

Benefits of a right anterolateral minithoracotomy rather than a median sternotomy in isolated tricuspid redo procedures

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Background: To compare results of tricuspid valve (TV) reoperation between incision via a right anterolateral minithoracotomy (RAMT) and median sternotomy (MS).

Methods: We performed a retrospective analysis of 49 patients who underwent isolated TV surgery as a reoperation at our institution between 2006 and 2015. Previous cardiac operations included mitral, aortic, and TV surgeries, atrial septal defect repair, and pericardiectomy. The mean age of the patients was 51.9±12.8 years, 14 (28%) were male and 35 (72%) were female. Follow-up was 95% (38/40) complete, with a mean duration of 41.3±19.5 months.

Results: Perioperative demographic and laboratory tests did not show any significant differences between the RAMT and MS groups. The drainage volume, total red cell unit, total serum volume and platelet were significantly different 1150±803.5/2,270±1,920, 4.8±4.1/8.7±8.9, 478.2±488.9/950.0±857.6, 0.04±0.21/0.38±0.64 (P<0.05), while other perioperative data were similar. There were no significant differences in early postoperative death and complications between the RAMT and MS groups. A multivariate linear regression analysis predicted that serum creatinine (Scr), age, and MS group were independent risk factors for bleeding. The Cox regression demonstrated that the MS group had a longer drainage duration (P<0.05) and had a relative hazardous risk (HR) of 2.691 (1.328, 5.450 CI) compared with the RAMT group.

Conclusions: The RAMT approach is an alternative, safe, and feasible procedure for isolated TV reoperation. It has the advantages of less drainage and reduced requirement for blood products.

Keywords: Retrospective; redo; isolated tricuspid operation; minimally invasive

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Introduction

Isolated tricuspid valve (TV) repair or replacement surgery is rarely performed and receives less attention than left-sided valve surgery. Although the 2014 AHA/ACC Guideline recommended that TV surgery should be performed at the same time as the first left heart valve surgery, a number of

patients underwent a first procedure without TV repair (1). It is certain that the tricuspid regurgitation (TR) will gradually deteriorate further and reoperation could be irreversible. A severely abnormal TR threatens the health condition of valve disease patients, especially in China where a great many patients still suffer from rheumatic fever (2) Isolated TV surgery, especially as a reoperation, is considered to be

high risk (3), in spite of the fact that the procedure is not technically complicated. The increased risk is usually due to the fact that patients who undergo surgeries are always late in the disease process and often have additional complications associated with right heart failure. So far, infrequent articles regarding patient outcomes following a TV reoperation have been published and they usually reviewed (4-8). Further, limited data exist that compare a minimally invasive procedure, right anterolateral minithoracotomy (RAMT), with a median sternotomy (MS). The drainage duration, which more precisely reflects the length of a hospital stays, was never analyzed in these articles with respect to cardiac surgeries. Thus, our study included a control group and an innovative index for evaluating the outcomes of the two different procedures.

Methods

A RAMT incision is an alternative approach to treat TR that may be necessary and particularly appropriate for patients with a high surgical risk. Since 2006, we have performed TV operations, isolated or in combination with other procedures, using a RAMT incision applying the port-access technique.

Here we present a retrospective, case-control study of 49 patients who underwent an isolated preoperative TV procedure in the Zhongshan Hospital, Fudan University (No. 2017-218). To be exactly for the patients, 14 were male (28.6%) and 35 were female (71.4%) with a mean age of 51.9 ± 12.8 years. Surgeries included TV repair (21 cases, 42.9%) and replacement (28 cases, 57.1%) and were conducted from May 2006 to July 2015. A total of 46 patients had undergone one previous cardiac surgery, two patients had undergone two previous surgeries, and one patient had undergone three previous surgeries, one was through a median sternal incision. To clarify, 18 patients (36.7%) had undergone an mitral valve replacement (MVR) or mitral valve repair (MVP); 17 (34.7%) a double valve replacement (DVR); 9 (18.4%) were Ebstein anomaly corrected cases; one atrial septal defect (ASD) repair; one ventricular septal defect (VSD) repair; one pericardiectomy with no previous coronary artery bypass graft (CABG). The last two patients (4%) had TV procedure, one was replace the TV and the other was repair it. According to the different operation process, patients were divided into two groups, a RAMT group (26 cases) and an MS group (23 cases). Data from all patients were retrospectively reviewed. Preoperative clinical and demographic characteristics and some laboratory tests are listed in *Tables 1,2*.

