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ORIGINAL ARTICLE

# Intraoperative Implantation of Temporary Endocardial Pacing Catheter During Thoracoscopic Redo Tricuspid Surgery

**Qian Lei [a*], Xin-Chuan Wei [a], Ke-Li Huang [b], Tao Yu [b], Xiao-Shen Zhang [b], Huan-Lei Huang [c], Hui-Ming Guo [c]**

[a]Department of Anesthesiology, Sichuan Academy of Medical Sciences and Sichuan Provincial People's Hospital, University of Electronic Science and Technology of China, Chengdu, 610072, China
[b]Department of Cardiac Surgery, Sichuan Academy of Medical Sciences and Sichuan Provincial People's Hospital, University of Electronic Science and Technology of China, Chengdu, 610072, China
[c]Department of Cardiac Surgery, Guangdong Cardiovascular Institute, Guangdong General Hospital and Guangdong Academy of Medical Sciences, Guangzhou, 510080, China

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**Background** The placement of a temporary epicardial pacing wire is a challenge during a minimally invasive redo cardiac operation. The aim of this study is to assess the application of temporary endocardial pacing in patients who underwent minimally invasive redo tricuspid surgery.

**Methods** Perioperative data of consecutive patients who underwent thoracoscopic redo tricuspid surgery were collected. All the tricuspid surgeries and combined procedures were performed under peripheral cardiopulmonary bypass without aortic cross-clamping. A sheath was introduced into the right jugular vein beside the percutaneous superior vena cava cannula and a temporary endocardial pacing catheter was guided into the right ventricle via the sheath prior to the right atrial closure. The pacemaker was connected and run as needed during or after operation.

**Results** A total of 33 patients who underwent thoracoscopic redo tricuspid surgery were enrolled. Symptomatic tricuspid valve regurgitation (93.9%) and tricuspid valvular prosthesis obstruction (6.1%) after previous cardiac operations were noted as indications for a redo surgery. The mean time from previous cardiac operation to this time redo surgery was 13.3 ± 6.4 years. Isolated tricuspid valve replacement was performed in 18 patients (54.5%) and tricuspid valve plasty combined with or without mitral valve replacement was performed in 15 patients (45.5%). A temporary endocardial pacing catheter was successfully placed in the right ventricle for all patients with good sensing and pacing. No temporary pacing related complications occurred from insertion to removal of pacing catheter in the patients.

**Conclusions** This application of temporary endocardial pacing provided a safe and effective substitute for epicardial pacing in patients who underwent minimally invasive redo tricuspid surgery.

**Keywords** Minimally invasive surgery • Tricuspid valve • Redo cardiac surgery • Temporary pacing

## Introduction

The benefits of minimally invasive cardiac surgery (MICS) have subsequently resulted in the tremendous growth of these procedures and led to the constant improvement of relative techniques [1–6]. There are several studies that support the effectiveness and safety of MICS in recent years [1,2]. Although MICS is performed in patients with uncomplicated

*Corresponding author. Tel.: +86 28 87393632. Email: leiqianggh@163.com

cardiac lesions due to safety considerations, it has still demonstrated beneficial effects in high-risk patients with the development of techniques [7–9].

Redo tricuspid surgery is associated with high operative risk because the patients often have complications such as right heart dysfunction [10]. Sternal re-entry is a time-consuming procedure and is associated with massive blood loss, injury to the heart, great vessels or coronary grafts. However, the tricuspid reoperation might be much more accessible through right thoracotomy without wide cardiac isolation as it is present close to the right chest wall. Several reports have shown that the clinical outcome of the right anterolateral thoracotomy minimally invasive surgery is satisfactory for a redo tricuspid valve operation [8,9,11]. Furthermore, the technique was performed without aortic cross-clamping and cardioplegia administration in minimally invasive reoperative valve surgery [12]. This is feasible in reducing the range of heart isolation, avoiding bleeding and injuries as much as possible because isolating the adhesive heart is difficult in the limited operation field. Nevertheless, the placement of temporary epicardial pacing wire is another challenge for the surgeons when performing this minimally invasive reoperation.

