# OUTCOME OF OPEN REPAIR OF THORACOABDOMINAL AORTIC ANEURYSM IN TAKAYASU ARTERITIS: A RETROSPECTIVE ANALYSIS

**[Dr. NEELAMJINGBHA SUN]**

MCh VASCULAR SURGERY

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SREE CHITRA TIRUNAL INSTITUTE FOR MEDICAL SCIENCES AND

TECHNOLOGY, TRIVANDRUM

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A THESIS SUBMITTED BY

**[Dr. NEELAMJINGBHA SUN]**

TO

SREE CHITRA TIRUNAL INSTITUTE FOR MEDICAL SCIENCES AND TECHNOLOGY, TRIVANDRUM.

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD

OF

**MCH VASCULAR SURGERY**

2023

# DECLARATION BY THE STUDENT

## CERTIFICATE

I, **Dr Neelamjingbha Sun** hereby certify that I had personally carried out the work depicted in the thesis titled, "**Outcome of Open repair of Thoracoabdominal aortic aneurysm in Takayasu arteritis: A retrospective analysis**"

No part of this thesis has been submitted for the award of any other degree ordiploma prior to this date.

Signature

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Date 27/8/2023

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The thesis entitled, "**Outcome of Open repair of Thoracoabdominal aortic aneurysm in Takayasu arteritis: A retrospective analysis**" was carried out under my direct supervision. No part of the thesis was submitted for the award of any degree or diploma prior to this date.

*Clearance was obtained from the Institutional Ethics Committee / Institutional Animal Ethics / Institutional Committee for Stem Cell Research / Otherappropriate committees (if any, specify) for carrying out the study.

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Date 28/8/23

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# APPROVAL OF THE THESIS

The thesis entitled

## OUTCOME OF OPEN REPAIR OF THORACOABDOMINAL AORTIC ANEURYSM IN TAKAYASU ARTERITIS: A RETROSPECTIVE ANALYSIS

Submitted by

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for the degree of

**MCh VASCULAR SURGERY**

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August 2023 Dr Neelamjingbha Sun

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# OUTCOME OF OPEN REPAIR OF THORACOABDOMINAL AORTIC ANEURYSM IN TAKAYASU ARTERITIS: A RETROSPECTIVE ANALYSIS

SYNOPSIS BY

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# SYNOPSIS

**INTRODUCTION:** Takayasu Arteritis (TA) is an immune mediated arteritis causing inflammation of the aorta and its branches, which can result in aortic aneurysms. We aim to describe the outcome of surgical management in these patients.

**MATERIALS AND METHODS:** Between 2003 – 2023, 41 TA patients with thoracoabdominal aortic aneurysm (TAAA) underwent operative repair.

**RESULTS:** There were 25 females and 16 males, in the age group of 19-53 years, with hypertension in 20 patients. Raised inflammatory markers were present in 30 patients. According to Crawford classification, there were two patients with type I, two with type II, 18 with type III, 13 patients with type IV and seven with type V aneurysm. Multiple steno-occlusive lesions were present in 21 patients, with majority affecting the renal artery. Partial cardiopulmonary bypass and spinal drain were used for types I, II and III. Thoraco-phreno-laparotomy was done for types I, II, III and V aneurysms. Retroperitoneal exposure of type IV aneurysms was done in eight patients and transperitoneal approach for five. Separate bypass to visceral branches was done in eight patients, of whom five had multiple bypasses and three patients only had renal bypass. Twelve patients underwent reimplantation of branches, out of which nine had multiple vessel reimplantation. Four patients underwent staged repair of the aneurysm, which included visceral debranching in the first day, followed by repair of the aneurysm in the next day. In the immediate postoperative period, ten patients developed acute kidney injury and two required dialysis. Other morbidities included ARDS, spinal cord dysfunction, bleeding, and wound complications. Four patients expired in the immediate postoperative period. Mean duration of ICU stay was 4.1days and hospital stay was 12.7days. Comparison of disease activity with morbidity and mortality was statistically insignificant. Patients were on follow-up for a mean duration of 41.02±43.91 months and median follow up of 24months. Over this time period four patients expired and four developed anastomotic pseudoaneurysm requiring intervention. On comparing the disease activity at the time of surgery with the long-term arteritis related complications that required intervention, the p-value was 0.59 and hence statistically not significant. The 5-year survival rate is 84.4%.

**CONCLUSION:** Surgical repair has good and satisfactory outcome, with low early and late mortality rates. Progression of disease can occur at any stage of the disease, hence indicating the need for long term follow-up and frequent imaging.

