

Early Experience of Cardiac Surgery in the Maldives

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ABSTRACT

Introduction

From stitching a heart wound to the current level of sophistication, cardiac surgery has come a long way as a discipline. Heart surgery in South Asia has advanced tremendously; both, quantitatively and qualitatively. This is a report of the first fifteen surgeries done in the Maldives where cardiac surgery has started as an organized program.

Methods

Data on the first fifteen consecutive cardiac surgeries done in our hospital, over a period of 7 months, was analyzed. We briefly describe our usual perioperative management, and the pretext of the beginning of the cardiac surgery program.

Results

Fifteen patients, 13 males, aged 59.9 ± 13.8 years, with a EuroScore of $0.9 \pm 0.4\%$, were operated. Eleven underwent CABG; and four had a valve replacement. Nine out of 11 had TVD, including 6 who had an LMCA disease. The first surgery was an off-pump CABG. The CABG group had a total of 2-5 grafts. Pump and cross-clamp times were $239.6 (\pm 56.1)$ min and $154.2 (\pm 45)$ min respectively. Five (33.3%) had at least one non-fatal complication. Two (13.2%) required re-exploration for mediastinal bleeding. The length of hospital stay was 16.5 days (± 6.9 days). The chest tubes stayed for an average of 4.8 (± 0.7) days. There was no in-hospital, 30-day and 90-day mortality recorded.

Conclusion

Cardiac surgery has begun in the Maldives. It is safe and feasible to sustain cardiac surgery program in the country, provided continued national support and international collaboration is ensured.

Keywords: Cardiac surgery; coronary artery bypass; Maldives; valve replacement

INTRODUCTION

Not many during the time of Theodor Billroth would have believed that cardiac surgery would attain the heights it now has. In 1882, he commented that performing a pericardiectomy is tantamount to an act of

prostitution in surgery, and in 1883 he went on to say that every surgeon who tried to stitch up a wounded heart would lose the respect of his colleagues.¹ Ludwig Rehn clearly did not give heed and in 1897 became the first surgeon to suture a wound in the right ventricle.² In

1938 Robert Gross, while he was still a chief resident, ligated a patent ductus arteriosus in a 7-year girl child while William Ladd, the chief surgeon at the hospital, was away, despite the latter discouraging him against the 'extravagant adventure'.¹ In 1945, Alfred Blalock, upon Helen Taussig's insistence, performed the first subclavian artery-pulmonary artery anastomosis [famously known as the Blalock-Taussig (BT) shunt] in a 15-month cyanotic baby girl.¹

In 1951, a team of 16 did the first heart operation using cardiopulmonary bypass. Albeit unsuccessful, it established that cardiac surgery is a team-game.¹ Gibbon's development of heart-lung machine which he successfully used in 1953, Lilehei's successful use of cross-circulation in 1954, and Harken's successful implantation of a caged ball aortic valve in 1960 ushered a new era in the history of cardiac surgery.^{1, 3, 4} Today thousands of heart surgeries are performed daily around the world⁵, although services are not evenly distributed around the world.^{6,7} For many years now and by many, there have been efforts to establish and groom cardiac surgical programs in developing and emerging nations.⁸⁻¹³ There has been no universal model applied to

promulgate these programs: every model has been borne out of the contemporary situation.

The first South Asian cardiac surgery was the closure of a stab wound to the left ventricle by an Indian surgeon in 1946. (14) In the ensuing seven decades, the field of cardiac surgery in the whole region has been revolutionized with many 'firsts' in most south Asian countries, viz. India, Pakistan, Nepal, Bangladesh, Sri Lanka and Afghanistan.^{14, 15} There have been reports depicting periods of stagnation and those of inspiration from many developing nations in the African subcontinent and elsewhere.^{6, 8, 12, 13, 16}

In south Asia, cardiac surgery has not been reported from 'tiny Bhutan and the Maldives'.¹⁴ Moreover, cardiac surgery program in the Maldives has been considered 'too difficult to sustain because of geographical isolation and too small a population'. Rather, 'it seemed more convenient to evacuate their patients to India or elsewhere and get the operation done'.⁹ These reports probably speak the historical truths, but a new era has begun in 'the tiny Maldives'. On 8 August, 2018, with the very first cardiac surgery ever done here, the country embarked on this noble path. This is a report of the first fifteen heart surgeries

done in the Maldives, an archipelago of more than 1200 islands in the Indian Ocean.