Surgical techniques

The MS group received a standard procedure while the RAMT group was through a 5–10 cm skin incision, which was made under the right nipple in men and in the right inframammary groove in women (*Table 3*). Port-access was through the fourth intercostal space without a rib section and all surgeries were performed by a single senior surgeon in our department. Patients with right side thoracic surgeries were excluded from our study. Arterial cannulation was inserted through the femoral artery using the Seldinger technique. The venous drainage cannula was achieved with single cannula through the right femoral vein to superior vena cava and without the caval isolated. Since a vacuum-assisted drainage (negative pressure approximately -40 to -60 mmHg) was established, then it could suck up most of the blood in operative field. The left heart suction was inserted into the coronary sinus occasionally aspirating the residual blood from coronary circulation. Right atrium and TV was located in a relative higher place, and this is the reason that one single femoral drainage tube could meet the demand of drainage. The ascending aorta was not clamped and the procedure was performed with the beating heart. For all procedure types, the surgical field was flooded with carbon dioxide at a flow of 0.5–1.0 L/min.

Intraoperative transesophageal echocardiography was routinely used to assess cardiac function, ensure correct positioning of the percutaneous venous cannula, to evaluate surgical results, and confirm the air removal process. Once surgeries were completed, patients were transferred to the ICU.

The drainage volume was recorded daily and the tube was removed when there was <50 mL per day or no more fluid examined by ultrasound even it was recorded above 50 mL, usually 4–6 days after operation. As to our transfusion policy for hemoglobin (HB) between 7 and 10 [hematocrit (HCT) between 21 and 30]—based on evidence of organ dysfunction, underlying ability to handle inadequate oxygenation, and potential and actual rates of bleeding. In our centre all kinds of hemostatic agents were seldom used because of its scarcity.

Data analyses

Continuous variables are expressed as the mean \pm SD. Categorical variables are presented as proportions. Differences between groups were evaluated using the Fisher's exact test for categorical variables and independent samples and the

Table 1 Baseline demographic data

Variable	RAMT group	MS group	P value
EF	61.6%±8.3%	66.5%±5.9%	0.026*
Age (years)	52.3±10.6	51.5±14.6	0.36
Sex (Male/female)	5/18	9/17	0.319
Weight (kg)	56.7±8.9	58.1±10.3	0.606
Height (m)	1.61±0.05	1.63±0.07	0.345
Body index	21.7±2.7	21.9±3.6	0.844
Perp NYHA			
II	9	7	0.751
III	13	17	
IV	2	1	
Basic HR	84.7±16.5	81.6±10.3	0.831
Pulmonary pressure (mmHg)	39.05±12.14	38.08±10.33	0.116
Atrial fibrillation	3/16	4/15	1
Right atrium (mm)	77.3±18.5	76.4±16.3	0.877
Comorbidity			
Systolic pressure (mmHg)	119.8±12.8	117.7±9.0	0.516
Diastole pressure (mmHg)	72.4±8.0	74.5±8.2	0.367
Diabetes	1/18	1/18	1

RAMT, right anterolateral minithoracotomy; MS, median sternotomy; NYHA, New York Heart Association; HR, hazardous risk.

Student's t test for continuous variables. A multivariate linear regression was used to explore the risk factor for bleeding. The cumulative probability of drainage duration and the predictors for each event were identified using a Cox proportional hazard regression analysis. The proportional hazards assumption was met in all models. The predictors of increased drainage volume were analyzed using a multivariate linear regression analysis. Results are presented as hazard ratios (HRs) with corresponding 95% confidence intervals (CI). All tests were 2-tailed. A P value <0.05 was considered to be statistically significant. All statistical analyses were performed with SPSS software, version 19.0 (IBM Corporation, Armonk, New York, USA).

Data collection and variable definitions

Hospital mortality included all deaths within 30 days after operation, irrespective of where the death occurred, and all deaths beyond 30 days among patients who had not been discharged.

Using several kinds of high dosage cardiotoxic drugs was defined as heart failure. New-onset acute kidney injury was confirmed by an increase in serum creatinine (Scr) by at least 26.4 µmol/L, Scr increased by over 150%, or the urine volume decreased to less than 0.5 mL/kg/h over 6 hours. Neurological complications included permanent (duration more than 72 h or a stroke) and transient [transient ischemic attacks or reversible cerebrovascular accidents (CVA)] neurological events. Other postoperative morbidities included reventilation or reintubation, new requirement for a permanent pacemaker, surgical re-exploration, readmission within 30 days, and deep sternal wound infection or sepsis.

