

Simplified Minimally Invasive Beating Heart Technique for Redo Isolated Tricuspid Valve Surgery

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Abstract

Background

Redo isolated tricuspid valve surgery has been associated with a high morbidity and mortality, and its optimal timing of surgical intervention remains controversial. Hence, we reviewed our early and midterm results with a simplified minimally invasive beating heart technique for isolated redo tricuspid valve surgery in patients at high risk.

Methods

Between June 2016 and August 2017, a total of 14 consecutive patients underwent isolated tricuspid valve operations after previous cardiac operations with minimally invasive beating heart technique through a right lateral thoracotomy in our center. Mean patient age was 54.0 ± 8.3 years, and 9 patients (64.3%) were women. Mean preoperative EuroSCORE was 8.1 ± 1.3 (6 to 11). Previous cardiac operations included 6 patients (42.9%) with mitral valve replacement, 1 patient (7.1%) with mitral valve replacement and tricuspid valve repair, 1 patient (7.1%) with tricuspid valve replacement, 5 patients (35.7%) with mitral valve and aortic valve replacement, and 1 patient (7.1%) with Ebstein repair. Midterm follow-up was complete for 12 patients (85.7%).

Results

Both in-hospital and thirty-day mortalities were 0%. Tricuspid valve replacement with bioprosthesis was performed in 12 patients (85.7%), and the remaining 2 patients (14.3%) underwent tricuspid repair (annuloplasty and leaflets reconstruction). Mean cardiopulmonary bypass time was 55.6 ± 10.7 minutes. Overall in-hospital duration and intensive care unit (ICU) time were 11.6 ± 8.8 days, 3.9 ± 2.8 days, respectively. Postoperative complications included 2 patients (1.4%) with prolonged ventilation, and 2 patients (1.4%) with acute kidney injury. There were no postoperative cerebrovascular accidents, myocardial infarctions, reoperations for bleeding, or deep wound infections. All patients were discharged uneventful. Except 2 patients lost follow-up, there were no adverse cardiovascular events and deaths occurred in other patients.

Conclusions

Simplified minimally invasive beating heart technique for redo tricuspid valve surgery is both feasible and safe, and the early and midterm results are excellent.

Introduction

Tricuspid valvular disease has been always considered less clinically important than mitral and aortic valves pathology, and its optimal timing of surgical intervention remains controversial [1]. Many patients undergo concomitant tricuspid valve surgery at the time of mitral or aortic valve intervention, while isolated tricuspid valve surgery is rarely performed [2]. However, there are a large population of secondary

isolated tricuspid valve regurgitation after previous cardiac operations, they are neglected and undertreated. Because of the low pressure and low resistance of right-side cardiac valves, patients with tricuspid valve regurgitation usually do not have significant symptoms at the early stage and are rarely referred for isolated surgical intervention of tricuspid valve until right heart failure, uncontrolled ascites or edema of lower extremity happened [3, 4]. Therefore, isolated tricuspid valve surgery has been reported associated with a high morbidity and mortality [5–7].

Median sternotomy for redo surgery is the standard approach, and also in patients where the tricuspid valve has to be treated. However, as the development of minimally invasive surgery for atrioventricular valves, atrial septal defects, and atrial fibrillation, this technique has also been used in redo surgeries [8, 9]. Some centers have reported their experiences about minimally invasive tricuspid valve surgery [10–12], but the details of surgical techniques variate among different centers, such as arterial inflow, venous drainage, aortic cross-clamping or not, cooling temperature, and so on. Should redo tricuspid valve surgery be done more complex or simple? In the past few years, our center modified the details of traditional surgical techniques and operated a group of patients at high risk. The early and midterm results were encouraging and both in-hospital and thirty-day mortalities were zero.

The primary objective of this study was to evaluate the safety and feasibility of our simplified redo tricuspid valve surgery on the beating heart through a minimally invasive approach. The secondary objective was to summarize our early and midterm management experiences for the high risk isolated tricuspid valve regurgitation.