METHODS

A retrospective review was done, of patients who underwent any kind of heart surgeries in the ADK Hospital, Maldives, between August 2018 and February 2019. Preoperative, operative, anesthetic and perfusion data; and postoperative information were analyzed using simple statistical tools.

The hospital

The ADK hospital in the capital city has been providing general as well as specialty services to Maldivians for the last 20 years. As a well-functioning 120-bedded general hospital with over 5000 outpatient attendance and over 300 major operations per month, there existed a conducive 'ground support' to jumpstart real cardiac surgical work. A cardiac catheterization lab (Artis zee biplane system, Siemens Healthcare GmbH, Erlangen, Germany) and a cardiac care unit (CCU) are in close proximity with the modular theatre (KLS Martin Group, Tuttlingen, Germany) equipped with a heart-lung machine (Sorin Group USA, Inc.), intra-aortic balloon pump (IABP) and CardioHelp extracorporeal membrane oxygenation (ECMO) systems (Maquet Gettinge Group,

Rastatt, Germany) and the anesthesia machine and cardiac monitors (Dräger Medical GmbH, Lubeck, Germany). Blood bank, Laboratory and Sterilization services, deemed essential, were already running in full scale.

The team

After the establishment of the department, more than a year was consumed in planning, organizing, and procurement; setting up a cath-lab, theatre and CCU; besides continuing some thoracic and vascular work. Through exclusive consultation and 'manhunt', and with unprecedented administrative support, a strong team was built. Noninvasive cardiac work began in Jan 2016. The first coronary angiography was done on 17th and the first percutaneous coronary intervention (PCI) on 28th April, 2018. First primary PCI, a success, done on 6th May, 2018 was surely a testimony to a gradually maturing system of cardiac care. The team comprised of cardiologists (India, Nepal), cardiac surgeons (Maldives, Nepal), cardiac anesthetists (Maldives), perfusionist (India), scrub nurses (Maldives, India) and other support staff. (Fig 1) Some of the referrals also came from Indira Gandhi Memorial Hospital (IGMH), the major government hospital in the country. A mock-drill was staged a week

before the kick-off to make sure the whole team, as diverse as it was, functioned as a unit, and spoke the same 'language'.

Perioperative care

The execution of the cardiac surgical program was fairly standardized. All referrals for probable surgery were duly evaluated by the surgical and the anesthetic team for appropriateness and operability. The final decision was always made with full involvement of the patient and the family, and then an informed consent obtained. Various factors like urgency, smoking and medication status, and 'preparedness' of the patient influenced the exact date of surgery. Management of perioperative medications were done in keeping with the 2017 EACTS Guidelines.¹⁷ As a hospital protocol, cefuroxime was used for antibiotic prophylaxis, repeated after initiation of cardiopulmonary bypass (CPB).

In the operation theatre, after placement of an arterial line for invasive monitoring, Fentanyl was used as primary induction agent to preserve hemodynamics. A combination of Midazolam, Sevoflurane and Vecuronium ensured a comprehensive hypnosis, anesthesia, analgesia and muscle-relaxation.²⁰ Placement of other lines and catheters would

then follow.

Operation, perfusion and postoperative care

Median sternotomy was our incision of choice. For Coronary artery bypass grafting (CABG), the left internal mammary artery (LIMA) would be mobilized and the better of the two great saphenous veins harvested before pericardiotomy. For other procedures, pericardium used to be opened immediately to assess the cavity, the heart and the aorta, among others. After adequate systemic heparinization, aortic and venous cannulations were done as usual (bicaval for valve procedures and a double-stage venous canula for CABGs). Our myocardial protection strategies included del-Nido cardioplegia (20 ml/Kg, repeated after 90 minutes as needed) and mild-moderate hypothermia. After cross-clamping the ascending aorta, cardioplegia was delivered for prompt diastolic arrest of the heart which was cooled at the same time. For CABG, distal anastomosis of reversed saphenous vein was done to the target coronaries, followed by the LIMA to left anterior descending artery. The proximal anastomosis would take place after removal of the cross-clamp. The patient was warmed (slowly, gradually and uniformly), ventilation resumed, heparin reversed, and

canulae removed in succession once the hemodynamics were acceptable. Pacing wires and drains would be placed, hemostasis secured, sternum wired and skin closed, and the patient shifted to CCU.