Transient bradyarrhythmias following cardiac surgery are common and most are managed with temporary epicardial pacing wires that are placed at the time of cardiac surgery. The indications for the insertion of temporary epicardial pacing wires in surgery are still controversial. Some centres place at least ventricular wires in almost all cardiac surgery patients, others only in those who have rhythm disturbance intraoperatively. However, temporary epicardial pacing wires have been routinely recommended for insertion after valve surgery because of increased need for temporary cardiac pacing [13]. Temporary pacing plays an important role in the early postoperative period of patients who underwent redo tricuspid surgery due to their high risk for the development of arrhythmias. However, it is difficult to isolate the adhesive right ventricle and suture the epicardial pacing wires under thoracoscopy. In our practice, a temporary endocardial pacing catheter for intraoperative and postoperative pacing was easily inserted into the right ventricle via the right jugular vein and this technique completely accomplishes the minimally invasive redo TV surgery. Therefore, temporary endocardial pacing catheter, as a substitute for an epicardial pacing wire, is routinely recommended for placements in patients undergoing thoracoscopic redo cardiac surgery for right atrial incision in our centres. A temporary endocardial pacing wire was demonstrated to be safe and effective in minimally invasive redo tricuspid surgery.

# Material and Methods

## Patients

The study was approved by the local Institutional Review Committees, and consecutive patients who underwent redo tricuspid valve operations with or without mitral valve procedures through total thoracoscopy from July 2013 to June 2016 in the two centres were enrolled. The selection criteria were as follows: (1) body weight $\geq$30 kg; (2) pulmonary arterial systolic pressure as measured by transthoracic echocardiography should be $\leq$90 mmHg; (3) no airway malformation.

## Anaesthesia, Cardiopulmonary Bypass and Surgery

Intravenous and inhalation combined anaesthesia with a left-sided double-lumen endotracheal intubation was performed. The endocardial temporary pacing catheter was routinely implanted intraoperatively. An 8 Fr sheath (SCW Medicath Ltd, Shenzhen, China) was placed into the right internal jugular vein and a 6 Fr temporary bipolar pacing catheter (St. Jude Medical Inc, MN, USA) was inserted into the sheath with a sterile protective sleeve (Figure 1A). Peripheral cardiopulmonary bypass (CPB) was set up through femoral arterial and venous cannulation and percutaneous superior vena cava cannulation. Neither of the vena cava was snared during CPB. Meanwhile, the intracardial procedures were performed during slow heart beating or ventricular fibrillation without aortic cross-clamping. The temperature of the patients was maintained at approximately 33 °C during CPB after spontaneous cooling. All the redo cardiac surgeries, including tricuspid surgery and the combined mitral surgery or left atrial thrombus removal, were performed under thoracoscopy via three holes made in the right chest wall. Right atrial incision was performed for tricuspid procedures and the left-sided procedure was performed via atrial septum incisions if required. The decision for valve replacement or plasty was judged by the surgeons. The pacing catheter was inserted into the right ventricle through the superior vena cava and tricuspid valve with the cooperation of anaesthesiologist and surgeon prior to the right atrial closure (Figure 1B). Transoesophageal echocardiography (TEE) was routinely utilised for intraoperative evaluation as well as the position of the pacing catheter and its effect on the tricuspid valve (Figure 1C). The temporary pacing catheter was removed when the patient's spontaneous heart rhythm was stable without any third degree atrioventricular block within 1 week, otherwise, a permanent pacemaker was considered.

## Data Collection

Perioperative data of the patients were recorded prospectively. Results are displayed in the standard format with continuous variables expressed as mean $\pm$ standard deviation and categorical data as n (%).

# Results

Three patients were excluded because one of them had a preoperative permanent pacemaker and lung adhesions

