Isolated reoperative tricuspid valve surgery: Outcomes and risk assessment

Isolated Reoperative Tricuspid Valve Surgery: Outcomes and Risk Assessment

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Abstract

Objective: To describe patient characteristics and post-operative outcomes, including early and late mortality, defined by death within 30 days and after 30 days post-surgery, respectively, as well as 20-year survival after isolated reoperative tricuspid surgery.

Methods: We retrospectively analyzed 169 patients who underwent isolated reoperative tricuspid valve surgery at our institution (between 1997 and 2000) and describe post-surgical outcomes including intraoperative, early and late mortality. All patients included completed 21 years of follow-up.

Results: The majority of our patients were females 147 (87%) with the mean age of 45.9 $\pm$ 12.9 years. The mean body mass index (BMI, kg/m^2) was 27.4 $\pm$ 6.0. Previous cardiac surgeries included tricuspid valve surgeries in 169 (100%) patients, with bioprosthetic valves, mechanical valves, annual rings and tricuspid repair surgeries utilized in 37 (21.9%), 21 (12.4%), 38 (22.4%) and 73 (43.2%) patients, respectively. The indication for previous tricuspid surgery was rheumatic heart disease in 154 (91.5%) patients.

The most common cause of reoperative valvular surgery was tricuspid regurgitation (TR) in 139 (82.2%), with 66% of patients having severe TR. Other reasons for reoperative surgery included tricuspid stenosis 22 (13%) and dehiscence 8 (4.7%). For the redo surgery, 125 (74%) patients underwent Tricuspid Valve Replacement (TVR), 90 (53%) of whom received bioprosthetic valves while 35 (21%) received mechanical valves. Forty-four patients (26%) underwent Tricuspid Valve Repair. Mortality within 30 days of surgery was 11.3% (20 patients) and 11.4% after 30 days, with 20 years survival being about 80%.

Conclusions: Based on our experience, reoperation for failed isolated tricuspid valve replacement or repair was associated with reasonable mortality and good survival rate over long period of time.

Keywords: Reoperative, Redo, Tricuspid surgery, Outcomes, Mortality, Risk assessment

1. Introduction

Tricuspid regurgitation (TR) is found in 24% of the normal population and is more common in women (28%) than in men (19%) [1]. The etiology of TR can be broadly divided into primary (such as Ebstein anomaly, atrioventricular defects and endocarditis), and secondary causes (such as pulmonary hypertension and dilated cardiomyopathy). Out of all cases of TR in adults, primary valvular disease accounts for 10%. Intracardiac leads and endomyocardial biopsies can cause TR, as the leads can perforate or adhere to or impinge leaflets and in some cases entangle the chordal apparatus. The development of $\geq$2+ TR in 38% of patients undergoing *de novo* device implantation has been reported [2].

Secondary TR commonly develops in response to right ventricular (RV) remodeling due to pulmonary hypertension, the resultant pressure overload

causing ventricular enlargement, papillary muscle displacement, leaflet tethering, and annular flattening and dilation. Secondary TR can also be caused by the mechanisms of RV dilation and chronic volume overload. "Idiopathic" secondary TR constitutes 10% of secondary TR cases, where no cause of regurgitation can be identified [3,4]. Rheumatic fever can lead primary TR by directly affecting the leaflets or secondary TR by affecting the annulus and subvalvular apparatus or both as same time.

Patients are often asymptomatic but have a poor prognosis if they have moderate or severe TR and are left untreated, with patients often experiencing several limitations due to right-sided heart failure, including liver and kidney failure, functional decline and frequent hospitalizations. A 1-year survival of 92%, 90%, 79% and 64% has been demonstrated for patients with no, mild, moderate or severe TR, respectively [5].

Tricuspid valve surgery has been historically associated with high operative mortality and associated morbidity [6—10]. This relative rarity of isolated tricuspid valve surgeries also possibly results from uncertainty surrounding long-term outcomes and concerns over in-hospital mortality. Widely variable estimations of in-hospital mortality have been reported due to small sample sizes and individual series spanning over years, with higher mortality being associated with multivalvular surgery, advanced heart failure and redo sternotomy [11—20].