The patient would be closely monitored and managed in the CCU, with attention to bleeding; assessment and correction of volume deficit; inotropic management; maintenance of normothermia; adequate anesthesia, analgesia and ventilation; tissue perfusion and oxygenation. Analgesia relied heavily on Fentanyl. Gradually weaned off the ventilator, a completely awake patient with acceptable respiratory mechanics and blood gases would be extubated. Post-extubation care would be instituted, patient gradually mobilized, inotropes tapered, feeding re-established, required medications begun; and lines, wires, catheters and tubes gradually removed over the next 4-6 days. Any deviation from the usual convalescence would be promptly identified and treated. Normally after a few days of drain removal, the patients would be shifted to a ward for ongoing care. After discharge, they would be followed at weekly intervals for 2 weeks, monthly for 3 months, and 3 monthly for the first year.

RESULTS

Fifteen patients were operated during seven months. Their demographic profile, risk assessment, diagnosis, surgery and some other clinical information are summarized in Table 1. With a ratio of 13:2, males outnumbered females. They ranged between 25-82 years (Mean: 59.9 ± 13.8). Nine were smokers, all males. Five, all males, were hypertensive, and three (two males) were diabetic. Average body mass index (BMI) was 24.3 ± 4.2 Kg/m². Patients' EuroScore II averaged at $0.9\% \pm 0.4\%$ (0.5%-1.7%).

Eleven patients, all males, underwent CABG; and four had a valve replacement. (Table 2) Nine out of 11 had triple vessel disease, including six who had a left main disease. The first heart surgery was an off-pump CABG, done emergently. Two CABGs were done on an urgent basis (Table 1); all other operations were done electively. The CABG group had a total of 2-5 grafts (2.9 on average). (Fig 2) We set out to use the LIMA in all patients but were unable to do so in three as the artery was sclerotic and diminutive. The operative times, pump times and the aortic cross-clamp (AOX) times appear in Table 3. Longer pump times were mainly the result of unexpected events like endarterectomy, coronary dissection or second pump run. Cardioplegia doses ranged

Table 1. Summary of patient data

S N	Age/ Sex	BMI	ES- II (%)	Smoker (Y/N)	Htn (Y/N)	Diagnosis	Preop function/angina	Surgery	Remarks
1	54/M	18.6	1.3	Y	N	CAD- LMCA (MI)	CCS IV	OPCAB; LIMA to LAD; rSVG to OM2	First cardiac surgery (and first OPCAB, too) in the country
2	25/F	21.2	0.8	N	N	RHD, S'MS, S'MR, Mod PAH, AF; PDA	NYHA III	MVR, LAAL; PDA Ligation	First open heart surgery in the country
3	57/M	19.0	0.8	Y	N	CAD- LMCA	CCS III	CABG; rSVG to LAD and OM2	LIMA sclerotic
4	55/M	23.9	1.0	N	Y	CAD- LMCA, RCA	CCS IV,	LIMA to LAD; rSVG to PD and OM1	Had MI- thrombolysed
5	56/M	21.1	0.5	N	N	RHD, S'MS, mild PAH, AFI,	NYHA II	MVR, LAAL	Reexplored in 10 hours for bleeding; no definite bleeder
6	82/M	22.3	1.6	Y	Y	CAD- LMCA, RCA	CCS II	rSVG to LAD, PD, OM2	LIMA poor, PD needed endarterectomy
7	79/M	21.2	1.5	Y	Y	CAD- LMCA, RCA	CCS III	LIMA to LAD, rSVG to D1, OM2 (PD poor target)	Had postoperative pancreatitis (idiopathic/drug- induced)
8	61/M	26.1	0.5	Y	Y	CAD- LMCA, RCA	CCS II	LIMA to LAD, OM2, D1 (RCA poor target)	POD7: Wound washout for seroma