Follow-up

All patients were seen 2–3 months postoperatively after which they were contacted for follow-up data. Follow-up data were obtained by telephone or at interview. The average follow-up period was 41.3±19.5 months and data were collected from 38 of 40 patients (95%). One patient died

Table 2 Baseline laboratory data

Variable	RAMT group	MS group	P value
Hepatic function			
Total bilirubin (μmol/L)	18.7±9.3	19.4±11.3	0.831
Direct bilirubin (μmol/L)	8.2±6.2	9.5±10.2	0.616
Albumin (g/L)	40.4±4.8	41±4.7	0.614
Proalbumin (g/L)	0.20±0.07	0.21±0.07	0.673
ALT (U/L)	24.2±12.5	32.7±40.4	0.335
AST (U/L)	37.6±19.0	30.0±12.2	0.097
ALP (U/L)	87.8±32.2	104.5±56.5	0.219
Renal function			
Bun (μmol/L)	7.5±3.7	6.7±1.8	0.291
Creatinine (μmol/L)	68.6±15.4	68.5±17.9	0.989
Uric acid (μmol/L)	378.8±142.8	387.4±126.7	0.824
Blood glucose (μmol/L)	4.7±0.6	7.1±10.2	0.282
Hemoglobin (g/L)	115.3±20.1	127.9±24.8	0.057
RBC (10 ¹² /L)	4.1±0.5	4.3±0.8	0.225
Hematocrit (%)	0.36±0.06	0.39±0.07	0.075
Platelet (10 ⁹ /L)	135.4±52.2	164.5±70.1	0.111
PT (s)	19.2±6.5	15.1±4.3	0.012*
ESR (mm/min)	20.9±17.8	19.2±17.1	0.775
CRP (mg/L)	2.8±5.3	2.4±3.4	0.743
Cholesterol (mmol/L)	3.8±1.0	4.8±1.3	0.079
Triglyceride (mmol/L)	0.9±0.4	1.3±0.7	0.071

*, meanings significant statistical difference. RAMT, right anterolateral minithoracotomy; MS, median sternotomy; ALT, alanine transaminase; AST, glutamic oxaloacetic transaminase; ALP, alkaline phosphatase; Bun, blood urea nitrogen; PT, prothrombin time; ESR, erythrocyte sedimentation rate; CRP, C reactive protein.

4 years postoperatively in the RAMT group and 2 patients withdrew from the study. Post-operative TV regurgitation and the left heart ejection fraction (EF) was followed by the latest echocardiogram report available for each patient.

Results

Baseline preoperative data contained basic demographic characteristics and laboratory tests of vital organ functions including cardiac, hepatic, and renal function that were not significantly different between the two groups, demonstrating good homogeneity (Tables 1,2). The RAMT group had a significantly lower EF compared with the MS

group (P<0.05). This was likely due to the fact that the RAMT group contained two patients who had undergone two prior operations and one patient had undergone three prior operations, in contrast with the MS group where all patients had undergone just one prior operation.

There was significantly less total drainage volume, postoperative red cell transfusion, serum volume and platelet usage for patients in the RAMT group compared with patients in the MS group (P<0.05) (Table 4). Operation time, cardio-pulmonary bypass (CPB) time, ventilation time, ICU time, and postoperative hospital stay were similar between the two groups.

Severe postoperative complications, including heart

Table 3 Difference between MS and RAMT

Difference	MS	RAMT
Incision	Longer; obviously	Shorter; secluded; no scar
Thoracic integrity	Incomplete	Stable
Separation	Severe fibrosis	No need to separate
CPB	Tradition CPB	Single vena drainage; no snaring
Aortic Crossclamping	Yes (beating heart)	No need

MS, median sternotomy; RAMT, right anterolateral minithoracotomy; CPB, cardio-pulmonary bypass.

Table 4 Perioperative data

Variable	RAMT	MS	P value
Operation time (h)	3.9±1.0	4.3±0.8	0.095
CPB time (min)	78.4±31.2	90.9±22.8	0.114
Ventilation time (h)	61.6±97.9	54.4±84.2	0.781
ICU time (h)	90.6±95.4	90.4.0±100.3	0.995
Post-OP stay (day)	10.1±6.6	11.3±7.9	0.578
24 h drainage (mL)	420.0±309.0	589.6±527.7	0.184
Total drainage (mL)	1151.7±803.5	2276.2±1925.4	0.012*
Total red cell (U)	4.8±4.1	8.7±8.9	0.033*
Total serum volume (mL)	478.2±488.9	950.0±857.6	0.021*
Platelet unit	0.04±0.21	0.38±0.64	0.015*

*, meanings significant statistical difference. RAMT, right anterolateral minithoracotomy; MS, median sternotomy; CPB, cardio-pulmonary bypass.

