JOURNAL OF SURGICAL RESEARCH • JANUARY 2018 (221) 224–231

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journal homepage: www.JournalofSurgicalResearch.com

Risk factors associated with perioperative morbidity and mortality following isolated tricuspid valve replacement

Jinmiao Chen, MD,[a,b,1] Mieradilijiang Abudupataer, MD,[a,b,1] Kui Hu, MD,[a,b,c] Aikebaier Maimaiti, MD,[a,b] Shuyang Lu, PhD,[a,b] Lai Wei, PhD,[a,b] Tao Hong, PhD,[a,b,*] and Chunsheng Wang, PhD[a,b,*]

[a] Department of Cardiac Surgery, Zhongshan Hospital, Fudan University, Shanghai, China
[b] Shanghai Institute of Cardiovascular Diseases, Zhongshan Hospital, Shanghai, China
[c] Department of Cardiovascular Surgery, People's Hospital of Guizhou Province, Guiyang, Guizhou, China

ARTICLE INFO

Article history:
Received 19 September 2016
Received in revised form
26 May 2017
Accepted 20 June 2017

Keywords:
Isolated tricuspid valve replacement
Risk factor
Mortality

ABSTRACT

Background: Reports of isolated tricuspid valve replacement (iTVR) are relatively rare. The present study aimed to evaluate independent risk factors of perioperative morbidity and mortality after iTVR.

Materials and methods: We retrospectively reviewed 118 consecutive patients (42 males; mean age, 49.1 ± 12.9 y) who underwent iTVR from May 2003 to April 2016 in our center. The multivariate logistic regression model was used to analyze the independent risk factors associated with perioperative morbidity and mortality following iTVR.

Results: One hundred one patients (85.6%) were classified as New York Heart Association functional class III or IV preoperatively. The overall perioperative mortality was 11.8% (14/118), and a significant difference was observed between the nonreoperative group and the reoperative group (6.7% *versus* 18.3%, $P = 0.047$). The multivariate logistic regression analyses identified that preoperative New York Heart Association functional class IV (OR [odds ratio] = 15.43, 95% CI [confidence interval] = 3.46-68.83, $P = 0.000$) and ascites (OR = 4.88, 95% CI = 1.24-19.27, $P = 0.024$) were independent risk factors of perioperative deaths. The previous cardiac surgery (OR = 3.28, 95% CI = 1.41-7.62, $P = 0.006$) was independently associated with perioperative major adverse events.

Conclusions: The present study revealed that iTVR has relatively high mortality and morbidity rates. Timely surgery may be recommended for this high-risk cohort of patients before the development of severe heart and end-organ failure.

Introduction

The tricuspid valve has been referred to as the forgotten valve; nevertheless, tricuspid regurgitation (TR) has recently been identified as a major risk factor for long-term mortality.[1] Severe tricuspid valve dysfunction could lead to heart and end-organ failure. Medical therapies such as diuretics may be useful for patients with severe TR and signs of right-sided

* *Corresponding author.* Department of Cardiac Surgery, Zhongshan Hospital, Fudan University, No.180, Fenglin Road, Xuhui District, Shanghai 200032, China. Tel./fax: +86 021-64041990.
E-mail addresses: hong.tao@zs-hospital.sh.cn (T. Hong), wang.chunsheng@zs-hospital.sh.cn (C. Wang).

[1] These authors contributed equally to this study.

http://dx.doi.org/10.1016/j.jss.2017.08.014

heart failure, but a surgery is required for patients who are unresponsive to medical therapies.[1]

Tricuspid valve replacement (TVR) is not common when compared with aortic or mitral valve replacements, but it is inevitable when tricuspid valve repair is not feasible or attempts at repair have failed.[2] Historically, TVR was reported with high operative mortality and morbidity rate.[3-5] However, patients who underwent isolated TVR (iTVR) were often intermingled with those who underwent concomitant left-sided valve surgery in most of previous studies.[6-8] The relative infrequency of iTVR, numerous concomitant procedures, and heterogeneity of patient populations have resulted in difficulty in obtaining the true risk factors of perioperative mortality and morbidity rates after iTVR. Only a few of studies have focused on this important issue; however, these studies were often limited by small study populations.[5] Thus, some uncertainties remain in the field of iTVR.

In this study, we aimed to evaluate the independent risk factors of perioperative mortality and morbidity following iTVR using a large cohort in a single center. Additionally, the surgical technique and timing were investigated.