# INTRODUCTION

Takayasu Arteritis (TA) is an immune mediated arteritis causing inflammation of the aorta and its branches[1,2]. It commonly affects women, in the second or third decade of life[3-5]. The disease is more common in Asians, with an incidence of 200-300 per million in India[6]. Aneurysmal disease in TA ranges between 30-45% and varies with geographical location, India having reports of 13.7% incidence, while 60% patients from Thailand have aortic aneurysm[7]. Descending aortic and thoracoabdominal aneurysms (TAAA) are common aortic aneurysms associated with Takayasu disease and the incidence of rupture is reported to be low[8,9].

Aneurysms are extensive, with studies showing 70% cases involving the entire descending thoracic aorta and most of the thoracoabdominal aorta[8,9]. The aneurysms are often saccular/fusi-saccular and calcified. However, there is paucity of data on the natural history of aortic aneurysms associated with TA. There are few small case series available in literature and most of these case reports describes the surgical management and outcome of these patients rather than the natural course of the disease.

Surgical intervention of these aneurysms is indicated in large, complicated, symptomatic, or rapidly expanding aneurysms. Standard technique used is prosthetic graft replacement. The procedure can be done by cross clamping alone or using partial cardiopulmonary bypass (CPB)[10]. There are many surgical challenges when dealing with TA associated aneurysms which are not seen in the degenerative aneurysms - 1) severe calcification of aorta, making it difficult to clamp and sew, 2) often multiple aneurysms at different levels are present, 3) subclavian artery is commonly occluded, which may increase the incidence of

spinal cord ischemia, 4) Viscero-renal vessels are often occluded, making the surgery more challenging, and 5) finally there is increased incidence of anastomotic pseudoaneurysm or metachronous new aneurysm at other areas, requiring long term strict follow up in these patients.

Most patients affected fall in the younger age groups with better surgical fitness and less co-morbidities. Kieffer et al reported satisfactory outcome following open repair of TAAA in 33 patients with TA between 1974-2001[10]. In their investigation on the natural history of TA, Ishikawa and Maetani et al reported an 82% survival at 15 years after the diagnosis, and 66% in patients with major complications, like aneurysm, retinopathy, hypertension[11]. Miyata et al also reported an increase in the long-term survival after surgical management in these patients[12].

The incidence of postoperative complications in these patients has reduced and outcome has improved owing to the advances in surgical techniques and perioperative management. However, most of the information on surgical repair come from case reports or small case series. A retrospective study on the outcome of patients from this single center over the past 20 years can contribute to the operative management of thoracoabdominal aortic aneurysms in patients with TA.

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# LITERATURE REVIEW

The first description of Takayasu arteritis came from the Japanese ophthalmologist, Mikito Takayasu in 1908, where he described ophthalmoscopic findings of ocular ischemia, retinal arteriovenous shunts in a "wreath-like" distribution around the optic disc, and microaneurysms of the retinal vessels in a 19years of age female[13]. Following this, Onishi also found similar findings in patients with pulseless upper extremities[14]. Whilst the cause of these findings was not defined well at that point of time, it became known as Takayasu arteritis[15,16]. Over the years, there have been multiple reports on the incidence of the disease, its various presenting features and pathology, as well as the modalities of treatment and complications associated with surgical therapy.

TA is predominantly reported in Asian countries. In a study by Yajima et al, on the comparison of TA amongst patients in Japan, Korea and India, it was found that most lesions in the Indian population were in the abdominal aorta, with hypertension as a common presenting feature[7]. This result was similar to findings in the Korean population. Japanese patients however, have lesions in the aortic arch with aortic regurgitation and congestive heart failure as the most common complications.

In the evaluation of patterns of aortic involvement with spiral CT angiography by Chung et al in 85 patients, 95% had aortic involvement with or without aortic branch involvement and 5% had only aortic branch involvement[17]. Left common carotid and left subclavian arteries were most commonly involved. Arterial involvement was contiguous in 81% patients and skipped lesions in 19%.

Eijun et al performed a study on CT evaluation of aortic aneurysm in 31 patients with TA between 1990 and 1999[18]. Seventeen aortic aneurysms were found in 14 of these patients. Patients with severe calcification of the aorta

showed significantly lower incidence of aneurysm formation. Nine of the 17 aneurysms increased in size during follow-up period. Of these nine aneurysms, three of them rapidly increased in size and ruptured during the followup period. These patients had aortic wall thickening identified on CT. The remaining six did not rupture, but showed slow increase in size. It was hence identified that aortic aneurysms with wall thickening can have fatal consequences.

TA is an inflammatory arteritis which can lead to vessel stenosis/occlusion, or aneurysmal disease. In comparison to stenotic lesions, aneurysmal disease is rare in TA. In a study by Fields et al, 17% of patients with Takayasu arteritis required surgery, the main indication being occlusive disease[19]. Operation for these selected patients was safe, with no operative mortality, myocardial infarction, major stroke, or renal failure. However, patients with active disease requiring surgical intervention were more likely to require reintervention or develop progressive symptomatic disease at another site. In spite of the disease activity at the time of surgery, long-term survival is excellent.