ES, Euroscore; CAD, coronary artery disease; TV, triple vessel disease; LMCA, left main coronary artery; RCA, right coronary artery; PD, posterior descending branch of RCA; OM, obtuse marginal; S', severe; MVR, mitral valve replacement; LAAL, left atrial appendage ligation; AVR, aortic valve replacement; AF, AFI, atrial fibrillation, flutter; LIMA, left internal mammary artery; LAD, left anterior descending artery; OPCAB, off-pump coronary artery bypass; rSVG, reversed saphenous venous graft; CCS, Canadian Cardiovascular Society; D, diagonal; PDA, patent ductus arteriosus; POD, postoperative day; PTFE, polytetrafluoroethylene; MV, mechanical ventilation; IM, intramyocardial.

Table 1. Summary of patient data, *continued* (1).

S N	Age / Sex	BMI	ES- II (%)	Smoker (Y/N)	Htn (Y/ N)	Diagnosis	Preop function/ angina	Surgery	Remarks
9	69/ M	33.3	0.9	N	Y	S' AS, S'AR, normal coronaries	CCS II	AVR	Thin aorta; reexplored after 3 days for bleed; plegia-site bleed controlled by wrapping with a PTFE strip; Chest infection (Klebsiella s/t Piperacillin, Meropenem) needing re- intubation and MV for 5 days
10	75/ M	22.3	1.7	Y	N	CAD- RCA, LAD, Ramus	CCS II	rSVG to PD and Ramus	LAD very poor the whole length, OM's poor; Poor LIMA; Ramus needed endarterectomy
11	68/ M	31.1	1.2	N	N	CAD- LAD, RCA, LCx	CCS II	LIMA to LAD, rSVG to PD, D1, OM2	-
12	62/ M	25.6	0.5	Y	N	CAD-TVD	CCS I	LIMA to LAD, rSVG to PD, OM2	RCA needed endarterectomy
13	60/ M	26.8	0.5	Y	N	CAD-TVD	CCS II	LIMA to LAD, rSVG to PD, OM1	OM2 dissected; taken down
14	56/ M	22.4	0.9	Y	N	CAD-TVD	CCS II; NSTEMI	LIMA to LAD, rSVG to OM2, PD, D1	LAD IM bridge; LIMA-LAD bleed requiring going back on pump
15	41/ F	29.2	1.7	N	N	RHD, S'MS, S'MR; AF	NYHA II	MVR; LAAL	-

from 1 to 5, with a mean of 1.6 ± 0.6 .

All the patients requiring valve replacement had mechanical valve (Medtronic PLC, Dublin, Ireland), parachuted down using 2.0 polyester everting horizontal mattress stitches. (Fig 3) All three of the mitral valve replacements were accompanied by the ligation of the left atrial appendage. A TEE was done in all four, and normal valve function and absence of

paravalvular leak ascertained.

Intraoperatively, three patients required defibrillation. Two required a re-run of the pump for bleeding. Three required an endarterectomy of the target vessel. Five out of 15 patients (33.3%) had at least one non-fatal complication. (Table 1 & 2) Two of them (13.2%) required re-exploration for mediastinal bleeding. In one of them who had a thinned

Table 2. Procedures and complications

<i>Frequency of procedures done</i>	
CABG	11
MVR	3
AVR	1
<i>Frequency of complications</i>	
Bleeding requiring re-exploration	2
Chest infection	1
Surgical site infection	1
Pancreatitis	1

Table 3. Perioperative data

Parameters	Mean ($\pm$ SD)	Range
Primary Operation duration (hr)	9 ($\pm$ 1.5)	6 – 12
CPB time (min)	239.6 ($\pm$ 56.1)	145 – 333
AOX time (min)	154.2 ($\pm$ 45)	87 – 237
Chest tube indwelling time (days)	4.8 ($\pm$ 0.7)	4 – 6
Length of stay in hospital (days)	16.5 ($\pm$ 6.9)	9 – 30
Duration of postoperative use of inotrope stopped last (hr)	77.8 ($\pm$ 25.7)	48 – 120