Table 5 Postoperative complications

Variable	RAMT [n=23, %]	MS [n=26, %]	P value
Heart failure	5 [22]	7 [26]	0.674
Pneumonia and sepsis	2 [9]	4 [15]	0.671
Bleeding	1 [4]	3 [12]	0.612
Death	5 [22]	5 [19]	1
AKI	3 [13]	9 [35]	0.104
Dialysis	3 [13]	3 [12]	1
Pacemaker implantation	2 [9]	4 [15]	0.671
Perivalvular leak	0 [0]	1 [4]	none
Stroke	1 [4]	0 [0]	0.469
Back to ICU	1 [4]	0 [0]	0.469
30 days readmission	1 [4]	0 [0]	0.469
Re-exploration	0 [0]	1 [4]	1
Tracheotomy	3 [13]	2 [8]	0.655
Reintubation	1 [4]	1 [4]	1

RAMT, right anterolateral minithoracotomy; MS, median sternotomy; AKI, acute kidney injury.

Table 6 Risk factor for drainage

Variable	Adjusted R2	F	P value
Scr	0.112	7.042	0.011 ^a
Group	0.225	7.954	0.001 ^b
Age	0.281	7.252	0.000 ^c

a, predict Scr; b, predict Scr + group; c, predict Scr + group + age. Scr, serum creatinine rate.

failure, pneumonia, bleeding, death, renal insufficiency, continuous renal replacement therapy (CRRT), reintubation, re-exploration, tracheotomy, perivalvular leak, and pacemaker implantation were not significantly different between the groups (*Table 5*).

A multivariate linear regression analysis revealed that the Scr rates, the MS group, and old age were associated with increased drainage volume, as defined by the regression from a stepwise model (*Table 6*). We also observed that the duration of drainage was a censored data. Therefore, we

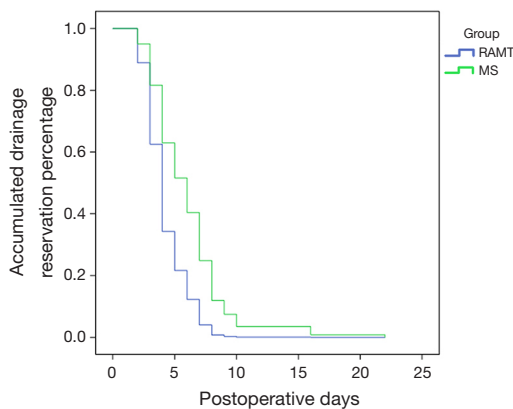


Figure 1 The extraction rate of the thoracic drainage tube. RAMT, right anterolateral minithoracotomy; MS, median sternotomy.

set the drainage extraction as an outcome with the duration time exactly adapt to the Cox regression model as the survival analysis. Ultimately, the whole model expressed a significant difference and the MS group was a predictor for increased drainage duration (*Figure 1*).

Discussion

The overriding need for TV surgery in the redo setting carries a high risk regardless of the access site. Too often we focus on the TV regurgitation causing symptoms but the underlying liver, lung and kidney reserves are too far irreversible regardless of what we do the valve. An “exhausted” dilated Right ventricle is an important factor in determining the outcome of these subsets of patients with severe intractable tricuspid regurgitation. It would be valuable to all surgeons to learn about the status of the right ventricle and left ventricle that they operated with metric and functional data. Earlierly our colleague Sun considered TAPSE (Tricuspid Annular Plane Systolic Excursion) could offer a good evaluation index to extinguish the severe patients should not be elected to be surgery candidate (9).

It is obvious that it is not only for cosmetic reasons that surgeons perform less invasive heart surgery procedures. A minimally invasive surgery via a right anterior incision has many advantages. We know that the port-access technique reduces bleeding by avoiding injury to the sternum. The oscillating saw extends the sawing time and results in a jagged fracture line that leads to a gap between the two parts of the sternum and may result in undesirable wound healing. Second, anticoagulants increase the bleeding volume and drainage. Chest reentry via another incision minimizes the

risk of detaching extensive fibrous adhesions. It also decreases the potential damage risk to cardiac tissue and main vascular tissue, especially the right ventricle. Valve disease in patients with patent grafts and in no need of CABG could be served by RAMT as well (10). Patients in the RAMT group easily recovered because of their relatively intact thoraxes that offered earlier mobilization and return to the activities of daily life. To date, this is the first report that used an MS group as the control to compare clinical data.