Aneurysmal disease in TA is rarely found. As reported by Yang et al, over a period of 20years, 39 out of 934 patients with Takayasu arteritis were diagnosed with aortic aneurysm related to vasculitis (4.2%)[20]. The female-to-male ratio was 1.79:1 and mean age of onset 31+/- 10years. Most frequent presentation was absence or asymmetry of upper or lower limb pulses. More than half had hypertension and 14 had elevated ESR. Of the 39 TA patients, 23 patients had thoracic aortic aneurysms, 12 patients had abdominal aortic aneurysm, and two patients had thoracoabdominal aortic aneurysm. In one patient, almost the whole aorta was involved, and another patient's ascending aorta and abdominal aorta were involved concurrently. Nine patients had aortic dissection. Ascending aorta, including the aortic root, was more frequently involved in the aneurysmal lesion, while aortic dissection was mostly located in the abdominal aorta. The most frequent aortic site involved in the aneurysmal lesion in TA was ascending aorta (18, 33.3%), followed by

abdominal aorta (15, 27.8%), aortic root (9, 16.7%), aortic arch (7, 13.0%), and descending thoracic aorta (5, 9.2%). Involvement of multiple sites in aortic aneurysmal formation was found in eight patients (20.5%), and multiple aortic aneurysms were found in five patients (12.8%). Stenotic and occlusive lesions were common, mostly involving renal arteries and left subclavian artery. Surgical repair of aneurysm was performed in 16 patients at the first visit and was postponed in four patients considering the active disease. Six patients underwent endovascular procedures, among whom five patients were involved with stenotic or occlusive lesions in renal arteries. A total of 24 patients were administrated prednisone, and eight of whom initiated the prednisone treatment (5–30mg) after operative repair. Immunosuppressive agents (cyclosporine, mycophenolate mofetil) were given to one patient in view of refractory disease. Anti-inflammatory medications were not given to 13 patients because of the quiescent status without any presentations of progression, while two patients refused to take corticosteroid treatment. Twenty-five patients (64.1%) were followed up with a median duration of 72 months (range, 25-110 months). Four patients underwent surgical procedures during the follow-up period, of whom one underwent repair of ruptured AAA.

In a study done by Cheng et al, out of 397 patients with TA, 66 patients were identified with aneurysms[21]. The mean age at onset was 30.4±11.5 years, with a male:female ratio of 1:2.7. Patients with aneurysm had a higher proportion of male ($p<0.01$), higher incidences of aortic regurgitation, and a lower incidence of visual disturbances as compared with patients without aneurysm. The prevalence of elevated ESR and CRP was higher in patients with than without aneurysm ($p<0.01$). Angiographic classification showed type V (30.3%) was the most frequent pattern in patients with aneurysm though Type I was dominant in patients without aneurysm. Multiple aneurysms were found in 30.3% of patients and the most common site of aneurysms was abdominal aorta (22.1%). Glucocorticoids were prescribed in 86.4% of patients with aneurysm, and surgical procedures were performed in 80.3%. Five out of

52 patients died during the median 3-year follow-up period.

Kieffer et al performed operative treatment on 33 patients with descending thoracic or thoracoabdominal aortic aneurysm in association with Takayasu disease over 27years[10]. There were 25 men and eight women with a mean age of 40.2 years (range 16-64 years). The most common presenting symptom was hypertension in 12 cases, followed by thoracic or abdominal pain in seven patients, isolated inflammatory syndrome in five, neurologic or ocular manifestations in three, rupture in three, and embolization to the lower extremity in one patient. In the remaining two cases discovery was coincidental. There were eight type I, six type II, four type III, and five type IV aneurysms according to Crawford's classification. Two patients had undergone previous repair of the thoracoabdominal aorta. Four patients required first-stage treatment of a renal artery lesion to control hypertension. Six patients had associated aneurysms of the proximal aorta, including five treated via the distal elephant trunk technique in first-stage procedures. Aneurysm repair consisted of prosthetic replacement of the thoracoabdominal aorta in 31 cases, exclusion bypass in one case, and stent graft placement in one patient. The procedure was performed with cross clamping alone in 13 cases, distal perfusion in 17 cases, and deep hypothermic circulatory arrest in three cases. Twenty patients (61%) had associated renal and/or intestinal artery lesions that were treated during the same procedure as that for the thoracoabdominal aorta in 19 patients (58%). A total of 24 procedures were performed on renal arteries (17 revascularizations, seven nephrectomies). Associated supra-aortic trunks lesions were present in 15 patients (45%) and were treated in 12 patients, including eight in first-stage procedures prior to thoracoabdominal aortic aneurysm repair. Three patients died of multiple organ failure, after reoperation in two cases and infection in one case involving prior long-term corticosteroid therapy. Three patients developed paraplegia, including one who had undergone emergency treatment following rupture. Two patients required reoperation, for hematoma in one case and bowel necrosis in one. Four patients developed respiratory complications

