrial fibrillation after surgery. Two patients (2.9%) returned to the sinus rhythm after surgery without the performance of the maze procedure or left atrial wall plication. One patient (1.5%) returned to sinus rhythm from permanent atrial fibrillation after surgery. None of the 35 patients (0%) with the implanted transvenous endocardial pacing lead had documented complications. The intraoperative TEE(Transesophageal echocardiography) showed the TEP (transvenous endocardial pacing) lead placed via the tricuspid valve caused a mild tricuspid regurgitation. No related complications occurred following the implantation or removal of the pacing lead catheters.

Discussion

The TENP lead was first used by physicians due to its convenience during bedside resuscitations of critical patients. The TENP lead catheter could be placed through several different venous channels, including the subclavian vein, the jugular vein, and the femoral vein. When the lead catheter was placed through the subclavian vein, patients could have increased risks of hemothorax and pneumothorax. The femoral vein has typically been the first choice, although a long distance is required to reach the right ventricle (RV). In addition, the femoral vein is frequently used to set up cardiopulmonary bypass (CBP) during cardiac surgery. The right jugular vein, which is nearly straight to the RV anatomically, has been found to significantly lower the risk of complications during TENP placement [7].

Several complications have been reported while implanting endocardial pacing leads. These include pneumothorax, arrhythmias, and pericardial tamponade [8,9]. In the present study, 35 (35/35) endocardial pacing leads were implanted successfully without any complication. All the pacing leads were implanted and precisely monitored by interoperative TEE. After surgery, a chest X-ray was used to evaluate the pacing effect and position of the pacemaker. An epicardial pacing lead has been used conventionally in cardiac surgery in many centers for years [10]. However, complications have been reported mostly during the epicardial pacing lead removal procedure. These complications include ventricular arrhythmias [11], cardiac tamponade, and dyspnea [12]. Some case reports also described complications during the implantation of epicardial pacing leads [13,14].

Transvenous endocardial pacing is associated with a lower rate of complication during the removal procedure. Furthermore, transvenous endocardial pacing is more suitable for thoracoscopic cardiac surgery.

Compared with the conventional epicardial lead, the transvenous endocardial lead in thoracoscopic cardiac surgery has less complications. One of our patients underwent a secondary cardiac surgery due to severe adhesion in the thoracic cavity and inaccessible ventricular surface. During the thoracoscopic cardiac surgery, because of the limited surgical field, it was difficult to isolate the adhesive right ventricle and distinguish the coronary vessels during the implantation of the epicardial cathode lead. The implantation of the temporary endocardial pacing lead was associated with a lower acute stimulation threshold and a lower rate of lead-related complications [15]. Several studies have shown that the application of a temporary endocardial pacing lead implantation could provide an option in thoracoscopic cardiac surgery [5].

When valvuloplasty is finished, TEE is performed to evaluate the valvular shaping effect. The position of the endocardial pacing lead can then be adjusted. According to the interoperate TEE, the implantation of the endocardial pacing lead caused little influence on the tricuspid valvular function of the patients in this study (n=35).

This study demonstrated that the TENP lead was a viable option when the implantation of a TEPP lead was risky. Currently, the TENP lead is conventionally used in thoracoscopic cardiac surgery. However, several possible complications can occur while implanting the lead, including implant failure, arterial puncture, cardiac perforation, and pericardial tamponade [8]. With the cooperation of an experienced anesthetist and skilled surgeon, cardiac perforation can be effectively avoided. The possibility of endocarditis can be reduced by using antibiotics after surgery and removing the endocardial pacing lead and right internal jugular catheter as early as possible. In our center, the TENP lead and its catheter were removed three or four days after the surgery, when the heart rate was stable; this helped to reduce the incidence of endocarditis.

Our center performs both median sternotomies and minimally invasive cardiac surgeries (MICS) that include thoracoscopic cardiac surgeries. There are several advantages to thoracoscopic surgery, including smaller incisions, larger images, brighter illumination, easier recording and broadcasting, and better exposure of the mitral valve. In addition, the assistant can share the same vision with the surgeon, which can be rarely performed during traditional sternotomy [16]. However, even though the incision on the surface seems smaller, the CPB time is not different between the median sternotomy and thoracoscopic surgery. Because thoracoscopy surgery has limited vision, there is a higher demand for better surgical operating skills.

Declarations

Not applicable.

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Table 1. Preoperative characteristics in patients who received either endocardial or transvenous epicardial pacing

		Endocardial pacing (n = 35)	Transvenous epicardial pacing (n = 33)	*p*
Age (yr) Male	48.7±17.7 13(19.12%)	48.7±17.7 13(19.12%)	52.7±12.9 26(38.24%)	0.292 0.001
Weight (kg)	57.4±12.6	57.4±12.6	60.7±10.3	0.239
Height (cm)	162.4±9.3	162.4±9.3	163.1±7.8	0.739
NYHA classification I II III IV	4(5.88%) 15(22.06%) 12(17.65%) 4(5.88%)	4(5.88%) 15(22.06%) 12(17.65%) 4(5.88%)	0(0%) 4(5.88%) 25(36.76%) 4(5.88%)	0.020 0.238
Pro-BNP (mmol/L)	756.9±1062.6	756.9±1062.6	1260.9±1306.0	
LVEF (%)	65.1±6.9	65.1±6.9	64.1±8.9	0.598
EuroSCORE II	1.7±2.2	1.7±2.2	1.4±0.8	0.607
PASP (mmHg)	38.7±17.1	38.7±17.1	49.4±17.7	0.031

Table 2. Intraoperative conditions and length of hospital stays in patients who received either endocardial or transvenous epicardial pacing

	Endocardial pacing (n = 35)	Transvenous epicardial pacing (n = 33)	Transvenous epicardial pacing (n = 33)	*p*
Operation time (h)	3.7±0.7	4.4±1.2	0.003	0.003
CPB time (min)	138.5±33.2	139.7±49.7	0.905	0.905
ACC time (min)	73.6±24.8	93.7±39.4	0.017	0.017
24-h drain volume (ml)	53.6±45.6	152.1±63.6	0.000	0.000
ICU time (h)	52.2±36.0	77.1±45.2	0.014	0.014
In-hospital duration (h)	17.5±7.3	21.6±8.6	0.036	0.036

ACC: aortic cross-clamp

	Endocardial pacing (n = 35)	Transvenous epicardial pacing (n = 35)	Transvenous epicardial pacing (n = 35)	p
Preoperative heart rate (cpm)	77.2±14.8	77.2±14.8	77.5±15.1	0.913
Preoperative atrial fibrillation	11(16.18%)	11(16.18%)	6(8.82%)	0.207
Postoperative heart rate (cpm)	87.4±18.7	87.4±18.7	80.2±13.6	0.074
Postoperative atrial fibrillation	7(10.29%)	7(10.29%)	5(7.35%)	0.600

Table 3. Cardiac monitor results in patients who received either endocardial or transvenous epicardial pacing