CPB, cardiopulmonary bypass; AOX, aortic cross-clamp

aortic wall, the cardioplegia canula insertion point was found to be the culprit. Failing all the conventional methods of hemostasis, an improvised PTFE strip was used to 'wrap' the aorta at the bleeding point, with success. (Fig 4) This patient had a stormy post-exploration period, marred by chest infection and requiring reintubation and mechanical ventilation at one stage. Expectedly, he stayed in the hospital for a total of 30 days, the longest of them all. The average length of hospital stay was 16.5 days ($\pm$ 6.9 days). None of the 15 patients required IABP insertion.

All the patients have satisfactory symptom-

relief until their last follow-up (9 months for four; 6 months for four and 3 months for seven), with a satisfactory compliance to postoperative medications. There was no in-hospital, 30-day and 90-day mortality recorded.

DISCUSSION

The average age of 59.9 years and the spectrum of procedures reflect the prevailing referral pattern. CABG has been the most commonly done cardiac surgery worldwide, and our center was no exception. Similarly, age and sex distribution of our patients was also in keeping with the published literature.¹⁸

There is no denying that operative durations,

average pump runs and the AOX times could be better. The answer, at least in part, probably lies in the organizational learning curve on top of the need for increasing the surgical volumes and identifying potential intraoperative 'speed-blockers'. It is generally accepted that operating times reduce with surgeon's experience, effective teamwork and cumulative experience.¹⁹ However, more numbers will be needed to evaluate if increasing cumulative experience of the surgeon pair will effect reduction in operative times, CPB times and the cross-clamp times. Long surgeries have been repeatedly demonstrated to be more prone to wound infection.²⁰⁻²² However, superficial sternal wound infection occurred in one patient (6.6%), in keeping with reported rates of 0.5-8%.²³ Our unplanned reoperation rate of 13.2%, in itself is higher than the published rates, partly because of low surgical volume.²⁴ However, according to Society of Thoracic Surgeons Database, 13% of patients after cardiac surgery have at least one of the major complications [prolonged intubation (>24 hr); stroke; renal failure ($\geq$ three-fold rise of creatinine/ new requirement for dialysis); unplanned reoperation and deep sternal wound infection].²⁰

One of the shortcomings was the inability to

use the LIMA for its poor quality in 3 patients. Although all of them report symptomatic relief with the venous grafts, an honest introspection tells us that our strategy must change towards using alternative arterial conduits in such cases in future. The absence of operative, in-hospital, 30-day or 90-day mortality was in keeping with a preoperative EuroScore II of 0.9% ($\pm 0.4\%$) which predicted a low risk for mortality. Nevertheless, the patients will have to be followed up for longer periods of time to generate more data on symptom, heart function and possible mortality.

Cardiac surgery is cost-intensive. Experience from Nepal^{14, 15} and Nigeria²⁵ show that where the initial costs of infrastructure and treatment are borne by the government, the program has a smooth take-off. In the absence of stable insurance, the only alternatives remain 'payment out-of-pocket' and philanthropy.¹² In our case, although the entire set-up was completely privately funded, the Maldivian government's policy of providing free health services to all its citizens through its own insurance company indeed was instrumental.²⁶ The direct or indirect 'sponsorship' of all the cardiac surgeries by the government has been a key to sustaining the program after initial launch. However, an average hospital

stay of 16.5 days is in part attributable to the administrative clearance time for such funding after the operation is done. Another contributor to an apparently longer stay is the fact that patients, mostly hailing from distant islands, wish to stay 'long enough' in the hospital before going home. Although there have been reports of a long hospital stay of 12 days from other initial series as well⁶, efforts must be made to reduce the length of stay to reduce the overall costs