requiring artificial ventilation for more than 48 hours. During follow-up, two patients died from complications after repair of the proximal aorta and one patient required nephrectomy. Despite the extent of aneurysmal lesions and high frequency of association with visceral and supra-aortic vessel lesions, the outcome of surgery in patients presenting with descending thoracic or thoracoabdominal aortic aneurysm in association with Takayasu disease was satisfactory.

Between 1979 and June 1999, Ando et al studied 87 patients with dilative lesions associated with Takayasu's arteritis who underwent surgery[22]. There were seven males and 80 females. The age of these patients ranged from 15 years to 76 years (mean, 49 _+ 13 years). Preoperative steroids were administered to 40 patients who presented with inflammatory findings. Surgical intervention was performed in 43 patients with thoracic aortic aneurysm (TAA) and diffuse dilatation of the ascending aorta with aortic regurgitation (AR) in 44. Operations performed for TAA were ascending aortic grafting in 25 patients, ascending-aortic arch grafting in six, descending-abdominal aortic grafting in five, and other aortic grafting in seven. Operations performed for dilatation of the aorta with AR were aortic valve replacement (AVR) in 42 patients, valved conduit reconstruction in two patients. Five patients (5.7%) died during the hospital stay. The follow-up period in 82 patients who survived the surgery ranged from 1month to 246 months (mean, 107 _+ 73 months). There were 15 patients of late deaths, and 10 patients died due to cardiovascular problems. The total actuarial survival rate was 79.7% at six years and 74.3% at nine years. Steroid therapy before and after surgery seems to positively affect the overall prognosis of patients with Takayasu' s arteritis.

TA is a longstanding disease and the importance of its follow-up is often cited for patients who are on medical management or for patients with stenotic lesions only. Hence, even in operated patients for aneurysmal disease, long term follow-up is necessary in order to identify early features of inflammation

in postoperative sites as well as to identify development of arteritis at other vessel sites.

Miyata et al in the retrospective analysis of operated patients with Takayasu arteritis identified 22 uninfected anastomotic aneurysms 14 patients (22 of 259 anastomoses, 8.5%)[23]. The interval between the previous operation and diagnosis varied from 1.6 to 30 years. It was found that inflammation or steroid intake had little influence on formation of anastomotic aneurysm. However, anastomotic aneurysms occurred after surgery for aneurysmal lesions.

Another study was done by Miyata et al on the long-term survival of 106 patients operated for Takayasu arteritis, between 1955 and 1995[12]. There were 87 women and 19men, whose age at the time of surgery ranged from five to 69 years. A total of 155 vascular procedures were performed, with indications like renovascular hypertension, aortic coarctation, aneurysm, carotid artery occlusion and subclavian arterial occlusion. In this study, 278 anastomosis were made in the surgeries. Follow-up data was available for 73 patients over 10years, 45patients over 20years, 22 patients over 30years and three over 40years. The cumulative incidence of anastomotic aneurysm at 20years was 13.8%. There were 31 late deaths observed in 94patients, with the major cause being congestive heart failure in 14patients, followed by anastomotic aneurysm in five patients. Other causes include intracranial haemorrhage, cerebral infarction. The overall survival rate was 73.5% at 20years after surgery. The patients who were older than 35 years at the time of surgery had a 2.74fold higher risk of death than those aged 35years or younger.

As endovascular modalities of managing aortic aneurysms improve over the years, data comparing open and endovascular management of thoracoabdominal aortic aneurysms have been reported, but are limited to atherosclerotic causes. However, open repair is still preferred modality in young individuals. Cekmecelioglu et al opined that when deciding between

open and endovascular approaches, one should consider which is more suitable for each patient[24]. Older patients generally benefit from a less invasive approach. Open repair should be considered for young patients and those with heritable thoracic aortic disease. Infection and fistulae are best treated by open repair, although endovascular intervention as a lifesaving bridge to definitive repair has evolved to become a critical component of initial treatment. Newer, low-profile devices make total endovascular thoracoabdominal aortic aneurysm repair more feasible and, thus, appealing. For younger and low-risk patients, the choice between open and endovascular therapy remains controversial. Despite the advantages of a minimally invasive procedure, data suggest that endovascular aortic repair incurs a greater risk of spinal cord deficit, and the durability of endovascular aortic repair remains unclear. It is difficult to compare outcomes between endovascular and open thoracoabdominal aortic aneurysm repair, primarily because of the current investigational status of endovascular devices, the variety of approaches to endovascular repair, differing patient populations, lack of prospective randomized studies, and minimal medium- and long-term follow-up data on endovascular repair.