Reoperative tricuspid valve surgeries carry a fairly high operative mortality. A study on 790 patients (with 51% being NYHA Class III or IV) reported a 30-day mortality after reoperation of 32% and survival at 1 and 3 years was 31% and 19% [13]. Pfannmuller and colleagues reported an overall 30-day mortality of 14.6% and 2-year survival of 63.0% ± 5.5% [21]. Results of another study highlighted the importance of maintaining a post-operative TR of less than 2+, as survival in patients with TR of 2+ or higher after redo valvular surgery was significantly poorer than those with a post-operative TR of less than 2+ [22]. A study reported in-hospital mortality of 13%, while survivors benefitted reasonably well with 5-year and 10-year survival rates of 86% and 64% [23].

2. Objective

Our study's objective was to describe patient characteristics and post-operative outcomes, including early and late mortality, defined by death within 30 days and after 30 days post-surgery, respectively, as well as 20-year survival after isolated reoperative tricuspid surgery.

3. Methods

We retrospectively analyzed 169 patients who underwent reoperative tricuspid valve surgery at King Faisal Specialist Hospital & Research Centre, Riyadh, Saudi Arabia (KFSH&RC), a prominent tertiary care Centre and a regional leader in healthcare, between January 1997 and January 2000. All patients (100%) included in the study completed 21 years of follow-up. The study was approved by the Ethics Committee at King Faisal Specialist Hospital and Research Centre, Riyadh, Saudi Arabia (KFSH&RC).

Electronic medical records were used to identify patients with reoperative tricuspid surgery and collect preliminary demographic data. Long term survival data, baseline characteristics and echocardiographic data were collected using medical records of return visits and phone calls. All the patients included in study are seen at our hospital for follow up to now. Seven patients were excluded from study, because they lost to follow-up, had a lot of missing data or didn't answer or return phone calls.

4. Statistical analysis

The statistical analysis of our data was done using the statistical software SPSS version 21 (IBM Inc, Chicago, IL.). Descriptive statistics for the continuous variables were reported as the mean ± standard deviation and the categorical variables were summarized as frequencies and percentages. The results were presented as a tables and charts. The statistical level of significance was set at $p < 0.05$. Survival analysis was done using Kaplan Meier Curve.

5. Results

The majority of our patients were females, 147 (87%), with mean age of 45.9 ± 12.9 years. The mean BMI (kg/m^2) was 27.4 ± 6.0. A considerable proportion of the patients were relatively younger and female, possibly due to the high prevalence of rheumatic heart disease in this part of the world. The most common etiology of initial tricuspid valve pathology was rheumatic heart disease, in 154 (91.1%), followed by endocarditis, 12 (7.1%) and others, 4 (2%). Further patient demographics and etiologies are shown in Table 1 and Table 2 respectively.

Previous cardiac surgeries included tricuspid valve surgeries in 169 patients (100%), with bioprosthetic valves, mechanical valves, annual rings and tricuspid repair surgeries used in 37 (21.9%), 21 (12.4%), 38(22.4%) and 73 (43.2%) patients, respectively. Mitral valve surgeries were done in 161 patients (91.0%). Previous aortic valve, aortic root and coronary bypass grafting surgeries were done in 74 (41.8%), 4 (2.3%) and 2 (1.1%) patients, respectively, Table 3.

Indications for isolated reoperative tricuspid valve surgery and pre-operative echocardiographic results are listed in Table 2. The most common cause of reoperative valvular surgery was tricuspid regurgitation (TR) in 139 (82.2%) patients, with 66% of patients having severe TR. Other reasons for reoperative surgery included tricuspid stenosis in 22 (13%) and dehiscence in 8 (4.7%) patients. Pre-operatively, 114 patients (64.4%) were on loop diuretics, while 94 (53.1%) had chronic atrial fibrillation. Twenty-seven patients (15.3%) had diabetes, while 25 (14.1%) had a permanent pacemaker. Pre-operative echocardiogram showed normal ejection fraction (LVEF >55%) in 100 patients (59.1%), mildly depressed (LVEF = 40−50%) in 47 (27.8%), moderately depressed (LVEF = 30−40%) in 15 (8.8%) and severely depressed (LVEF<30%) in 7 (4.1%) patients. Additionally, 111 (66%) and 36 (21%) patients had severe and moderate tricuspid regurgitation (TR), respectively.

Table 1. Baseline characteristics and preoperative laboratory tests.