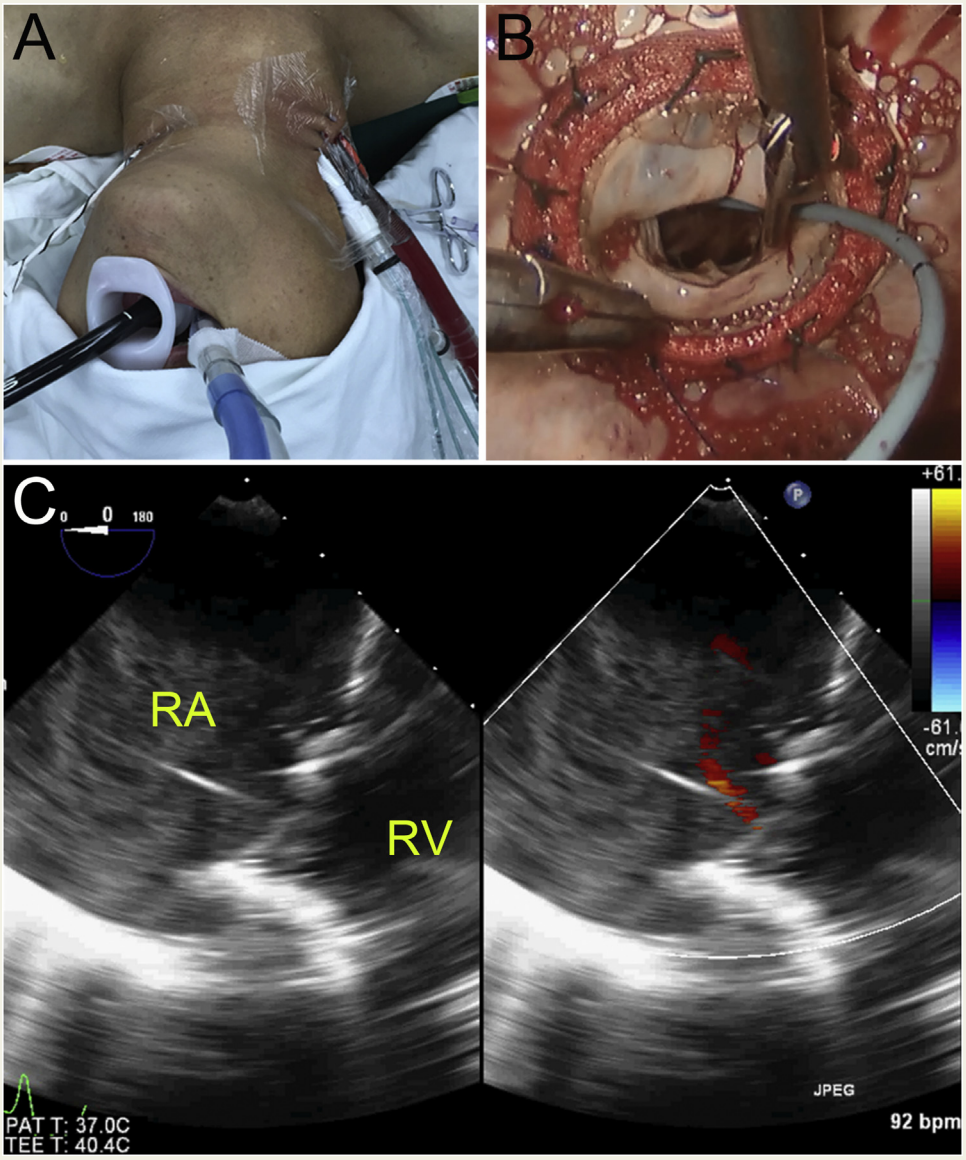


**Figure 1** Method of placing and verifying temporary endocardial pacing catheter during thoracoscopic redo tricuspid valve surgery. (A) A pacing catheter was inserted into the sheath with sterile protective sleeve in the right internal jugular vein. (B) The tip of pacing catheter was placed into the right ventricle through tricuspid valve prior to right atrial closure. (C) Transoesophageal echocardiography was utilised to verify if the catheter was placed into the right ventricle via tricuspid valve with only trace or mild tricuspid regurgitation.
Abbreviations: RA, right atrium; RV, right ventricle.

necessitated sternotomy in two cases. A total of 33 patients underwent thoracoscopic tricuspid procedures combined with or without mitral valve procedures were enrolled in this cohort. Preoperative characteristics of the patients are summarised in Table 1. Table 2 demonstrates the previous cardiac operations. For one patient, this was the third time of cardiac surgery. The mean time from previous operation to this time redo surgery was 13.3 ± 6.4 years.