# MATERIALS AND METHODS

A retrospective observational study was done in patients with Takayasu arteritis operated for thoracoabdominal aortic aneurysm at our centre from January 2004 to June 2023. The perioperative and long-term outcomes were studied in these patients.

***Inclusion criteria:***

Patients with:

1) Takayasu arteritis with Thoracoabdominal aortic aneurysm who underwent open repair in the study period

***Exclusion criteria:***

Patients with:

1) Ascending aortic aneurysm
2) Purely stenotic lesions with Takayasu arteritis
3) Patients who underwent medical management or stenting only
4) Aortic aneurysms with aetiology other than Takayasu arteritis

***Study:***

The preoperative evaluation of patients included a detailed history, physical examination, blood tests, chest X-ray, electrocardiography and echocardiography. Aneurysm was diagnosed on basis of a Computed tomography (CT) angiogram and were classified according to the Crawford classification of thoracoabdominal aortic aneurysms. Takayasu arteritis was diagnosed based on presenting clinical features and raised inflammatory markers. Presence of stenotic and occlusive lesions, along with involvement of visceral branches were noted. In patients with renal dysfunction plain CT or MRI was used for diagnosis and planning.

Patients who presented in the active state of the disease with minimal symptoms and small aneurysm were conservatively managed till remission. However, patients who were symptomatic, aneurysm expansion and had features of impending rupture, were taken up for surgery even during the active phase of the disease.

All the patients were informed about the open as well as endovascular options for repair. Patients who consented for open repair and underwent the same, were included in the study. Patients were encouraged to start incentive spirometry as soon as plan for open surgery was made. The preoperative medicines for Takayasu arteritis and hypertension were continued along with addition of bronchodilators as required. The blood pressure, heart rate and inflammatory markers were monitored preoperatively.

Open surgical repair was done in all patients. The surgery was done under general anaesthesia. CSF drain was placed in patients with descending thoracic aorta aneurysm and thoracoabdominal aortic aneurysm. Incisions depended on the extent of the aneurysm. Partial cardiopulmonary bypass was used when required. Endoaneurysmorrhaphy was done in all cases with a bifurcated or tubular polyester graft. All anastomotic sites were re-enforced with a Teflon felt. Visceral branches with stenotic or occlusive lesions were also addressed. The patients were shifted to the surgical intensive care unit immediately after surgery. All patients were electively intubated overnight after surgery and extubated on postoperative day one. After weaning off ventilators and inotropic support they were shifted to the ward. The patients were encouraged to ambulate once pain free. Oral feeding was started once abdomen was soft and bowel sounds resumed.

Post-operative outcomes were reported using variables like ventilator dependence, acute kidney injury, cardiac events, sepsis and wound issues. Additional information was also recorded regarding postoperative bleeding, re-exploration and duration of total stay. Long term outcomes and need for re-intervention were also noted.

***STATISTICAL ANALYSIS***

Analysis was done in this group to explore immediate and long-term outcomes of surgical repair. The continuous normally distributed values were expressed as means and standard deviation and compared using paired or unpaired t tests as required. Categorical variables were compared with the chi-square test. Fisher's exact test was used when the sampling distribution was uneven.

The variables including age, type of aneurysm, disease activity was analyzed with respect to morbidity and long term complications. Univariate analysis was done for all the variables. Survival rates were also analyzed using Kaplan Meier survival charts

# RESULTS

## 1-BASELINE CHARACTERISTICS

A total number of 41 patients met the inclusion criteria and were included in the study. The age of the study group ranged from 19-53 years. Females comprised most patients (n=25, 60.9%), while 16 patients were males (30.1%) (Figure 1).

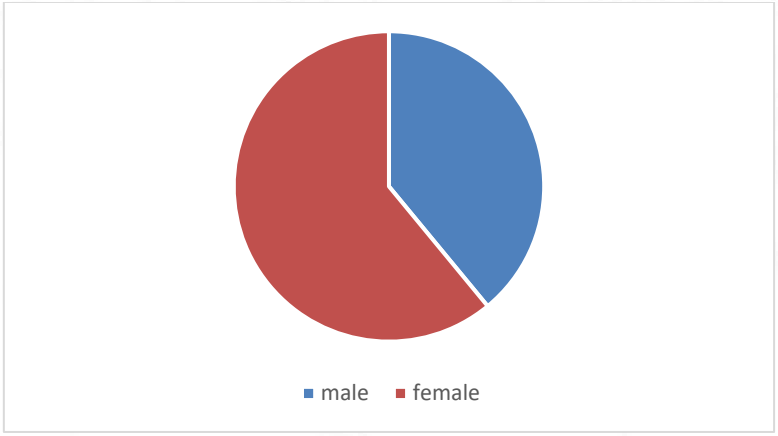


**Figure 1 – Gender wise distribution of patients**

Majority of aneurysms were Crawford type III (n=18) and type IV (n=13). Seven patients had type V aneurysm, while two patients each had type I and type II aneurysm (Figure 2). Mean diameter of aneurysm is 6.7cm, with a range of 5-14.7cm. There were 29 patients who had saccular aneurysms.

