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Case Report

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Successful Anaesthetic Management of Triple Valve Surgery (Double Valve Replacement and Tricuspid Valve Ring Repair)- Challenges and Troubleshooting

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ABSTRACT

Heart valve diseases are extensive and include double (mitral-aortic, mitral-tricuspid), or triple (mitral, aortic, and tricuspid) valvular regurgitation, stenotic or mixed lesions. The surgical correction of valvular lesions usually consists of the repair or replacement of all valves affected by a pathologic process.We present a challenging complex valvular case of a 61 year old hypothyroid female diagnosed with severe mitral stenosis with moderate mitral regurgitation, severe aortic stenosis with mild aortic regurgitation and severe tricuspid regurgitation with high pulmonary artery pressures.She successfully underwent Double valve replacement (Mitral and aortic) and Tricuspid Annuloplasty Ring repair.

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Introduction

Triple valve surgery (TVS) is still a challenge for surgeons because of prolonged cardiopulmonary bypass (CPB) and myocardial ischaemic times. The reported operative mortality rate for TVS ranges between 2.5 and 25%; long-term survival is also diminished, with reported survival rates at 5 and 10 years of 75–82 and 61–75%, respectively [1].

Skill full and meticulous preoperative assessment, induction of anaesthesia, intraoperative management, weaning from cardiopulmonary bypass and postoperative management is of paramount importance for uneventful outcomes.

Case Report

A 61 years old post-menopausal, hypothyroid female presented to our tertiary care center with complaints of easy fatigue, worsening dyspnea on exertion (NYHA grade 3), swollen feet and palpitations since last 6 months. Occasional fainting episodes were also documented. Patient's son informed that she was started on Tab. Cordarone 200 mg BD, Tab. Acitrom 2 mg OD, Tab. Lasix 40 mg BD, Tab. Thyronorm 62.5 mcg OD in her previous admission 3 months ago in some other remote hospital.

She has Penicillin drug allergy and also underwent bilateral total knee replacement under combined spinal epidural 15 years ago. The surgery was uneventful.

She was examined in detail by the cardiology team, on clinical examination holosystolic murmur and atrial fibrillation with fast ventricular rate were found.She was admitted for medical stabilization and optimisation for further treatment.

Blood Investigations	Result
HB/WBC/PLATELET COUNT	14.0 gm%/5800 per microlitre/1.27 lacs
PROTHROMBIN TIME/INR	12.8 secs/1.12
SERUM ELECTROLYTES-NA/K/ CL-	133 mmol/L/4.19 mmol/L/99.7 mEq/L
UREA/CREATININE	14/0.79 mg/dl
LFT	TOTAL BILIRUBIN-0.99 mg/dl PROTEIN/ALBUMIN-7/4.2 gm/dl SGOT/SGPT-21/14 units ALKALINE PHOSPHATASE-123 IU/ Litre
HEPATITIS B,HEPATITIS C,HIV	NON REACTIVE
HBA1c	5.1%
Thyroid function test	With in normal limits
BLOOD GROUP	A POSITIVE

Chest X-ray revealed prominent bronchovascular markings (pulmonary plethora),calcified aortic knuckle,double density sign and cardiomegaly. ECG showed atrial fibrillation with fast ventricular rate.Coronary angiography (CAG) showed normal coronaries.

2D Transthoracic Echocardiography (TTE) revealed an LVEF of 50% with global Left ventricle (LV) hypokinesia, Severe Mitral Stenosis (MS) (MVA-0.8 cm^2) mean pg-10 mmhg, maximal calcification of mitral valve, mild to moderate subvalvular deformity, moderate mitral regurgitation (MR), Severe Aortic Stenosis (AS) (AVA-0.9 cm^2),mild 2+ aortic regurgitation (AR),aortic cusps- thick and calcific,Aortic Annulus-2.2 cms, Aortic root-3.3 cms, STJ (Sino tubular junction) 2.8 cms, Ascending aorta-3.3 cms, Severe Tricuspid Regurgitation (TR) PASP-50 mmhg, Dilated Left atrium 4.8 cms, normal Right ventricle (RV) function, TAPSE- 25 cms (Tricuspid Annular Plane Systolic Excursion), Tricuspid Annulus size 3.9 cms. Patient was advised trans esophageal echocardiography (TEE) for further confirmation of 2D Echo findings, but she refused.Hence, TEE was not performed.Normal airway examination was noted.

Carotid and Peripheral Doppler studies were noted as normal.