Performed procedures are listed in Table 3 and most of the patients (72.7%) underwent isolated tricuspid valve replacement or plasty. Additional combined procedures, including mitral valve replacement with or without left atrial thrombus removal, were performed in nine patients (27.3%). Table 4 shows the perioperative patient characteristics. A temporary endocardial pacing catheter was implanted in all patients successfully with good pacing and sensing. Post-CPB TEE identified the pacing catheter in the right ventricle via tricuspid valve without moderate or more tricuspid regurgitation. No related complications occurred following the removal of pacing catheters. The implantation of a permanent pacemaker was necessary in one patient with irreversible third-degree atrioventricular block and the pacing catheter was placed in the coronary sinus by cardiologists. Two patients died due to postoperative multiple organ

**Table 1** Preoperative characteristics (n = 33).

| Variable | Values |
|---|---|
| Age (yr) | 51.9 ± 12.0 |
| Male/Female | 12 (36.4%)/21 (63.6%) |
| Height (cm) | 160.1 ± 6.4 |
| Weight (kg) | 53.7 ± 9.2 |
| NYHA classification | |
| II | 21 (63.6%) |
| III | 10 (30.3%) |
| IV | 2 (6.1%) |
| LVEF (%) | 65.2 ± 7.6 |
| Euroscore II | 4.74 ± 3.01 |
| Pulmonary artery systolic pressure (mmHg) | 41.0 ± 9.4 |
| Prosthesis obstruction after TVP | 2 (6.1%) |
| TR grade | |
| Severe | 26 (78.8%) |
| Moderate | 5 (15.2%) |

Abbreviations: NYHA, New York Heart Association; LVEF, left ventricular ejection fraction; TVP, tricuspid valve plasty; TR, tricuspid regurgitation.

dysfunction syndrome and the in-hospital mortality was 6.1%. Postoperative low cardiac output syndrome occurred in one patient, who was treated with extracorporeal membrane oxygenation and intra-aortic balloon pump.

**Table 2** Previous operations (n = 33).

| 1st Intervention | 1st Redo | No. (%) |
|---|---|---|
| MVR + AVR + TVR | | 1 (3.0%) |
| MVR + AVR + TVP | | 2 (6.1%) |
| MVR + AVR | | 11 (33.3%) |
| MVR | | 6 (18.2%) |
| MVP | | 1 (3.0%) |
| AVR | | 1 (3.0%) |
| TVR | | 1 (3.0%) |
| CABG + MVP | | 1 (3.0%) |
| ASD repair + MVP | | 1 (3.0%) |
| ASD repair | | 3 (9.1%) |
| PS correction | | 1 (3.0%) |
| LAM removal | | 1 (3.0%) |
| CMC | | 2 (6.1%) |
| CMC | MVR | 1 (3.0%) |

Abbreviations: MVR, mitral valve replacement; AVR, aortic valve replacement; TVR, tricuspid valve replacement; TVP, tricuspid valve plasty; MVP, mitral valve plasty; CABG, coronary artery bypass grafting; ASD, atrial septal defect; PS, pulmonary stenosis; LAM, left atrial myxoma; CMC, closed mitral commissurotomy.

**Table 3** Procedures performed.

| Procedure | No. (%) |
|---|---|
| TVR | 18 (54.5%) |
| TVP | 6 (18.2%) |
| TVP + MVR | 8 (24.2%) |
| TVP + MVR + LATH removal | 1 (3.0%) |

Abbreviations: TVR, tricuspid valve replacement; TVP, tricuspid valve plasty; MVR, mitral valve replacement; LATH, left atrial thrombus.

# Discussion

Although controversy still remains regarding the indications for temporary pacing during cardiac surgery, the placement of a temporary pacemaker is usually necessary, especially to wean the patient from CPB or deal with rhythm disturbances. Admittedly, epicardial pacing wires are mostly placed during regular cardiac surgeries. Intraoperative epicardial pacing wires are usually implanted on the anterior right ventricular muscle in an area without pericardial fat or coronary vessels and can come out through the skin next to the incision. The anterior right ventricular area is easily accessible and it provides good pacing and sensing. However, it is not always uneventful to suture or remove an epicardial pacing wire.

However, the endocardial pacing avoids several disadvantages. Meanwhile, it was irreplaceable in some patients who underwent cardiac surgery when the ventricular surface was inaccessible. Due to limited exposure during the thoracoscopic redo tricuspid surgery, it is difficult to isolate the adhesive right ventricle and distinguish the coronary vessels for placement of epicardial pacing wires. However, the implantation of the temporary endocardial pacing catheter becomes a safe and easy technique with the cooperation of the anaesthesiologist and surgeon. In the present study, the application of a temporary endocardial pacing catheter implantation provides a good option for intraoperative and postoperative temporary cardiac pacing in minimally

**Table 4** Perioperative patient characteristics.

| Variable | Values |
|---|---|
| Operation time (h) | 2.86 ± 0.78 |
| CPB time (min) | 87.4 ± 23.7 |
| MV time (h) | 32.3 ± 42.5 |
| ICU duration (h) | 93.0 ± 90.1 |
| In-hospital duration (d) | 10.2 ± 5.3 |
| 24-h drain volume (ml) | 261.7 ± 257.1 |

Abbreviations: CPB, cardiopulmonary bypass; MV, mechanical ventilation; ICU, intensive care unit.

invasive redo cardiac surgery that requires right atrial incision.