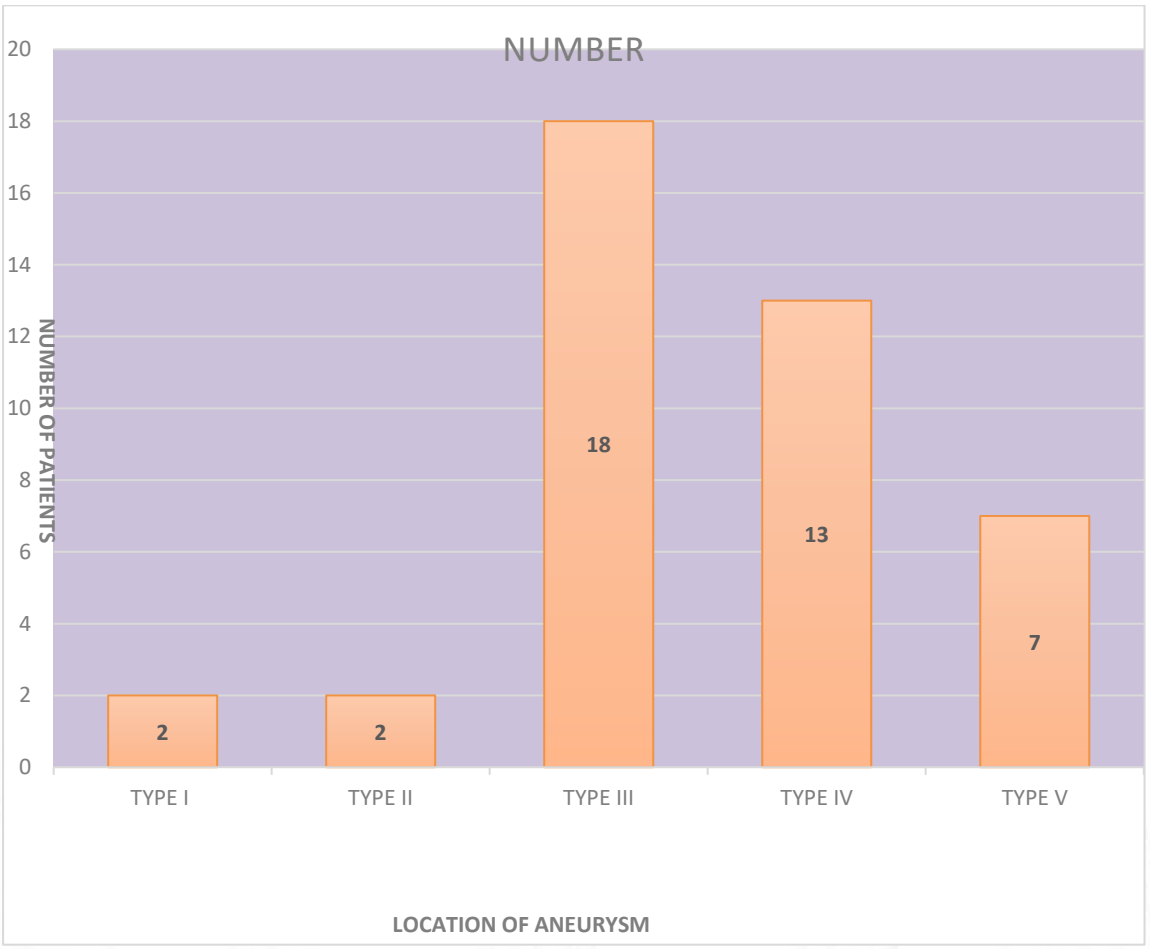


**Figure 2 –Distribution of aneurysms according to Crawford classification**

Stenotic and occlusive lesions were present in patients, and 21 of them had multiple lesions. Renal artery lesions were most common (n=21) and eight patients had associated atrophic kidney. Celiac artery disease was present in 10 patients, Superior Mesenteric Artery (SMA) in 15, common iliac artery in three patients. Subclavian artery disease was present in 20 patients and five had common carotid artery disease (Table 1). Aortic dissection was present in three patients.

| BRANCH VESSEL INVOLVED | PERCENTAGE |
|---|---|
| Subclavian Artery | 20(48.7%) |
| Common Carotid Artery | 5(12.1%) |
| Celiac Axis | 10(24.3%) |
| Superior Mesenteric Artery | 15(36.5%) |
| Renal Artery | 21(51.2%) |
| Common Iliac Artery | 3(7.3%) |

**Table 1 – Stenotic lesions in branch arteries**

Takayasu arteritis disease activity, as measured by raised inflammatory markers, was present in 30 patients in the preoperative period. All patients were operated electively, except for one patient who had rupture and cardiac arrest at the time of presentation to the hospital.