Materials and methods

Study population

We retrospectively reviewed the medical records of all patients who underwent tricuspid valve surgery in our center. From May 2003 to April 2016, a total of 4552 patients underwent tricuspid valve repair ($n = 4353$) or replacement ($n = 199$) in our center. iTVR was defined as TVR with no concomitant left-sided valve surgery. Two patients with corrected transposition of great arteries were also excluded. Finally, 118 patients were enrolled to form the basis of this study (Fig. 1). The study protocol was approved by the Ethics Committee of Zhongshan Hospital of Fudan University and was in accordance with the Declaration of Helsinki. Informed consent was obtained from each patient involved in this study.

Study protocol

Preoperative characteristics, operative details, and postoperative data were obtained retrospectively at the time of follow-up. The simplified model for end-stage liver disease (MELD) score was used to predict mortality in patients undergoing tricuspid valve surgery.[9] Respiratory failure was defined as the need for mechanical ventilation (>72 h), tracheostomy, or reintubation. Acute renal failure was defined as the requirement of dialysis or increase in creatinine to >2 mg/dL or by >50% from baseline. Perioperative mortality was defined as deaths that occurred within 30 d after iTVR or during the same hospitalization. Major adverse events (MAEs) were defined as occurrences of dialysis, rethoracotomy for bleeding, respiratory failure, complete atrioventricular block, or death within 30 d after iTVR or during the same hospitalization.

Surgical procedure

The decisions to perform TVR were principally based on the following indications: tricuspid valve repair was unfeasible or attempts at repair failed. The iTVR procedures were performed through standard median sternotomy, right lateral thoracotomy, or right lateral mini-thoracotomy with a 4- to 5-cm incision. Central cannulation (bicaval venous cannulation and ascending aorta cannulation) or peripheral cannulation

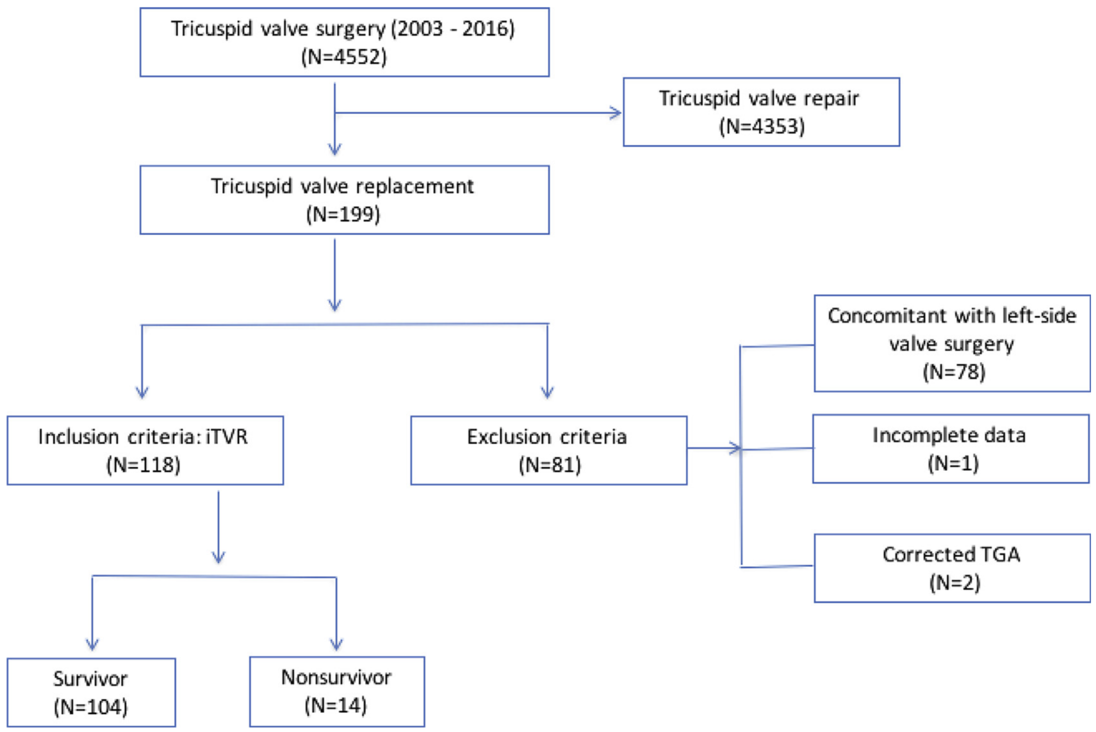

Fig. 1 – Patient selection. TGA = transposition of great arteries. (Color version of figure is available online.)