The occurrence of tricuspid lesions is not uncommon after a previous cardiac operation. They could occur following tricuspid valve surgeries [14] as well as left-sided cardiac surgery [15]. Redo tricuspid surgery is associated with high-risk and in-hospital mortality might be as high as 35.1% [14]. On one hand, the relatively delayed operation time and poor condition of patients are associated with poorer prognosis rates. On the other hand, trauma due to sternal re-entry also increases the risk of operation. Therefore, besides the aggressive intervention for tricuspid valve earlier, minimally invasive techniques are also helpful for the patients who undergo redo tricuspid surgery. With the development of minimally invasive cardiac surgery, several centres began to adopt endoscopic thoracotomy for redo tricuspid surgery and achieved effective results [8,9,12]. Access to the lateral thoracotomy avoids median sternal reentry and massive heart dissection. Aortic isolation was avoided by not using the aortic cross-clamping technique and vena cava isolation was similarly avoided by not using the vena cava snaring technique [8,11]. Furthermore, the temporary endocardial pacing wire implantation avoided right ventricular isolation. Redo cardiac surgery could be completed well with only a part of the right atrial isolation requirement. The significant reduction in the isolation decreases the risk of bleeding, injuries to heart, great vessels and unobstructed grafts as well as operation time.

High risk cardiac operations, such as redo tricuspid surgery, also demonstrated a high incidence of postoperative cardiac arrhythmias and unstable haemodynamic status. The conduction system becomes more susceptible during tricuspid surgery because the tricuspid valve is present close to the Koch's triangle, which contains the compact part of the atrioventricular node. Therefore, routine temporary pacing is necessary for patients who undergo redo tricuspid surgery. Obviously, it is not feasible to routinely isolate the right ventricle and find a suitable epicardial site for insertion of temporary pacing wire with thoracoscopic redo tricuspid surgery. The present method of temporary endocardial pacing wire implantation makes the routine application of temporary pacing a feasible and safe technique during thoracoscopic surgery with minimised heart dissection.

Combining the puncturing technique of anaesthesiologist and the operating skill of surgeon made the exact placement, which was almost 100%, of the pacing wires into the right ventricle without complications possible. However, other effects, such as tricuspid regurgitation, endocarditis, and heart wall perforation may occur. The degree of tricuspid regurgitation after pacing catheter placement can be evaluated with TEE and the position of catheter is adjusted as needed. Our results show that the endocardial pacing catheter affects tricuspid valvular function slightly without any requirement for the catheter position adjustment. Infection was prevented by using sterile procedures during the placement of the pulmonary artery catheter. Removing the catheter as early as possible is helpful in reducing the incidence of infective endocarditis. As the right ventricular wall was not isolated and was often adhesive in redo surgery, the occurrence of heart perforation was not frequently observed.

We enrolled nine patients who underwent mitral valve replacement and tricuspid valve plasty. The right atrial incision greatly facilitates the placement of endocardial pacing catheter by the surgeon. As far as isolation of mitral valve surgery with thoracoscopy, the interatrial groove incision was usually performed to expose the left atrium directly. For these patients, different options of temporary pacing were chosen with regard to the degree of heart adhesion. A sheath was routinely inserted into the right jugular vein by the anaesthesiologist, but the pacing catheter was not necessarily required. If the surgeon considered the heart adhesion was slight and the anterior right ventricular surface was clear, an epicardial pacing wire would be placed. Otherwise, an endocardial pacing catheter was inserted via the sheath in the right jugular vein by the anaesthesiologist. If the attempt of placing the catheter into the right ventricle fails, a right atrial incision with purse string suture might be needed to place the catheter well, with the assistance of surgeon. Thus, a temporary endocardial pacing catheter was routinely applied in the patients who underwent redo tricuspid surgery.

## Conclusions

This application of temporary endocardial pacing provides a safe and effective substitute for unsuitable epicardial pacing in patients who undergo minimally invasive redo tricuspid surgery.

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