Patients And Methods

The study protocol was approved by the Ethics Committee for the Protection of Human Subjects at the Zhongshan Hospital Fudan University (Shanghai, China). Individual patient informed consent was not required in this study. The study design was a retrospective observational study.

Patient Demographics and Characteristics

Between June 2016 and August 2017, a total of 14 consecutive patients who underwent redo isolated tricuspid valve operations with minimally invasive beating heart technique through a right lateral thoracotomy at Zhongshan Hospital, Fudan University were retrospectively reviewed. Mean patient age was 54.0 ± 8.3 years (range, 43 - 64 years), and 9 patients (64.3%) were women.

The indications for tricuspid valve operation of our present group were the presence of severe or more tricuspid regurgitation along with New York Heart Association class III-IV or more symptoms or other signs of right heart failure, including uncontrolled pedal edema, ascites, pleural effusion in 13 patients, and mechanical tricuspid valve dysfunction in 1 patient.

All patients had medical history with previous cardiac operations and underwent first-time reoperative cardiac procedures. The previous cardiac operation was performed through a median sternotomy. 6

patients (42.9%) had previously underwent a mitral valve replacement, 1 patient (7.1%) had underwent mitral valve replacement and tricuspid valve repair, 1 patient (7.1%) had underwent a tricuspid valve replacement because of Ebstein anomaly, 5 patients (35.7%) had underwent mitral valve and aortic valve replacement, and 1 patient (7.1%) had underwent a Ebstein repair.

The tricuspid valve pathologic characteristics included annulus dilatation, leaflet restriction and thicken associated with severe or more tricuspid regurgitation in the majority patients (13 patients [92.9%]), except 1 patient with mechanical failure after tricuspid valve replacement.

Surgical technique

Although, the techniques of minimally invasive tricuspid valve surgery have been reported elsewhere, there are still many differences in details of our center. Following induction of anesthesia and intubation with a dual lumen endotracheal tube, all patients were routinely placed with transesophageal echocardiography (TEE) and implanted with endocardial temporary pacing lead through right internal jugular vein by the anesthetist. Patients were then positioned supine with the right shoulder elevated 30 degrees. In our center, cardiopulmonary bypass was established by femoral platform. An oblique incision was usually made in the right groin to expose the femoral artery and vein for cannulation. Utilizing a Seldinger technique, the femoral artery was cannulated with a 16 Fr to 20 Fr arterial cannula (Edwards Lifesciences, or Medtronic, USA), and the femoral vein was cannulated with a 24 Fr venous cannula (Edwards Lifesciences). TEE was used to assist placement of the femoral venous cannula, which was inserted up to the superior vena cava.

After initiation of cardiopulmonary bypass, vacuum assistance (10 to 15 cm H₂O) was usually used to accomplish total drainage of the atrium in the authors' center. A 5 cm right anterolateral thoracotomy was performed over the fourth intercostal space. The fourth intercostal space was entered. Lungs were deflated and the right atrium was identified by pushing on the atrial wall with long forceps. Pericardial and atrial tissues are usually bonded tightly as a result of previous operations. Therefore, the pericardium was not dissected from the right atrium, but incised directly. Using traction lines to expose the right atrium and keeping the balance between arterial inflow and venous drainage, the tricuspid valve visualized and replacement or repair was being performed on the beating heart with good visual field.

Follow up

The follow up was performed by direct interviews in our outpatient department to evaluate their clinical status, or by telephone contact with patients and/or family members. The 3 months follow up was 100% complete. The midterm follow-up (37.7 ± 5.5 months) was 85.7%.

Statistical analysis

Surgical treatment technique was not randomized, but rather was determined by the best medical judgment for each individual case. Data were collected from chart review, and were entered into a

dedicated Microsoft Excel table.

Categorical variables are represented as frequency distributions and single percentages. Values of continuous variables are expressed as a mean \pm standard deviation (SD). All analyses were performed with the SPSS statistical package version 17.0 (SPSS Inc, Chicago, IL, USA).