After interdisciplinary discussion with cardiology, anaesthesia and CTVS team, an elective Double valve replacement (Mitral and Aortic) along with Tricuspid annuloplasty ring repair was planned. After detailed counselling a well-informed high risk consent was taken from the patient and relatives with adequate blood and blood products reservation was also confirmed.

On the day of surgery after confirming the fasting status ,the patient was wheeled inside the operation theatre. Pre-anaesthesia induction we took 14 g peripheral line (Right forearm), 20 g right radial arterial line and neck lines in Right internal jugular vein (8.5# Sheath-PA catheter inserted and removed after noting down pressures since Tricuspid ring repair was to be performed and 7# triple lumen catheter). Pulmonary artery pressure was 42/19/32 mmHg with systemic pressure of 105/48/66 mmHg. Atrial fibrillation with controlled ventricular rate was seen on ECG.Anaesthesia induction was started after preoxygenation with 100% oxygen (FIO2-1) with I. Midazolam 2 mg, I. Fentanyl 150 mcg, I. Etomidate 16 mg, I. Vecuronium 8 mg. Airway was secured with 7.5 no ET tube (Position confirmed on auscultation and ETCo2 graph). Right Femoral arterial line was inserted post induction. Temperature probe was also attached.

TEE probe was inserted with utmost precaution.

Other than the TTE findings a Left atrial appendage (LAA) thrombus was documented on TEE examination which was not reported in TTE.

Our surgical plan was to remove LAA thrombus then perform Mitral valve replacement (MVR) first followed by Aortic valve replacement (AVR) and finally Tricuspid annuloplasty ring repair (TVR) at the last. This sequence (mitral first, then aortic, and tricuspid last) ensures optimal surgical exposure and minimizes complications such as embolization, hemodynamic instability and prosthetic interference during the surgery [2].

Aortic and bicaval cannulations were performed and cardiopulmonary bypass was initiated after adequate heparinization (ACT-792 seconds). After the aorta was clamped, ostial cardioplegia and retrograde cardioplegia were given. LAA thrombus was removed.

Mitral valve was replaced with Mitris Resilia size-25 mm, Aortic valve was replaced with Inspiris Resilia size-21 mm, Tricuspid valve repair was done using Tricuspid annuloplasty ring Edwards MC3 size-32 mm.

Under TEE guidance aorta was unclamped after no air bubbles were seen in the chambers, an episode of Ventricular tachycardia was noted, immediate cardioversion followed by ventricular pacing @90/mt was started, gradual ventilation began and with inotropic support- Infusion Epinephrine 0.1 mcg/ kg/minute, Infusion Norepinephrine 0.1 mcg/ kg/minute, and Infusion Milrinone 0.5 mcg/kg/minute.

On TEE evaluation, first valve seating of the prosthetic mitral valve was confirmed ensuring there were no paravalvular leaks. Leaflet Motion was adequate and they were functioning without restriction. Pressure gradient across the mitral valve was 3 mmhg.

TEE evaluation of the prosthetic aortic valve confirmed the proper positioning and functioning of the aortic prosthesis and there were no paravalvular leaks. Transvalvular gradient was 6 mmhg. TEE ensured there was no injury to the aortic root or ascending aorta during surgery. TEE evaluated the placement and fixation of the annuloplasty ring. Mild residual tricuspid regurgitation was present. Transvalvular gradient was 1.8 mmhg. Doppler echocardiography is used to assess for any residual regurgitation or improper functioning of the valve. Right Ventricular (RV) function was found to be normal function post-repair is to ensure improvement in hemodynamics. Patient came off cardiopulmonary bypass uneventfully with inotropic support and ventricular pacing @ 90/minute and blood pressure was 112/68 mmhg.

Hemostasis was achieved after blood and blood products transfusion. We transfused 3 units packed cells (PRBCs), 4 units fresh frozen plasma (FFPs), 4 units random donor platelets (RDPs). Patient was on Tab. Acitrom 2 mg which was stopped 3 days prior to the surgery and with long pump time multiple transfusions were given to gain adequate hemostasis. Total aortic cross clamp time was 158 mts and total CPB time was 178 minutes.