Demographics	
Age (y)	45.9 ± 12.9
Female	87%
Male	13%
Weight (kg)	67.2 ± 15.5
Height (cm)	156.6 ± 7.8
BMI (kg/m^2)	27.4 ± 6.0
Other pre-operative history	
Loop diuretics	114 (64.4%)
Intra-aortic balloon pump	1 (0.1%)
Chronic atrial fibrillation	94 (53.1%)
Permanent pacemaker	25 (14.1%)
Diabetes	27 (15.3%)
Peripheral vascular disease	4 (2.3%)
Dialysis	4 (2.3%)
Pre-operative laboratory	
Platelets (109/μL)	230.9 ± 86.8
Hemoglobin (g/L)	109.9 ± 23.1
Creatinine (μmol/L)	89.8 ± 56.0
Urea (mmol/L)	8.7 ± 9.9
Albumin (g/L)	38.8 ± 7.1

Y=Years, Kg = Kilogram, cm = Centimeters, BMI=Body mass index.
uL = Microliter, g/l = gram per liter, umol/L = micromole per liter.
mmo/L = millimole per liter.

Table 2. Indication for redo tricuspid surgery, preoperative echo.

Indication for Previous tricuspid surgery	
Rheumatic Heart Disease	154 (91.5%)
Endocarditis	12 (7.1%)
Trauma	1 (0.8%)
Ebsteins' anomaly	2 (1.2%)
Indication for re-do surgery	
Tricuspid stenosis	22 (13.0%)
Tricuspid regurgitation	139 (82.2%)
Dehiscence	8 (4.7%)
Pre-operative echocardiogram	
Ejection Fraction	
Normal	100 (59.1%),
Mildly depressed	47 (27.8%)
Moderately depressed	15 (8.8%)
Severely depressed	7 (4.1%)
Tricuspid regurgitation	
Mild	30 (17.8%)
Moderate	28 (16.6%)
Severe	111 (66%)

Normal ejection fraction (EF) > 55%, Mildly depressed EF = 40−50%, Moderately.
Depressed EF = 30−40%, severely depressed EF<30%.
Tricuspid regurgitation severity classification as per Nishimura RA, Otto CM, Bonow RO, Carabello BA et al., 2017 AHA/ACC Focused Update of the 2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Circulation. 2017 Jun 20; 135(25):e1159-e1195.

5.1. Reoperative surgical characteristics

Out of 169 patients who underwent isolated reoperative tricuspid surgery, 125 (74%) underwent Tricuspid Valve Replacement, 90 (53%) of which received bioprosthetic valves while 35 (21%) received mechanical valves. Forty-four patients (26%) underwent Tricuspid Valve Repair.

All patients who underwent reoperative tricuspid surgery were discharged on Coumadin (INR 2.5−3.5). Patients who underwent bioprosthetic tricuspid replacement or tricuspid valve repair took Coumadin for only three months, while the rest of the patients took Coumadin indefinitely.

Reoperations were performed through a median sternotomy with extracorporeal circulation. Intra-

Table 3. First (previous) tricuspid surgery, concomitant other cardiac surgeries.

Tricuspid valve	n = 169
Bioprosthestic	37 (21.9%)
Mehanical	21 (12.4%)
Annular ring	38 (22.4%)
Tricuspid repair	73 (43.2%)
Mitral valve	161 (91.0%)
Aortic valve	74 (41.8%)
Aortic Root	4 (2.3%)
Coronary bypass grafting	2 (1.1%)

operatively, cardiopulmonary bypass time was 160.7 ± 96.1 minutes, while aorta cross-clamp time was 106.8 ± 60.4 minutes. All patients underwent reoperative tricuspid surgery on-pump with a beating heart.

5.2. Post-operative outcomes

Post-operative outcomes are summarized in Table 4. Operation to discharge time was 36.1 ± 77.4 days. Thirty patients (16.9%) returned to the operating theatre during admission; 15 patients required an early reoperation because of postoperative hemorrhage, 6 had sternal wound dehiscence, 2 had mediastinitis, 2 needed epicardial pacemaker implantation and 5 had infection of the sternotomy site. Fifteen patients (8.5%) developed new atrial fibrillation, while 32 (18.1%) received permanent pacemaker implantation. Other postoperative complications included stroke (1, 0.6%) and dialysis (13, 7.3%). Creatinine and urea were 95.0 ± 46.9 μmol/L and 8.7 ± 16.8 mmol/L, respectively. Mean ejection fraction (EF) was 48.0 ± 10.0%.