Based on our own previous experiences on port-access mitral valve operations, we extended this technique to redo operations. As far as perioperative transfusion, our data were identical to Bolotin’s report (11) that suggested a RAMT group had an advantage of lower red blood cell transfusion rates. In our RAMT group, we obtained less mediastinal drainage so less blood products were required. Furthermore, we also found no difference in mortality and cardiopulmonary bypass times, concurrent with their report. Our MS group as a significant independent risk factor was also the first that used a multivariate linear regression model, which provided strong evidence to guide a surgeon when making a decision for the isolated tricuspid redo procedure.

Comparing the baseline contrast, especially EF and the preoperative prothrombin time ($P < 0.05$), the RAMT group were at a disadvantage compared with MS group. Nevertheless, identical results in terms of postoperative complications led to the conclusion that the RAMT group was not inferior to MS group. In our study, we applied an innovative index, which measured drainage duration to assess the effects of two different procedures. Patients could not be discharged until extracted the drainage tube, particularly, some people with persistent or relative longer retention of drainage tube. So we presumed that postoperative drainage duration sometimes response the recovery precisely than postoperative stay. According to the Cox regression model ($HR = 2.691$ and $P = 0.021$), the MS group was relatively hazardous. Given that the hospital stay was not significantly different between two groups (*Table 4*), drainage duration is a superior predictor and might be a good substitution for an index of post operative recovery.

Refer to our one single vein drainage technique, it might be controversial, but it really worked effectively. As a redo surgery, detaching the adhesion sometimes was exactly troublesome and impossible. Once we were forced to waive the snaring the inferior vena cava because of severe adhesion only combined with the vacuum assisted CPB tech and we finally achieve acceptable field. From then on

we just apply this one single drainage tech into the isolated tricuspid procedure and we recommend this tech to some experienced surgeons and CPB perfusionists.

Due to the high risk and mortality associated with a TV procedure, surgeons and patients were reluctant to undergo another operation. Been delayed, the best opportunities for surgeries were missed, resulting in severe heart failure or end-organ dysfunction. Accumulated documents suggest that TV surgery should be done earlier rather than later (12).

Most surgeons would recommend a TV repair rather than a replacement. Bernal *et al.* (3) believed that a TV repair could maintain curative effects and the procedure failed in only 7% of patients. However, postoperative moderate-to-severe TR mostly caused by a TV repair developed in a significant proportion of patients. The recurrence of TR was time-related as observed in long-term follow-up. In light of our study, there were no differences between TV repair and replacement. TV repair may adapt to congenital heart disease while replacement is more suitable to treat rheumatic valve disease.

Although this minimally invasive technique has advantages, it cannot be performed on patients requiring concomitant cardiac procedures, excepting for mitral and TV operations, atrial fibrillation ablation, closure of an atrial septal defect, and a patent foramen ovale. In addition, patients who previously received a right-sided thoracotomy were excluded because of difficulty in mobilizing the lung.

More and more alternative treatment were introduced into structural heart disease, sutureless valves was the inception of minimally invasive aortic surgeries. Midterm follow up show that 3f Enable valve represents a safe and effective treatment for aortic valve stenosis, providing an excellent hemodynamic profile compared with transcatheter techniques (13). Transcatheter aortic valve implantation (TAVI) also plays an important role in aorta stenosis and insufficiency and become an overwhelming trend. There are already some catheter based clinic trials on tricuspid (14), although it is just a beginning, it is promising.

Limitations

Although our study demonstrates very favorable results for the RAMT approach, the retrospective approach and low sample size may have affected the precision. Multiple linear regression result may have some bias base of lesser samples. Further study, particularly of RCT, should focus on this as right heart function becomes increasingly concerning.

Conclusions

Our study provides explicit evidence that isolated tricuspid redo surgery with a port-access technique is feasible. It reduces operative bleeding and the requirement of blood products, and is particularly helpful in patients who are at high risk for a repeated sternotomy.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethnical Statement: The study was approved by ethics board of Zhongshan Hospital (No. 2017-218).

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