Arterial Blood Gas Analysis Post-Surgical Closure
Hb- 9.8gm Ph- 7.36 Pco2- 40 Po2 (Fio2-0.6)- 257.4 K+ -4.09
Hco3- 22.4 BE (-)2.7 Sao2- 98.5 Lactates- 4.25 Calcium- 0.97
ACT- 143 HGT- 163 mg/dl
Cardiac output- 4.19 L/min Cardiac Index-2.4 L/min/m^2
SVR- 954 dynes/secs/cm^{-5} PVR-171dynes/secs/cm-5 SV-37 ml

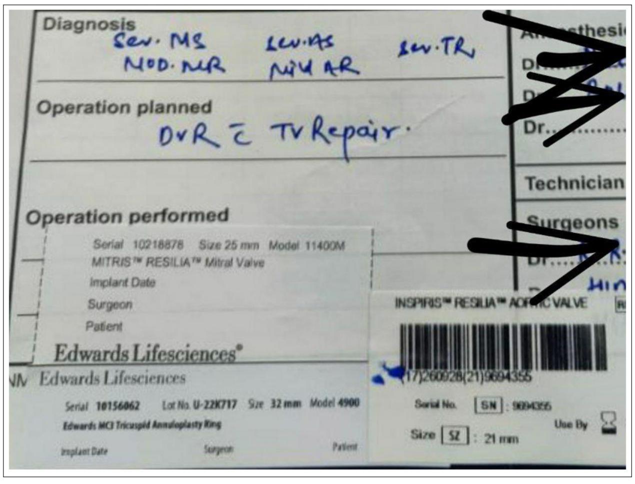


Figure 1: Various Prosthetic Valves used in the above Case

Discussion

Combined surgery for aortic, mitral, and tricuspid valves (TVS) and preoperative TVS still remains a formidable challenge for both the surgeon and the anesthetist. Despite substantial improvements in myocardial protection and CPB techniques, TVS is still a major challenge for more advanced valvular disease and also due to complexity of the operation. In addition, outcomes of TVS are often complicated by different underlying pathophysiologic conditions, associated cardiovascular diseases, and concomitant operative procedures.

General Considerations for All Valve Replacements are as follows:

Monitoring: Continuous intraoperative transesophageal echocardiography (TEE) is used to monitor the function of the prosthetic valves and to assess for paravalvular leaks, ventricular function, and volume status of the patient.

Cardiopulmonary Bypass (CPB): CPB time is usually long triple valve surgery (TVS).Hemodynamic goals during CPB include maintaining perfusion pressure, oxygen delivery, and minimizing ischemia and reperfusion injury to the myocardium.

All above hemodynamic goals must be individualized based on patient's preoperative ventricular function, valve pathology, and the patient's overall status. Collaboration and communication between the anaesthesiologist, surgeon, and cardiologist is essential for optimizing patient outcomes during these complex procedures [3,4].

Specific Considerations for Individual Valve Replacement are as follows:

For patients undergoing mitral valve replacement (MVR), aortic valve replacement (AVR), and tricuspid valve replacement or repair during anaesthesia induction, the primary hemodynamic goals are aimed at optimizing cardiac output, maintaining appropriate mean arterial pressures, and preventing life threatening complications such as arrhythmias or worsening heart failure.

Mitral Valve Replacement (MVR)

a) **Preload:** Patients of mitral stenosis have a stiff left atrium and are preload-dependent. Hence, it's important to maintain an adequate preload without overloading the left atrium, which could lead to pulmonary congestion or pulmonary edema.
b) **Heart Rate:** A slow to normal heart rate (60-80 bpm) is preferred to allow sufficient diastolic filling time. Tachycardia/atrial fibrillation should be avoided as it reduces diastolic filling time and increases left atrial pressure.
c) **Afterload:** Avoid increases in systemic vascular resistance (SVR) that would exacerbate left atrial pressure. Afterload reduction can be helpful, but this must be carefully balanced to avoid hypotension in mitral stenosis patients.
d) **Rhythm:** Sinus rhythm is critical, as atrial contraction contributes significantly to ventricular filling in mitral stenosis. Atrial fibrillation, which is common in these patients, should be treated with priority if present.
e) **Contractility:** Left ventricular function is preserved in mitral stenosis, but care should be taken if there is associated left ventricular dysfunction [5,6].

Aortic Valve Replacement (AVR)

a) **Preload:** In aortic stenosis, the left ventricle is mostly hypertrophied and needs a higher preload to maintain adequate stroke volume. Care should be taken to avoid hypovolemia, which could lead to severe hypotension.
b) **Heart Rate:** A slow to normal heart rate is ideal (60-80 bpm). Tachycardia/atrial fibrillation should be avoided, as it can reduce diastolic time, impairs coronary perfusion, and increase myocardial oxygen demand.
c) **Afterload:** Afterload should be maintained or slightly increased in patients with aortic stenosis, as the hypertrophied left ventricle requires adequate systemic vascular resistance (SVR) to maintain perfusion pressure. Sudden decrease in afterload can cause severe hypotension.
d) **Contractility:** Positive inotropic support may be needed if left ventricular function is impaired, particularly after valve replacement when the left ventricle must adjust to a sudden reduction in afterload.
e) **Rhythm:** Sinus rhythm is very important, as atrial contraction contributes to left ventricular filling, particularly in a hypertrophied heart [5,6].