Table 1 – Preoperative clinical characteristics and laboratory data.

Variables	All (n = 118)	Survivor (n = 104)	Nonsurvivor (n = 14)	P value	Non-MAEs (n = 86)	MAEs (n = 32)	P value
Age, y	49.1 ± 12.9	48.4 ± 12.1	54.8 ± 17.4	0.081	47.7 ± 12.1	52.9 ± 14.2	0.055
Sex, male	42 (35.6)	37 (36.6)	5 (35.7)	0.774	32 (37.2)	10 (31.3)	0.548
NYHA class IV	15 (12.7)	8 (7.7)	7 (50.0)	0.000	7 (8.1)	8 (25.0)	0.083
NYHA class	3.0 ± 0.5	2.9 ± 0.5	3.5 ± 0.5	0.000	2.9 ± 0.5	3.2 ± 0.5	0.002
Diabetes mellitus	5 (4.0)	5 (4.8)	0 (0)	1.000	4 (4.7)	1 (3.1)	0.882
Hypertension	17 (14.4)	17 (16.3)	0 (0)	0.219	14 (16.3)	3 (9.4)	0.513
BMI	22.4 ± 3.5	22.5 ± 3.5	21.2 ± 3.5	0.207	22.7 ± 3.5	21.5 ± 3.6	0.115
SBP (mm Hg)	117.7 ± 12.3	118.1 ± 12.5	115.1 ± 11.0	0.405	117.3 ± 12.8	118.9 ± 11.1	0.529
DBP (mm Hg)	74.8 ± 10.0	75.5 ± 9.9	68.9 ± 8.4	0.019	75.5 ± 10.7	72.8 ± 7.5	0.205
Dyspnea	107 (90.7)	93 (89.4)	14 (100)	0.431	77 (89.5)	30 (93.8)	0.731
Liver congestion	45 (38.1)	36 (34.6)	9 (64.3)	0.032	27 (31.4)	18 (56.3)	0.013
Ankle swelling	70 (59.3)	60 (57.7)	10 (71.4)	0.326	48 (55.8)	22 (68.8)	0.203
Ascites	21 (17.8)	14 (13.5)	7 (50.0)	0.003	11 (12.8)	10 (31.3)	0.020
Cyanosis	6 (5.1)	5 (4.8)	1 (7.1)	0.540	5 (5.8)	1 (3.1)	0.904
Atrial fibrillation	62 (52.6)	51 (49.0)	11 (78.6)	0.038	40 (46.5)	22 (68.8)	0.032
Previous cardiac surgery	49 (41.5)	40 (38.5)	9 (64.3)	0.066	31 (36.0)	18 (56.3)	0.048
Cc (mL/min)	87.0 ± 28.8	89.9 ± 28.7	65.3 ± 19.3	0.002	90.9 ± 29.8	76.4 ± 23.4	0.015
Chronic renal insufficiency	9 (7.6)	5 (4.8)	4 (28.6)	0.009	5 (5.8)	4 (12.5)	0.409
Total bilirubin (mg/dL)	1.2 ± 0.8	1.1 ± 0.6	1.7 ± 1.4	0.010	1.1 ± 0.6	1.3 ± 1.0	0.143
Conjugated bilirubin (mg/dL)	0.5 ± 0.4	0.5 ± 0.3	0.8 ± 0.8	0.009	0.5 ± 0.3	0.6 ± 0.6	0.071
ALT (U/L)	23.6 ± 15.7	24.0 ± 16.0	20.6 ± 14.2	0.461	24.2 ± 16.5	22.0 ± 13.6	0.511
AST (U/L)	28.5 ± 13.1	27.8 ± 13.3	33.9 ± 10.2	0.103	27.3 ± 13.8	31.8 ± 10.8	0.099
Simplified MELDs	4.2 ± 3.4	3.9 ± 3.3	6.1 ± 3.7	0.027	4.1 ± 3.4	4.6 ± 3.3	0.484
Simplified MELDs >7	23 (19.5)	16 (15.4)	7 (50.0)	0.007	15 (17.4)	8 (25.0)	0.357
Hemoglobin (g/L)	128.9 ± 26.8	130.9 ± 26.6	113.2 ± 24.3	0.024	132.9 ± 27.4	117.4 ± 21.8	0.006