Results

The patient demographics and characteristics are depicted in Table 1. Apart from 1 patient with opening restriction of artificial mechanical tricuspid valve, severe or even tornado tricuspid regurgitation occurred in all patients (++++ in 11 patients, >++++ in 2 patients). All patients had clinical manifestations of right heart failure, including repeated chest tightness and asthma, uncontrolled pedal edema, ascites, and pleural effusion. The average EuroSCORE was up to 8.1 ± 1.3 for the present patients and predicted mortality was nearly 11.2%. New York Heart Association (NYHA) functional class rating reached grade III in 8 patients, and grade II in 6 patients. Left ventricular ejection fraction (EF) was basically normal in $58.8 \pm 6.7\%$ of patients, while right ventricular function was progressive deterioration due to severe tricuspid valve regurgitation and tricuspid annular plane systolic excursion (TAPSE) was 14.5 ± 2.9 mm. 12 patients (85.7%) suffered from atrial fibrillation.

Table 1. Patient Demographics and Characteristics

Variable	All Patients(n=14)
Age (y)	54.0 ± 8.3
Female	9 (64.3%)
NYHA class	
I	0
II	0
III	6
IV	8
Mean EuroSCORE	8.1 ± 1.3
LVEF	58.8±6.7%
TAPSE (mm)	14.5±2.9
Mean PAP (mmHg)	34.1±10.7
Creatinine level (umol/L)	94.7±40.9
Bilirubin level (umol/L)	26.3±20.8
INR	2.4±0.7
Thrombocytes (10 ⁹)	126.6±55.2
Atrial fibrillation	12 (85.7%)
Atrial flutter	1 (7.1%)
Hypertension	3 (21.3%)
Diabetes mellitus	1 (7.1%)

NYHA, New York Heart Association; EuroSCORE, European system for cardiac operative risk evaluation; LVEF, left ventricular ejection fraction; TAPSE, tricuspid annular plane systolic excursion; PAP, pulmonary artery pressure; INR, international standard ratio

Intraoperative course is described in Table 2. All patients underwent minimally invasive beating heart tricuspid valve replacement or repair (TVR/Rep) without aortic clamping. There were no cases during the operation requiring urgent conversion to the median sternotomy. 12 patients (85.7%) had their tricuspid valve replaced whereas 2 patients (14.3%) had their tricuspid valve repaired. A biological prosthesis was used in all cases when the valve had to be replaced. Average valve size was 30.8 ± 0.6 mm. 1 patient underwent TVRep with semiflexible ring, and 1 patient underwent tricuspid valve reconstruction with calf

pericardium. Average cardiopulmonary bypass time was 55.6 ± 10.7 minutes. Intraoperative exploration revealed that 11 patients with severe tricuspid regurgitation were caused by enlarged tricuspid annulus and atrioventricular enlargement. 1 patient was found to have limited tricuspid valve opening due to artificial mechanical tricuspid valve thrombosis, and 2 patients were found to have organic damage of valve texture due to previous tricuspid valve plasty. 6 patients (42.9%) need blood transfusions due to preoperative anemia. Average red blood cell (RBC) transfusion was 1.0 ± 1.6 units for all patients.

Table 2. Operative characteristics of the patients

Variable	All patients(n=14)
Functional TR	11
Mechanical valve dysfunction	1
Etiology (previous TVRep)	2
CPB time (min)	55.6 ± 10.7
TVRep	2
TVR	12
Average valve size (mm)	30.8 ± 0.6
Conversion to sternotomy	0
Intraoperative RBC units	1.0 ± 1.6

TR, tricuspid regurgitation; CPB, cardiopulmonary bypass; TVR, tricuspid valve replacement; TVRep, tricuspid valve repair; RBC, red blood cell

Postoperative course is described in Table 3. Both in-hospital and overall thirty-day mortalities were 0%. Overall in-hospital duration and ICU time were 11.6 ± 8.8 days, 3.9 ± 2.8 days, respectively. Postoperative complications included 2 patients (1.4%) with prolonged ventilation, required ventilator-assisted supporting more than 72 hours. 2 patients (1.4%) developed acute renal insufficiency after operation and needed perioperative hemodialysis treatment. There were no complications such as cerebrovascular accidents, myocardial infarction, reoperation for bleeding, deep wound infection and other complications occurred. Postoperative implantation of a permanent pacemaker was not necessary for all patients. All patients were discharged successfully.