Hypertension was present in 20 patients, of whom three patients had undergone renal artery angioplasty and three had underwent nephrectomy in the past. Six patients also had a history of spontaneous abortions. Patients also had associated cardiac co-morbidities on preoperative evaluation – six had aortic regurgitation (AR), four had mitral regurgitation (MR), three had regional wall motion abnormality (RWMA), one patient had left main coronary artery (LMCA) aneurysm and one had sinus of Valsalva aneurysm, while one

patient had undergone aortic valve replacement five years before surgery. The mean albumin was 4.09 gram/litre, mean serum creatinine was 1.37milligram/decilitre

| BASELINE FEATURES | NUMBER (PERCENTAGE) |
|---|---|
| Hypertension | 20 (48.7%) |
| Nephrectomy | 3 (7.3%) |
| Renal artery angioplasty | 3 (7.3%) |
| Spontaneous abortion | 6 (14.6%) |
| Optic atrophy | 2 (4.8%) |
| Right brachial embolectomy | 1 (2.4%) |
| Left subclavian/celiac/left common iliac artery stenting | 1 (2.4%) |
| Transient ischemic attack | 1 (2.4%) |
| Posterior circulation stroke | 1 (2.4%) |
| Left carotid-subclavian bypass | 1 (2.4%) |
| Right common carotid artery aneurysm repair | 1 (2.4%) |
| Tuberculosis | 3 (7.3%) |
| Aortic regurgitation | 6 (14.6%) |
| Mitral regurgitation | 4 (9.7%) |

| | |
|---|---|
| Regional wall motion abnormality | 3 (7.3%) |
| Sinus of Valsalva aneurysm | 1 (2.4%) |
| LMCA aneurysm | 1 (2.4%) |
| Post aortic valve replacement | 1 (2.4%) |

**Table 2 – Baseline characteristics**

## 2-SURGICAL PROCEDURE

The surgical approach was planned according to the type of aneurysm and its extent. Types I, II, III and V were approached using thoraco-phreno-laparotomy. Partial cardiopulmonary bypass (CPB) by femoral artery-femoral vein cannulation and spinal drain were used for patients with type I, II and III aneurysms. For the type IV aneurysms, retroperitoneal abdominal exposure was done for eight patients and midline transperitoneal approach for the remaining aneurysms, however, CPB and spinal drain was not used for these patients (Image 1).