BMI = body mass index; Cc = creatinine clearance: (140−age [y]) × weight (kg) × (0.85 if female) (72 × serum creatinine [mg/dL]); DBP = diastolic blood pressure; SBP = systolic blood pressure; AST = aspartate transaminase; ALT = alanine transaminase; LN = natural logarithm.
Chronic renal insufficiency: creatinine clearance ≤50 mL/min; Simplified MELDs = 3.8 × LN (Total bilirubin) + 9.6 × LN (Creatinine) + 6.4. MAEs: Major adverse events were defined as occurrences of dialysis, rethoracotomy for bleeding, respiratory failure, complete atrioventricular block, or death postoperatively.
Data given as mean ± standard deviation or n (%).

(the femoral artery and vein cannulation) was adopted for cardiopulmonary bypass. Depending on the patients' conditions, iTVR was performed by the arrested or beating heart technique. Myocardial protection was achieved by anterograde or a combined anterograde and retrograde cold blood high potassium cardioplegia on the arrested heart. Prosthesis selections were mainly according to the patients' preferences and surgeons' suggestions.

Statistical analyses

Statistical analyses were performed with SPSS 20.0 software (SPSS Inc., Chicago, IL). Data were expressed as mean ± standard deviation or proportion. Continuous variables were compared by Student's *t*-test or Mann-Whitney *U* test, and categorical variables were compared by chi-squared analysis or Fisher's exact test, as appropriate. Potential independent predictors of perioperative mortality and MAEs were identified by univariate logistic regression analyses, and all significant univariate predictors ($P < 0.1$) were then entered into the stepwise multivariate logistic regression model. Some clinically important and interesting variables were also entered. Variables entered into the multivariate logistic regression model included age, diastolic blood pressure, body mass index, New York Heart Association (NYHA) class IV, liver congestion, ascites, atrial fibrillation, previous cardiac surgery, simplified MELDs >7, hemoglobin, severe right atrium (RA) enlargement, severe right ventricle (RV) enlargement, pulmonary hypertension, beating heart technique, and bioprosthetic valve. For all analyses, a P value < 0.05 was considered statistically significant.

Results

Population characteristics

Table 1 presents the preoperative characteristics of these 118 patients. Most of patients (64.4%) were females, and the mean

Table 2 – Echocardiographic data.

Variables	All ($n = 118$)	Survivor ($n = 104$)	Nonsurvivor ($n = 14$)	P value	Non-MAEs ($n = 86$)	MAEs ($n = 32$)	P value
LVEF (%)	66.0 ± 6.3	65.8 ± 6.3	66.9 ± 7.0	0.537	65.7 ± 6.3	66.5 ± 6.5	0.536
LAD (mm)	45.9 ± 14.6	45.2 ± 13.6	50.1 ± 19.6	0.249	43.9 ± 13.8	49.5 ± 16.1	0.084
LVESD (mm)	28.6 ± 7.1	29.1 ± 7.3	25.6 ± 4.4	0.201	28.8 ± 7.4	27.8 ± 6.4	0.499
LVEDD (mm)	41.4 ± 8.5	41.7 ± 8.6	39.8 ± 8.2	0.459	40.9 ± 9.1	42.1 ± 7.0	0.541
RA severe enlargement	78 (66.1)	66 (63.5)	12 (85.7)	0.177	54 (62.8)	24 (75.0)	0.213
RV severe enlargement	42 (35.6)	36 (34.6)	6 (42.9)	0.759	30 (34.9)	12 (37.5)	0.792
SPAP (mm Hg)	37.6 ± 11.4	38.1 ± 11.2	34.2 ± 12.7	0.266	37.4 ± 11.2	37.6 ± 12.2	0.931
Pulmonary hypertension	35 (29.7)	31 (29.8)	4 (28.6)	0.829	24 (27.9)	11 (34.3)	0.494
Ventricular septum (mm)	9.0 ± 1.4	9.0 ± 1.3	9.0 ± 1.8	0.931	8.9 ± 1.3	9.1 ± 1.6	0.554