Table 3. Postoperative outcomes of patients

Variable	All patients(n=14)
Duration of ICU stay(d)	3.9 ± 2.8
Duration of hospital stay(d)	11.6 ± 8.8
Prolonged ventilation(n)	2 (14.3%)
Reoperation for bleeding	0
Postoperative neurologic event	0
New-onset renal insufficiency requiring dialysis	2 (14.3%)
Wound infection	0
In-hospital mortality	0
30-d mortality	0
Permanent pacemaker	0

ICU, intensive care unit

Table 4 shows the preoperative functional New York Heart Association (NYHA) class of the patients and shows NYHA status during follow-up after TVR/Rep. Cardiac function improved significantly in all patients before discharge. All patients with preoperative NYHA cardiac function grade III recovered to grade II or I. During 3 months follow-up, 12 patients (85.7%) had significantly improved NYHA class to (I-II) compared with their preoperative status (III-IV). The follow-up was 100% complete. The mean midterm follow-up period was 37.7 ± 5.5 months, and the follow-up was complete for 12 patients (85.7%). 2 patients who lost follow-up after TVR or TVRep due to change of contact address. There were no adverse cardiovascular events and deaths occurred in patients who could be followed up. 8 patients cardiac function recovered to NYHA grade I and could engage in normal activities, while the other 4 patients can take care of themselves (NYHA II). No reoperations were necessary during the follow up period.

Table 4. Preoperative and Postoperative New York Heart

NYHA Classification	I	II	III	IV
Preoperative (n=14)	0	0	6	8
Before discharge (n=14)	0	6	8	0
Follow-up (n=14, 3 months)	4	8	2	0
Follow-up (n=12, to the present)	8	4	0	0

Discussion

In the present study, we observed mortality and morbidity of redo isolated tricuspid valve surgery were greatly improved by using simplified minimally invasive beating heart technique. All patients discharged uneventful. Our favorable early and midterm results may be not only related to the minimally invasive access, which avoid extensive dissection and minimize the risk of bleeding, but also related to beating heart technique, which decrease or eliminate the ischemia reperfusion injury that follows standard maneuvers of aortic cross-clamping and clamp release. However, for patients undergoing reoperative surgery, the traditional median sternotomy approach has a high risk of bleeding and is prone to heart injury. In addition, obese and diabetic patients are particularly prone to sternal infection and the occurrence of sternal instability [13]. Although minimally invasive technique has been reported elsewhere [14-17], there are still many technical details of our center. No one can deny that every technical detail makes a perfect operation. In our center, all patients were routinely implanted with endocardial temporary pacing lead through right internal jugular vein by the anesthetist before the operation, because the walking path of the conduction beam is infinitely close to the operation area and nobody can surely avoid III atrioventricular block for tricuspid valve replacement. To provide a bloodless working environment, some surgeons like using bicaval cannulation techniques with caval tapes or balloon [10,18,19]. We took "one incision, two cannulas" technique for all of our cases [20]. Femoral venous cannula was inserted up to the superior vena cava under the assistance of TEE. The position of superior and inferior vena cava is at the lowest point compared with the tricuspid valve position. Therefore, there is no need to worry that a large amount of gas will enter the venous drainage line [21]. Meanwhile, vacuum was also used to achieve a good venous drainage. By applying these techniques, we are easily achieving a bloodless surgical field.