Tricuspid Valve Replacement (Tricuspid Annuloplasty or Replacement)

a) **Preload:** Patients with tricuspid regurgitation often tolerate slightly higher preload levels due to the right-sided heart failure. However, excessive fluid administration can worsen right ventricular failure and result in hepatic congestion and peripheral in are often administered perioperatively to these patients.
b) **Heart Rate:** A normal heart rate is (60-80 bpm) is acceptable. Tachycardia should be avoided as it can reduce right ventricular filling and exacerbate tricuspid regurgitation.
c) **Afterload:** Pulmonary vascular resistance (PVR) should be kept low to facilitate right ventricular function. Increases in PVR (e.g., due to hypoxia, hypercarbia, acidosis) can lead to worsening right ventricular failure. Systemic afterload should be maintained or slightly reduced to decrease the volume overload on the right ventricle in these patients.
d) **Contractility:** Inotropic support may be required in cases of severe right ventricular dysfunction. Agents like milrinone or dobutamine are very commonly used, as we used in this case too.
e) **Rhythm:** Sinus rhythm is always preferred. Right atrial contraction plays a significant role in right ventricular filling, especially in patients with tricuspid regurgitation [5,6].

Table 1: Hemodynamic Goals in Valvular Lesions

THE HEMODYNAMIC GOALS FOR VALVULAR LESIONS *

Valvular Lesion	Inotropy	Heart Rate (bpm)	Preload	Afterload
Aortic stenosis, hypertension	↔	60-70	↑	↔ ↑
Aortic regurgitation	↔ ↑	80-90	↔	↔ ↓
Mitral stenosis	↔	60-70	↑	↔
Mitral regurgitation	↔ ↑	80-90	↔	↔ ↓

↑, increase; ↓, decrease; ↔, no change.

*No studies have been performed in unstable, respiratory compromised patients.

Table 2: Hemodynamic Goals in Valvular Lesions (https://images.app.goo.gl/dTwpQhqBPz1nR7f27)

	Aortic Stenosis	Hypertrophic Cardiomyopathy	Aortic Insufficiency	Mitral Stenosis	Mitral Regurgitation
Preload	Full	Full	Increase slightly	Maintain; avoid hypovolemia	Increase slightly
Afterload	Maintain CPP	Increase; treat hypotension aggressively	Decrease to reduce regurgitant fraction	Prevent increase	Decrease
Rate	Avoid bradycardia (decrease CO) and tachycardia (ischemia)	Normal	Increase	Low normal	Increase slightly, avoid bradycardia
Rhythm	Sinus	Sinus is critical	Sinus	Sinus or rate controlled atrial fibrillation	Sinus or rate controlled atrial fibrillation

CO, cardiac output; CPP, coronary perfusion pressure.

For an anaesthetist to manage valvular cases, he/she must be thoroughly trained in TEE for evaluation of pre surgical and post-surgical valve status and LV, RV function. It's a mandatory tool in examination of adequate correction and residual defects if any. Let's discuss few TEE parameters one should be well versed with in managing these cases.

Table 3: Grading of Mitral Stenosis [6]

GRADING OF MITRAL STENOSIS

Indicator	Mild	Moderate	Severe (Critical)
Mean gradient (mmHg)	<5	5 to 10	>10
Area (cm^2) (normal area 4-6 cm^2)	>1.5	1.0 to1.5	< 1.0
Pulmonary Artery systolic pressure (mmHg)	<30	30 to50	> 50

Table 4: Grading of Mitral Regurgitation [6]

GRADING OF MITRAL REGURGITATION

Method	Mild	Moderate	Severe
Qualitative			
Vena contracta (mm) (MO long axis)	<3	3-7	>7
Jet area/LA area	<20%	20%- 40%	> 40%
Jet length/LA length	2-6	6-12	>12
Jet area(cm^2)	< 4	4-8	>8
Quantitative			
Regurgitant volume (ml /beat)	<30	30-60	≥ 60
Regurgitant fraction (%)	<30	30-50	≥ 50
Regurgitant orifice area(cm^2)	<0.20	0.20-0.40	>0.40
OTHER			
Pulmonary vein Doppler (PWD)	Blunting S wave	S wave< D wave	Systolic Reversal of flow