LVEF = left ventricular ejection fraction; LAD = left atrial diameter; LVESD = left ventricular end-systolic diameter; LVEDD = left ventricular end-diastolic diameter; SPAP = systolic pulmonary artery pressure.
Pulmonary hypertension: SPAP> 40 mm Hg. MAEs: major adverse events were defined as occurrences of dialysis, rethoracotomy for bleeding, respiratory failure, complete atrioventricular block, or death postoperatively.
Data given as mean ± standard deviation or *n* (%).

age was 49.1 ± 12.9 y (range, 14-74 y). The etiologies of tricuspid valve dysfunction were degenerative ($n = 36$, 30.5%), rheumatic ($n = 35$, 29.7%), congenital ($n = 34$, 28.9%), endocarditic ($n = 8$, 6.8%), and traumatic ($n = 5$, 4.2%). For NYHA functional class, 101 patients (85.6%) were classified as NYHA functional class III or IV before operations. Most patients were symptomatic. Dyspnea was present in 107 patients (90.7%), ankle swelling in 70 patients (59.3%), liver congestion in 45 patients (38.1%), and ascites in 21 patients (17.8%). A total of 62 patients (52.6%) had atrial fibrillation. Forty-nine patients (41.5%) had undergone a previous cardiac operation: mitral valve replacement with or without tricuspid annuloplasty ($n = 18$), aortic and mitral valve replacement with or without tricuspid annuloplasty ($n = 15$), repair of congenital tricuspid valve anomalies ($n = 12$), closure of atrial septal defect ($n = 2$), aortic and mitral valve replacement and TVR ($n = 1$), and correction of tetralogy of Fallot ($n = 1$). The mean interval between two operations was 12.1 ± 8.9 y. Echocardiographic data are shown in Table 2. The severe RV dilation was observed in 42 patients (35.6%), and severe RA enlargement was detected in 78 patients (66.1%). Severe TR was found in 95.8% patients.

Surgical treatment

The iTVR procedures were performed through standard median sternotomy ($n = 89$, 75.4%), right lateral thoracotomy ($n = 6$, 5.1%), or right lateral mini-thoracotomy ($n = 23$, 19.5%). There was a trend of increasing use of minimally invasive approaches (Fig. 2). The arrested heart technique was performed in 56 patients (47.5%), and the mean aortic cross-clamp time was 44.2 ± 21.8 min. The beating heart technique was used in 62 patients (52.5%). Most of patients ($n = 102$, 86.4%) received bioprosthetic valves. A 29- or 31-mm prosthesis was used in 94.1% patients (Table 3). A higher percentage of right lateral thoracotomy and mini-thoracotomy were adopted in reoperative patients than in nonreoperative patients (55.1% *versus* 2.9%, $P < 0.05$).

Perioperative outcome

The mean length of postoperative intensive care unit stay was 4.0 ± 5.2 d, and the mean duration of postoperative hospital stay was 11.7 ± 7.9 d. The overall perioperative mortality rate was 11.8% (14/118), and a significant difference was observed between the nonreoperative and reoperative groups (6.7% *versus* 18.3%, $P = 0.047$). The causes of deaths were acute low cardiac output ($n = 9$, 64.3%) and progressive right heart failure with multiorgan failure ($n = 5$, 35.7%). Patients with a simplified MELD score of 7 or greater had a significantly higher mortality rate than patients with a simplified MELD score of less than 7 (30.4% *versus* 7.4%, $P = 0.007$). No significant difference of operative mortality was found between the biologic and mechanical prosthesis groups (9.8% *versus* 25.0%, $P = 0.183$), maybe because of the limited cases in the latter group. Pacemaker implantation was necessary in five patients (4.2%) due to grade III atrioventricular block. Respiratory failure was observed in 16 patients (13.6%), acute renal failure was present in 35 patients (29.7%) including the requirement for dialysis in 13 patients (11.0%), and reoperation for bleeding was necessary in three patients (2.5%) (Table 4). The rate of MAEs was higher in the reoperative group than in nonreoperative group (36.7% *versus* 20.3%, $P = 0.048$).