Some early reports showed a higher incidence of stroke with femoral versus aortic artery cannulation. The reason may be that peripheral cannulation increase the incidence of retrograde embolism from the descending thoracoabdominal aorta. However, femoral artery cannulation was routinely established for minimally invasive surgeries in our center and there was no stroke happened in our present series. Lamelas evaluated all of the minimally invasive cardiac procedures utilizing femoral arterial cannulation over the past 6 years, and the incidences of stroke (1.17%) and peripheral arterial trauma (0.07%; eg, dissection, pseudoaneurysm, and fistula) were acceptable [22]. Nifong LW et al also reported femoral artery cannulation had been associated with a lower stroke rate [23]. Shann and Melnitchouk also stated that the femoral artery is often used for procedures that utilize a right anterolateral minithoracotomy incision [24]. Overall, the main principle of minimally invasive surgery should leave the limited view for surgical procedures to the most degree by the establishment of peripheral CPB.

In our series, although most of redo tricuspid regurgitation due to functional change, 85.7% (12/14) of patients underwent tricuspid valve replacement instead of repair. Considering the patients' states of our series, such as younger mean age (54.0 ± 8.3 years old), previous cardiac surgery, chronic atrial fibrillation, and most patients with severe congestive heart failure (NYHA III-IV), we think that tricuspid valve replacement is the best option to avoid recurrent tricuspid regurgitation. We agree with

Pfannmuller's opinion, and we also routinely use biological prostheses regardless of patient age, even in patients with a previously implanted mechanical valve (regardless of whether it is in an aortic or mitral position, or both) to avoid trouble for endocardial temporary pacing lead implantation and excessive anticoagulation, which is mandatory with a mechanical prosthesis in a tricuspid position [25]. Some researchers reported tricuspid valve replacement was always associated with significant higher mortality [1,16]. Some researchers reported there were no statistical differences in early and late outcomes between the isolated tricuspid valve repair versus replacement surgery [6]. However, some study shown improved mortality for replacement and in accordance with our results [3]. In our opinion, replacement or repair is decided by the surgeons' comprehensive judgement of patients' states and personal experiences.

Study Limitations

There are several limitations of this study. Firstly, this study was only a retrospective clinical observational trial in a single center, which may inevitably be biased in patient selection and in technique used. A final determination would need a prospective, multi-center study involving larger sample size. Secondly, it is a small series with only 14 patients, which may influence the generalizability. Additionally, although the early and midterm follow up results are excellent, we do not have long-term follow up data with our present technique. Finally, surgical treatment technique cannot be randomized, but rather was determined by the best medical judgment for each individual case. Therefore, we do not have appropriate control group.

Conclusions

In this series of high-risk patients, redo tricuspid valve operations with a simplified minimally invasive beating heart technique are both feasible and safe, and are associated with low mortality and morbidity, the early and midterm results are encouraging. Further studies are required to allow a direct comparison between our present technique and median sternotomy. Long-term data are also needed regarding the durability of these procedures.

Abbreviations And Acronyms

CPB, cardiopulmonary bypass

EuroSCORE, European system for cardiac operative risk evaluation

ICU, intensive care unit

INR, international standard ratio

LVEF, left ventricular ejection fraction

NYHA, New York Heart Association

PAP, pulmonary artery pressure

RBC, red blood cell

TAPSE, tricuspid annular plane systolic excursion;

TR, tricuspid regurgitation

TVR, tricuspid valve replacement

TVRep, tricuspid valve repair

Declarations

Ethics Approval and consent to participate

The study protocol was approved by the Ethics Committee for the Protection of Human Subjects at the Zhongshan Hospital Fudan University (Shanghai, China). The study design was a retrospective observational study. Individual patient informed consent was not required in this study.

Consent for publication

All authors have read and approved the content and agree to submit it for consideration for publication in your journal.

Availability of supporting data and materials

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

SYL, KS and WCY carried out data collection, and drafted the manuscript. LMX participated in the operations and helped in drafting the manuscript. LLD and TH carried out data analysing and helped in revising the manuscript critically. CSW and SGY did the operations, conceived of the study, and helped in revising the manuscript critically. All authors read and approved the final manuscript.

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