Other criteria of severe MR

1- Systolic flow reversal in contralateral pulmonary vein.(PWD)
2- E wave height > 1.4 m/s on transmitral Doppler.(CWD)
3- Intensity of regurgitant jet is similar to diastolic jet on transmitral Doppler.(CWD)
4- V wave cut-off sign.(CWD)
5- LV PISA > 1cm (alias velocity at 40 cm/s).
6- Wall-hugging jet of any size that encircles the LA.
7- Jet enters a pulmonary vein or LA appendage.(evidence of pulmonary venous flow reversal).
8- Flail leaflet.
9- LV dilatation:- LV end systolic dimention > 4.5 cm or EF < 55% (TG mid short axis view).
10- LA dimention > 5.5 cm

Table 5: Grading of Aortic Stenosis [6]

GRADING OF AORTIC STENOSIS

Indicator		Normal	Mild	Moderate	Severe
Valve area (cm^2)		3.0-4.0	>1.5	1.0-1.5	<1.0
Peak velocity (m/s)		1.4-2.2	< 3	3.0-4.0	>4.0
Pressure gradient (mm Hg)	Peak	8-20	20-40	40-70	>70
	Mean		<20	30-50	>50

Table 6: Grading of Aortic Regurgitation [6]

GRADING OF AORTIC REGURGITATION

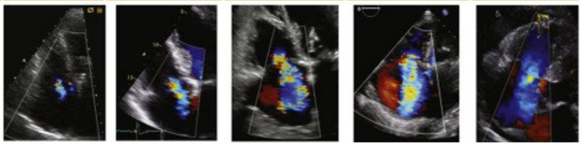
Method	Mild	Moderate	Severe
COLOUR FLOW DOPPLER			
Jet height/LVOT (MO AV Long axis 120°-130°)	<25%	25-65%	>65%
Jet / LVOT area (%).(MO AV short axis 40°)	5-25	25-60	>60
Vena contracta (mm) .(MO AV Long axis)	<3	3-6	>6
Regurgitant orifice area (cm2) .(MO AV short axis)	<0.10	0.1-0.3	>0.30
SPECTRAL DOPPLER (Deep TG long axis and TG long axis 0°)			
PT ½ (ms) (CWD)	>500	200-500	<200
Slop of AR jet decay (m/s) (CWD)	<2	2-3	>3
CW density	Weak "flat top"	Increased angle on CW	Dense,steep slope
Desc. Ao reversal (descending aortic long axis)(PWD)	Early mild	Intermediate	Holodiastolic abd
OTHER			
Regurgitant volume	<30 ml	30-60 ml	>60 ml
Regurgitant fraction	20-30%	30-50%	>50%

Vena contacta:- narrowest portion of the jet located just distal to the regurgitant orifice.

Other criteria of severe AR

1- Jet extanding beyond insertion of papillary muscle.(MO AV Long axix view120°-**130°**)
2- Presystolic closure of the mitral valve and diastolic mitral regurgitation.
3- Peak velocity of systolic ejection > 2 m/s
4- Intensity of regurgitant jet = Intensity of systolic jet
5- LV dilatation:- LV end systolic dimention > 4.5 cm (TG mid short axis view)

Table 7: Grading of Tricuspid Regurgitation Assessment [7]

Parameters	MILD	MODERATE	SEVERE	MASSIVE	TORRENTIAL
Vena Contracta width (biplane average)	<3 mm	3-6.9 mm	7 mm - 13 mm	14-20 mm	≥21 mm
EROA by PISA	<20 mm^2	20-39 mm^2	40-59 mm^2	60-79 mm^2	≥80 mm^2
3D Vena Contracta Area or Quantitative Doppler EROA	-	-	75-94 mm^2	95-114 mm^2	≥115 mm^2
Example:					

In conclusion, transesophageal echocardiography (TEE) played a very pivotal role in the management of this triple valve surgery case. The utilization of TEE throughout the perioperative period underscored its importance in enhancing patient safety and improving surgical outcomes in our complex valve replacement case.

Conclusion

In conclusion, the successful management of this triple valve replacement case highlights the importance of meticulous anaesthetic planning and precise intraoperative monitoring. The combined replacement of the aortic, mitral, and tricuspid valves posed significant challenges in maintaining hemodynamic stability, which were effectively managed through real-time transesophageal echocardiography (TEE) guidance and tailored pharmacologic support. Postoperative evaluation demonstrated excellent prosthetic valve function and no residual regurgitation or paravalvular leaks, confirming the procedure's success. This case underscores the critical role of a multidisciplinary approach in optimizing outcomes in complex valve surgeries.

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