Both immediately and at 20 years follow-up, leg swelling, shortness of breath, hospital readmission and emergency departments visits improved significantly. Twenty out of the 90 patients who underwent reoperation using bioprosthetic tricuspid valve needed a third re-do operation at 10−15 years, mainly due to symptomatic degeneration of the bioprosthetic valve.

Ten out of the 35 patients who underwent reoperation using mechanical tricuspid valve need a

third re-do operation; 3 patients in the first year because they stopped Coumadin which lead to stuck valve, 3 developed perivalvular leak with severe hemolysis, 2 developed infective endocarditis and 2 patients had their tricuspid valve surgery done as part of another valve surgery.

Five out of the 44 patients who underwent reoperation using tricuspid repair needed a third re-do operation; 2 for infective endocarditis, 1 for severe tricuspid stenosis and 2 as part of another valve surgery. 3 months post operatively, about 11 patients developed significant bleeding, requiring blood transfusion due to supratherapeutic INR. All of them did well and continued on Coumadin after appropriate dose was chosen.

In-hospital death or early mortality, defined as death within 30 days from surgery, was 11.3% (20 patients). Reasons for death were infection in 10 patients, multi-organ failure in 6, massive bleeding in 2 and adult respiratory distress syndrome (ARDS) in 2 patients. There were 20 deaths (11.3%) after 30 days from surgery (late mortality). 11 patients died due to severe end-stage heart failure, 3 died during reoperation for cardiac surgery and 6 died due to unknown reasons.

Survival was evaluated using Kaplan-Meier curve, as shown in Fig. 1. Survival at 20-years was 80%. The outcomes and implications of this study are shown in Fig. 2.

6. Discussion

Tricuspid valve surgery accounts for only 5% of cardiac surgeries [23]. Surgery for isolated TR is rarely performed, despite it being the only definitive treatment. Tricuspid valve repair or replacement is more commonly performed along with other cardiac procedures and less commonly as an isolated operation. Accordingly, the literature base for isolated tricuspid valve surgery is sparse. This sparsity of literature is more pronounced for redo tricuspid valve surgery, which carries high post-operative mortality and morbidity. The high mortality and morbidity observed with redo tricuspid valve surgery is believed to be associated not only with the redo surgery but also organ dysfunction.

The patients included in the study were predominantly females (87%), younger age (mean 46 years) and obese. The indication for the previous tricuspid surgery was mainly rheumatic heart disease in about 92% of our patients, which could be the main contributing factor for the reoperative tricuspid surgery. Rheumatic heart disease is a systemic illness and can result in friable tissue, affecting the stability of the initial valve.

Table 4. Type of re-do Tricuspid surgery and post-operative data.

Redo tricuspid Surgery	
Tricuspid Valve Repair	44 (26%)
Annuloplasty band	32 (18.9%)
Non-annuloplasty valve	12 (7.7%)
Tricuspid Valve Replacement	125 (74%)
Bioprosthetic valve	90 (53%)
Mechanical valve	35 (21%)
Post-operative	
Operation to discharge time (days)	36.1 ± 77.4
Return to theatre during admission	30 (16.9%)
New atrial fibrillation	15 (8.5%)
Permanent pacemaker implantation	32 (18.1%)
Stroke	1 (0.6%)
Creatinine (μmol/L)	95.0 ± 46.9
Urea (mmol/L)	8.7 ± 16.8
Dialysis	13 (7.3%)
Intra-operative	
Cardiopulmonary bypass time (min)	160.7 ± 96.1
Aorta cross-clamp time (min), 10 patients only	106.8 ± 60.4