The successful launch of the program demands for some reflections. This has truly been an international collaboration, and a model in itself. Driven by the team's motivation, nurtured by administrative support and garnered by state-sponsorship (for patients), the program did make history in the country. In the long run, however, sustaining the program will be more challenging because of the fluidity of human resources. Raising the surgical volume will also be a challenge. Improvement in outcome parameters and quality indicators generally follow a modest rise in surgical case load, but that assumes the teamwork and institutional capacity remain the same if not better. A permanent native cardiac surgeon is going to be the key to the longevity of the program. There have been examples of 'medical

missions' to help start a program, but it has been repeatedly demonstrated that it takes a 'home-grown' team to sustain the program and take it to a greater heights.^{6, 8, 9, 14, 27}

CONCLUSION

Cardiac surgery has begun in the Maldives. It is safe and feasible to sustain cardiac surgery program in the country, provided continued national support and international collaboration is ensured.

CONFLICTS OF INTEREST

None declared.

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Fig 1. The theatre team after the first cardiac surgery in the Maldives. Members are named.

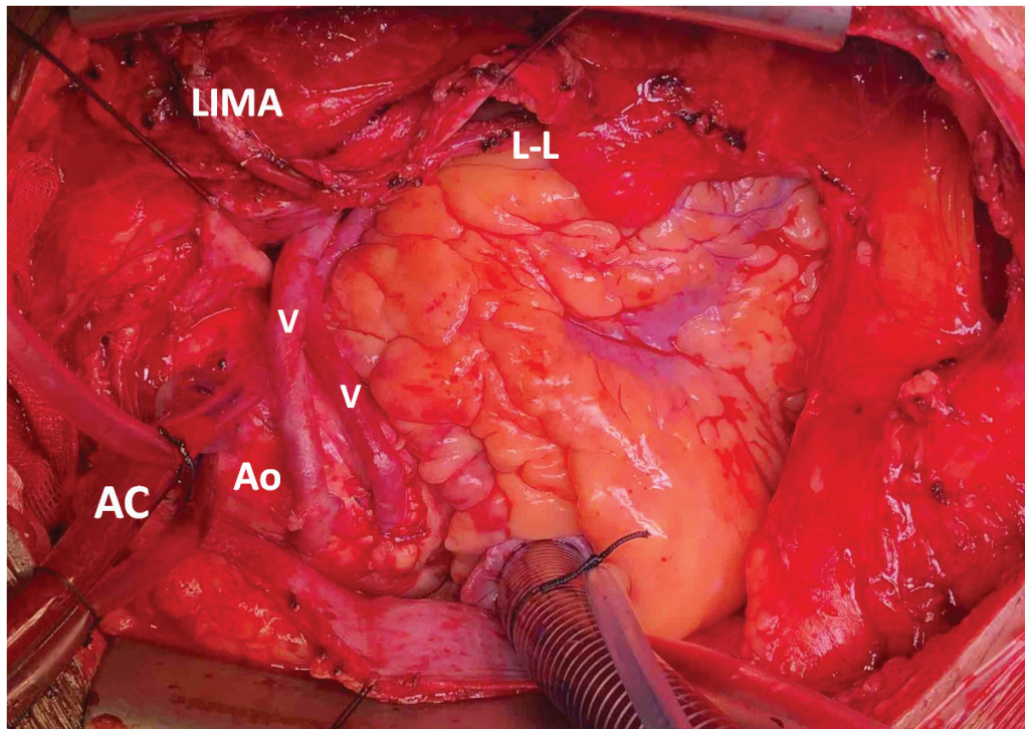


Fig 2. Coronary artery bypass graft operation, after the completion of all anastomoses (surgeon's view). [LIMA, left internal mammary artery; L-L, LIMA-left anterior descending anastomosis; V, saphenous vein graft; Ao, ascending aorta; AC, aortic canula]