Predictors of morbidity and mortality

Tables 5 and 6 shows the results of univariate and multivariate logistic regression analyses for perioperative mortality and MAEs after iTVR. Because renal insufficiency and total bilirubin are measured as parts of the simplified MELD score, they are excluded from the model. Multivariate logistic regression analyses revealed that the independent risk factors

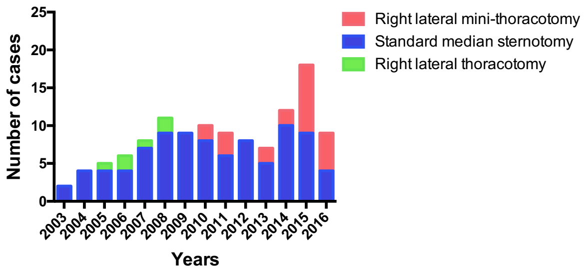

Fig. 2 – The trend of surgical approach from 2003 to 2016. (Color version of figure is available online.)

of perioperative deaths were preoperative NYHA functional class IV (OR [odds ratio] = 15.43, 95% CI [confidence interval] = 3.46-68.83, P = 0.000) and ascites (OR = 4.88, 95% CI = 1.24-19.27, P = 0.024). The previous cardiac surgery (OR = 3.28, 95% CI = 1.41-7.62, P = 0.006) was independently associated with perioperative MAEs. Interestingly, age and pulmonary hypertension (>40 mm Hg) were associated with neither perioperative mortality nor MAEs. Furthermore, the surgical technique (beating heart or arrested heart) and prosthetic valve types were not independent risk factors of perioperative mortality and MAEs.

Discussion

In this study, we reported our single-center experience of iTVR operations during a 13-y period. The key findings of this study were that iTVR had a relatively high mortality and morbidity rate and that early surgery may be better for this high-risk cohort of patients with tricuspid valve disease before the development of severe heart and end-organ failure.

The decision to operate on the tricuspid valve is always difficult when it is the only valve requiring treatment, especially when the surgery may require replacement rather than repair. Appropriate patient selection and surgical timing for iTVR are crucial for optimal outcome, but there is a lack of objective criteria. Thus, referral for surgical correction is often delayed until patients develop advanced cardiac impairment and end-organ failure, which leads to high in-hospital mortality rates ranging from 8.2%-20%.[7,10-13] In our study, NYHA functional class IV and ascites were the independent risk factors of perioperative mortality. The presence of NYHA functional class IV and ascites implied that patients had severe heart and end-organ failure. In addition, a significantly higher perioperative mortality rate was found in patients with a simplified MELD score of 7 or greater than in patients with a simplified MELD score of less than 7 (30.4% *versus* 7.4%, P = 0.007). The data supported that end-organ failure, such as liver and renal failure, could increase the perioperative mortality rate in turn. The perioperative mortality rate could decrease to 6.8% when patients were treated in an earlier state (NYHA functional class <IV), and even no death occurred in NYHA functional class II (0 of 18). Despite the lack of universal consensus regarding the optimal timing of iTVR, our experience suggested that we may intervene in an earlier stage before the development of irreversible right ventricular failure with end-organ failure.

Subjective symptoms are often nonspecific in patients with TR and may only become evident after advanced end-organ damage. Moreover, a discrepancy is common between subjective symptoms and echocardiographic findings.[14] It is apparent that RV function plays an important role in

Table 3 – Operative data.

Variables	All (n = 118)	Survivor (n = 104)	Nonsurvivor (n = 14)	P value	Non-MAEs (n = 86)	MAEs (n = 32)	P Value
CPB time (min)	81.5 ± 36.8	79.0 ± 33.7	101.4 ± 52.5	0.038	79.1 ± 35.9	87.9 ± 38.9	0.257
Beating heart	62 (52.5)	52 (50.0)	10 (71.4)	0.132	40 (46.5)	22 (68.8)	0.032
ACC time (min)	44.2 ± 21.8	43.1 ± 21.8	59.0 ± 17.1	0.160	44.0 ± 22.4	45.2 ± 19.6	0.874
Concomitant surgeries							
ASD	21 (17.8)	19 (18.3)	2 (14.3)	0.995	16 (18.6)	5 (15.6)	0.707
VSD	3 (2.5)	3 (2.9)	0 (0)	1.000	3 (3.5)	0 (0)	0.562
Arrhythmia surgery	2 (1.7)	2 (1.9)	0 (0)	1.000	2 (2.3)	0 (0)	1.000
Type of prosthetic valve							
Bioprosthetic	102 (86.4)	92 (88.5)	10 (71.4)	0.183	76 (88.4)	26 (81.3)	0.483
Mechanical	16 (13.6)	12 (11.5)	4 (28.6)		10 (11.6)	6 (18.7)	
Standard median sternotomy	89 (75.4)	81 (77.9)	8 (57.1)	0.172	68 (79.1)	21 (65.6)	0.131
Right lateral mini-thoracotomy	23 (19.5)	18 (17.3)	5 (35.7)	0.203	14 (16.3)	9 (28.1)	0.148
Right lateral thoracotomy	6 (5.1)	5 (4.8)	1 (7.2)	0.540	4 (4.7)	2 (6.3)	0.904

ACC = aortic cross-clamp; ASD = atrial septal defect; CPB = cardiopulmonary bypass; VSD = ventricular septal defect.
MAEs: major adverse events were defined as occurrences of dialysis, rethoracotomy for bleeding, respiratory failure, complete atrioventricular block, or death postoperatively.
Data given as mean ± standard deviation or n (%).