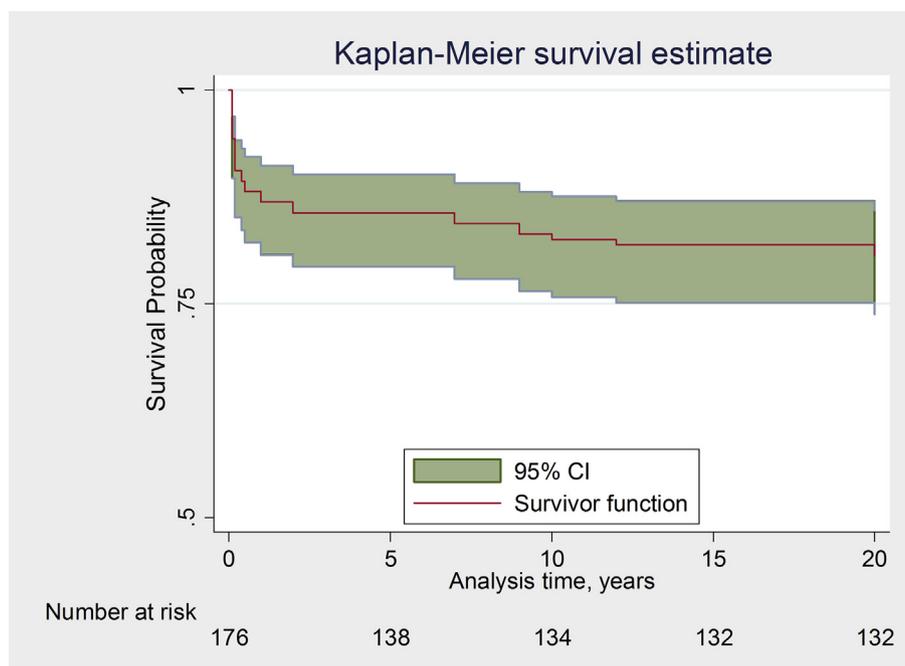Umol/L = micromole per liter, mmol/L = millimole per liter, min = minutes.

Fig. 1. Kaplan-Meier's survival curve for reoperative tricuspid surgery.

Most of our patients (74%) underwent tricuspid valve replacement, while 26% underwent tricuspid valve repair. A previous study reported similar long-term event-free rate regardless of the type of surgery, and a high recurrence of TR in re-repair [24]. It has been well known that residual TR after surgical repair can lead to biventricular failure, death or reoperation [25]. Another study found no significant difference in cumulative survival at 10 years between patients who underwent tricuspid valve replacement or repair [26]. Patients who underwent TV reoperation after TV repair had high in-hospital (35%) and long-term (10-year survival rate of 40%) mortality rates [27]. Repair is generally preferred in patients undergoing left-sided surgery as it facilitates minimizing bypass times [28,29]. With regards to the method of annuloplasty in repair, review papers have supported the superiority of ring annuloplasty over De Vega annuloplasty [30]. TV replacement may be required in patients with extreme annular dilation, previous failed TV repair or leaflet abnormalities [29,31,32].

The main driving factor for early mortality was infections, which can be potentially prevented with improving antiseptic techniques. The main driving factor for late mortality was end-stage heart failure, which can be prevented with early recognition and intervention. Many surgeons may consider 11% as a high mortality rate in such young patients (average age of 46 years). Nonetheless, most of these patients were obese females with a history of rheumatic heart disease, going into second sternotomy which may have contributed significantly to their death.

Patients with preoperative left ventricular ejection fraction of 40% or less tended to do worse post-operatively. This group of patients may benefit from emerging technology of percutaneous tricuspid valve replacement in the future.

Bleeding will continue to be one of the major contributing factors to mortality and morbidity in patients for reoperation, potentially due to extensive adhesions and granulation of old tissues around the valve. Our data is consistent with previously published data, indicating the group who underwent bioprosthetic valve replacement developed bioprosthetic valve degeneration after 10 years whereas the group who underwent mechanical valve replacement developed the typical problem of mechanical prosthesis, related to coumadin therapy. Patients with a high INR, tend to bleed and a low INR leads to valve leaflets motion restriction.

The group who underwent repair had the least complications in comparison to other groups. Therefore, we recommend continuing to repair the tricuspid valve when possible and replace using bioprosthetic valve, especially with emerging new technologies of percutaneous valve replacements. The percutaneous valve can be used very safely with high success rate for degenerating bioprosthetic tricuspid valve.