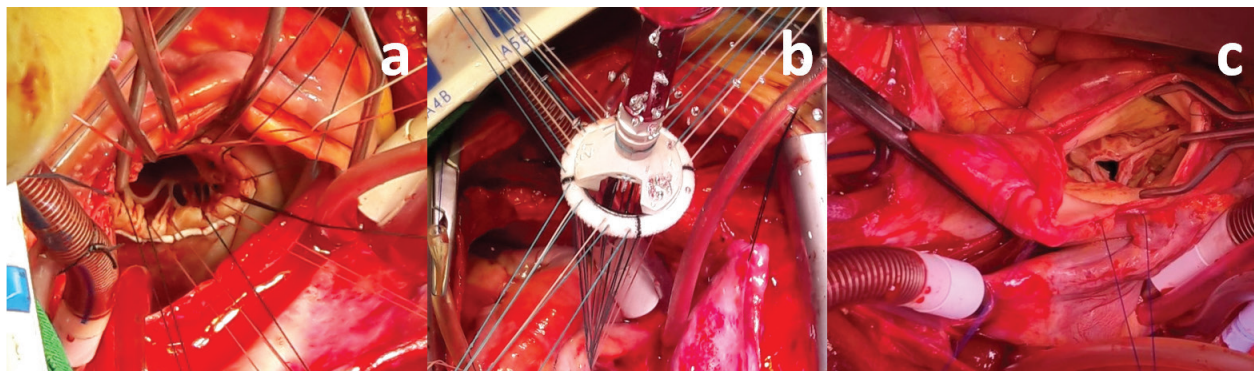


Fig 3. The glimpses of valve replacement surgeries (surgeon's view, patient's head towards picture's left). a. Everting stitches being placed after excision of the diseased mitral valve. b. The mechanical mitral valve being parachuted down to the mitral position. c. The stenotic aortic valve just before excision . Note the left atrial retractor in (a) and the aortic retractor in (c).

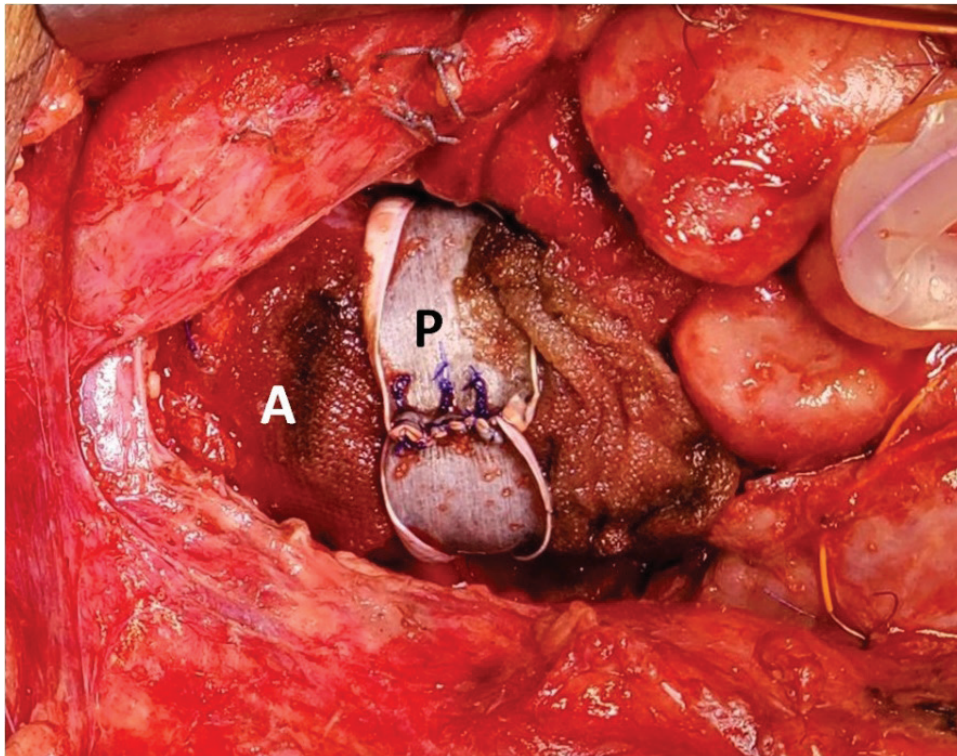


Fig 4. The aorta wrapped, for hemostasis, with a PTFE (polytetrafluoroethylene) 'band' made by longitudinally opening up a tube graft, in patient 9 in Table 1. Note the folded chest tube caudally on the right. [A, ascending aorta covered in surgical cellulose; P, PTFE 'band']