Table 4 – Postoperative outcomes.

Variables	All (n = 118)	Survivor (n = 104)	Nonsurvivor (n = 14)	P value
In-hospital death	14 (11.8)	-	-	-
Respiratory failure	16 (13.6)	10 (9.6)	6 (42.9)	0.003
Complete atrioventricular block	5 (4.2)	5 (4.8)	0 (0)	1.000
Acute renal failure	35 (29.7)	21 (20.2)	14 (100)	0.000
Dialysis	13 (11.0)	3 (2.9)	10 (71.4)	0.000
Rethoracotomy for bleeding	3 (2.5)	2 (1.9)	1 (7.1)	0.318
Postoperative ICU stay (d)	4.0 ± 5.2	3.2 ± 3.2	10.1 ± 10.7	0.000
Postoperative hospital stay (d)	11.7 ± 7.9	11.9 ± 7.5	10.1 ± 10.7	0.439
Drainage for first 24 h	579.7 ± 497.8	546.6 ± 482.8	855.8 ± 556.4	0.041
RBC transfusion (U)	4.7 ± 6.1	4.4 ± 6.1	9.0 ± 6.0	0.104
Plasma transfusion (mL)	566.7 ± 626.7	525.3 ± 597.3	1320.0 ± 742.9	0.005
Major adverse events	32 (27.1)	18 (17.3)	14 (100)	0.000

ICU = intensive care unit; RBC = red blood cells.
Data given as mean ± standard deviation or n (%). Respiratory failure: the need for more than 72 h of mechanical ventilation, tracheostomy, or reintubation; Acute renal failure: requiring dialysis, increase in creatinine to >2 mg/dL, or by >50% from baseline. Major adverse event: defined as occurrences of dialysis, rethoracotomy for bleeding, respiratory failure, complete atrioventricular block, or death postoperatively.

postoperative outcome. Thus, RV function needs to be assessed thoroughly and serially during preoperative clinical evaluation. However, RV function is very difficult to determine correctly. Echocardiography provides some parameters of RV size and systolic function, but these parameters are mostly qualitative and subjective in nature, owing to the complex geometry of the right heart.[15] In our study, no significantly independent risk factor was found in the traditional echocardiographic variables. More sensitive and quantitative parameters are needed to evaluate RV function and predict the outcomes of iTVR.[7,16] We have started to investigate tricuspid annular plane systolic excursion for the assessment of RV function in these patients since 2014, but more data are still required to fully attest the effect of tricuspid annular plane systolic excursion in iTVR. Emerging new technologies such as 3D echocardiography, tissue Doppler, and speckle tracking are widening the spectrum of the pathophysiologic information obtained, but further clinical validation is still needed.[17,18] Magnetic resonance imaging is regarded as the clinical reference technique for a more quantitative measure of RV

Table 5 – Univariate logistic regression for perioperative mortality and major adverse events after iTVR.