Our patients benefited from a considerably good 20-year survival rate of around 80%. Earlier intervention has been recommended to avoid further post-operative morbidity and mortality. A study

Reoperation on failed isolated previous tricuspid valve surgery can be done with favorable mortality and good survival
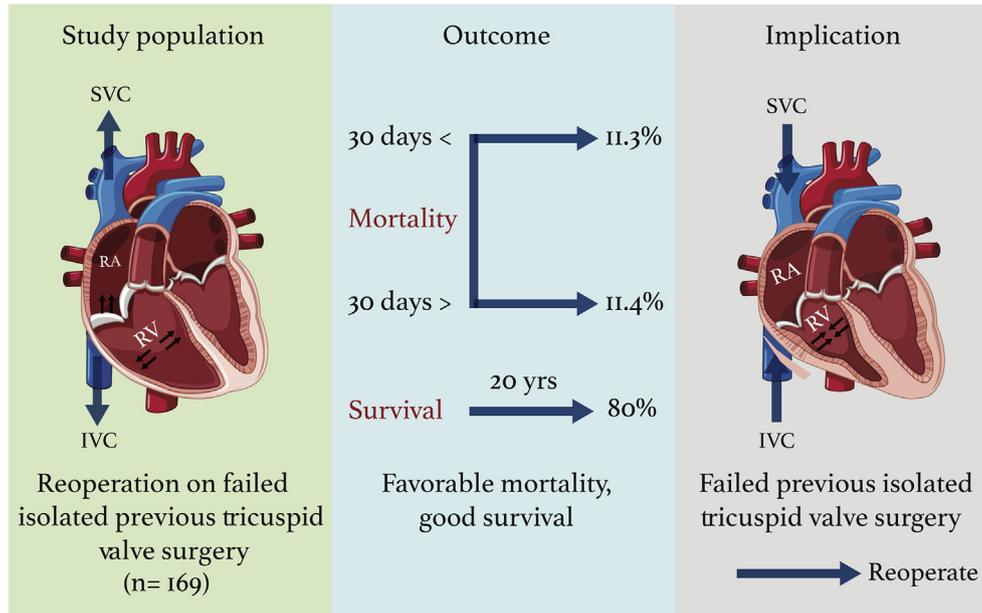
King Faisal Specialist Hospital & Research Centre, KFSH&RC Riyadh, Saudi Arabia, Dr. Tahir Mohamed,etal
SVC= Superior Vena Cava, RA=Right Atrium, RV=Right Ventricle, IVC=Inferior Vena Cava

Fig. 2. Graphic drawing summarizing study population, outcome and implications.

reported age, male gender, postoperative low cardiac output syndrome and stroke as risk factors for early death [23]. The same study, however, upon multivariate analysis revealed that, TVR itself was a major risk factor for operative death, with a hazard ratio of 3.188, in addition to the preoperative status.

Most of our reoperative tricuspid surgeries were done on-pump on a beating heart, since this is a pure right-sided heart disease, while few patients had a cross-clamp time longer than average because the surgeon had to perform extensive debridement of tricuspid annulus after removal of the old valve due to extensive friable tissue, likely due to rheumatic heart disease. The length of the hospital stay in our study is longer than the average in many western countries, mainly due to rehabilitation being part of inpatient hospital services in Saudi Arabia. In other words, the length of stay includes the acute care plus rehabilitation for the patients post-operatively.

6.1. Study limitations

its retrospective nature and having been done at a single Centre. It may be subject to the usual selection bias but, nonetheless, still provides pertinent information regarding our long experience with the treatment of a difficult clinical condition. Inability to perform sophisticated statistical analysis may hinder excluding some of the confounding factors. Not including the preoperative function and volumes of the right ventricle should be considered as a limitation of this study. Our surgical results, are, undoubtedly, good in the context of the illness we are dealing with, nonetheless these surgeries were done 20 years ago.

7. Conclusion

Tricuspid reoperative surgery has been associated with great mortality and morbidity. We present one of the largest case series on reoperative tricuspid valve surgery, which included 169 patients managed at King Faisal Specialist Hospital & Research Centre, Riyadh (KFSH&RC). Many of the patients had complex comorbidities and poor cardiac function. Most of our patients underwent tricuspid valve replacement (TVR) and benefited from considerably good survival rates.

Author contributions

Conception and design of Study: Tahir I. Mohamed, Omar J. Baqal. Literature review: Tahir I. Mohamed, Omar J. Baqal, Aly M. Alsanei.

Conflict of interest

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