Variables	For perioperative mortality		For major adverse events	
	P value	OR (95% CI)	P value	OR (95% CI)
Age, y	0.086	1.046 (0.994-1.102)	0.389	1.014 (0.982-1.048)
NYHA class IV	0.000	12.000 (3.364-42.812.83)	0.236	1.974 (0.641-6.079)
DBP (mm Hg)	0.022	0.932 (0.877-0.990)	0.235	0.975 (0.935-1.017)
BMI	0.528	0.946 (0.794-1.125)	0.125	0.902 (0.790-1.029)
Liver congestion	0.040	3.400 (1.060-10.905)	0.235	1.647 (0.723-3.754)
Ascites	0.002	6.429 (1.957-21.118)	0.869	1.092 (0.383-3.115)
Atrial fibrillation	0.049	3.810 (1.005-14.454)	0.012	3.080 (1.278-7.424)
Previous cardiac surgery	0.074	2.880 (0.901-9.209)	0.006	3.276 (1.409-7.617)
Simplified MELDs >7	0.366	1.789 (0.507-6.319)	0.359	1.578 (0.595-4.183)
Hemoglobin (g/L)	0.021	0.970 (0.945-0.995)	0.270	0.991 (0.975-1.007)
RA severe enlargement	0.879	0.913 (0.284-2.931)	0.216	1.778 (0.714-4.425)
RV severe enlargement	0.992	1.006 (0.314-3.224)	0.792	1.120 (0.483-2.599)
Pulmonary hypertension	0.924	0.942 (0.274-3.233)	0.495	1.353 (0.568-3.225)
Beating heart	0.142	0.400 (0.118-1.357)	0.086	0.447 (0.205-1.109)
Bioprosthetic	0.093	0.326 (0.088-1.204)	0.319	0.570 (0.189-1.723)

BMI = body mass index; DBP: diastolic blood pressure.
Major adverse event (MAE): defined as occurrence of dialysis, rethoracotomy for bleeding, respiratory failure, complete atrioventricular block, or death postoperatively. Simplified MELDs = 3.8 × LN (Total bilirubin) + 9.6 × LN (Creatinine) + 6.4.

Table 6 – Multivariate logistic regression for perioperative mortality and major adverse events after iTVR.

Variables	For perioperative mortality		Variables	For major adverse events	
	P value	OR (95% CI)		P value	OR (95% CI)
NYHA class IV	0.000	15.43 (3.46-68.83)	Previous cardiac surgery	0.006	3.28 (1.41-7.62)
Ascites	0.024	4.88 (1.24-19.27)			

volumes and ejection fraction.[17,19] For RV ischemic disease, multidetector computed tomography and nuclear imaging technique may offer important additional information.

Considering the difficulty in separating the adhesions through the original incision, right lateral thoracotomy or mini-thoracotomy was performed in nearly a quarter of patients in our center. Right lateral mini-thoracotomy may have some advantages in reoperative high-risk patients, owing to an excellent exposure of the RA and the tricuspid valve and avoidance of extensive tissue dissection.[20,21] In line with other studies, no clear significant difference was observed in acute mortality rate between the beating heart and the arrested heart technique.[22,23]

The choice between mechanical and biologic prostheses for TVR is an ongoing debate.[24,25] Two meta-analyses compared mechanical and biologic prostheses without finding any statistically significant differences in the early and late survival or reoperation rates.[26,27] In our center, we tended to use biologic prostheses (86.4% of patients). The low RA and RV pressure with poor RV contractility predisposed these patients to mechanical valve thrombosis. Furthermore, with the development of percutaneous valve-in-valve therapy and percutaneous valves in the inferior vena cava, biologic prostheses may show larger advantages.[28-31]

Study limitations

This study was limited by its retrospective nature. All study subjects were treated in a single tertiary center, which may raise the possibility of referral bias. Another bias was the heterogeneity of the patient cohort, in particular with the previous surgical procedures and the various pathologic conditions of the tricuspid valve. Finally, this study lacks information regarding late complications or causes of deaths after discharge from the hospital, which will be the focus of our future study. However, to the best of our knowledge, the current study represents one of the largest series of patients who have undergone iTVR.

Conclusions

This retrospective study demonstrated that iTVR had a relatively high mortality and morbidity rate. Early surgery may be better for these high-risk patients before the development of severe heart and end-organ failure.

Acknowledgment

This work is supported by the Shanghai Municipal Commission of Health and Family Planning (Grant No.201540385), the National Natural Science Foundation of China (Grant No.81570422, 81500194), Shanghai Leading Talent Project (Grant No.14XD1401000), Joint Project Funding for Major Diseases in Shanghai (Grant No.2014ZYJB0402), Youth Foundation of Zhongshan Hospital (Grant No.2015ZSQN48), and Talent Training Program Foundation for the Excellent Youth Supported by Zhongshan Hospital (Grant No.2015ZSYXQN12). Authors' contributions: J.C., M.A., K.H., A.M., T.H., and C.W. were involved in the study design. J.C, S.L., L.W., and A.M. participated in data collection. J.C. performed the statistics and data interpretation. J.C., M.A., and C.W. participated in article writing and revision. All the authors have read and approved the final article.

Disclosure

The authors have no conflicts of interest to declare.

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