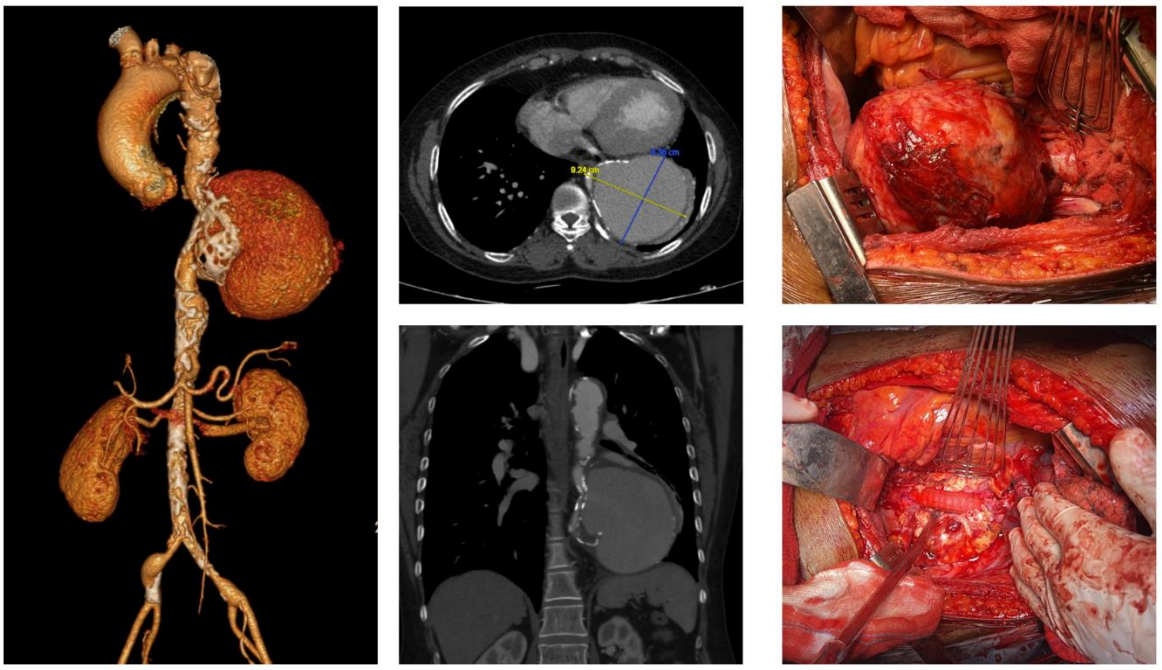

**Image 1: Saccular aneurysm in descending thoracic aorta with extensive aortic calcification. Patient underwent repair using partial cardiopulmonary bypass.**

Renal arteries and visceral artery branches were also addressed in patients with stenotic/occlusive lesions. Separate bypass to visceral branches was done in eight patients, of whom five had multiple bypasses and three patients only had renal bypass. Twelve patients underwent reimplantation of branches, out of which nine had multiple vessel reimplantation. (Image 2)

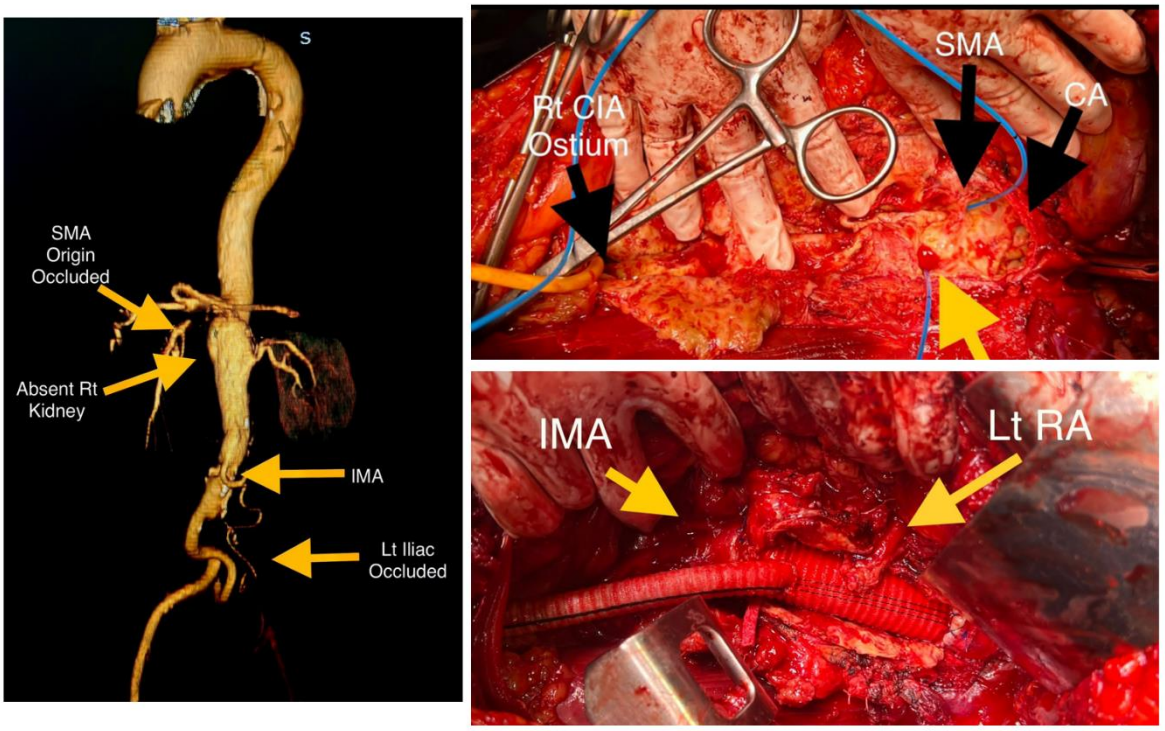


**Image 2: Type IV TAAA with absent right kidney, occluded SMA origin and left iliac artery. Patient underwent repair of aneurysm by including the celiac, SMA and right renal in proximal anastomosis, with left renal artery re-implantation and bypass to left common iliac artery. (SMA – Superior Mesenteric Artery, TAAA – Thoracoabdominal aortic aneurysm)**

There were four patients who underwent staged repair of the aneurysm. The staged repair included visceral debranching in the first day, followed by repair of the aneurysm in the next day. This technique allowed the patient to be adequately resuscitated and warmed overnight after visceral debranching, while also reducing the amount of heparin and time on CPB. (Image 3)

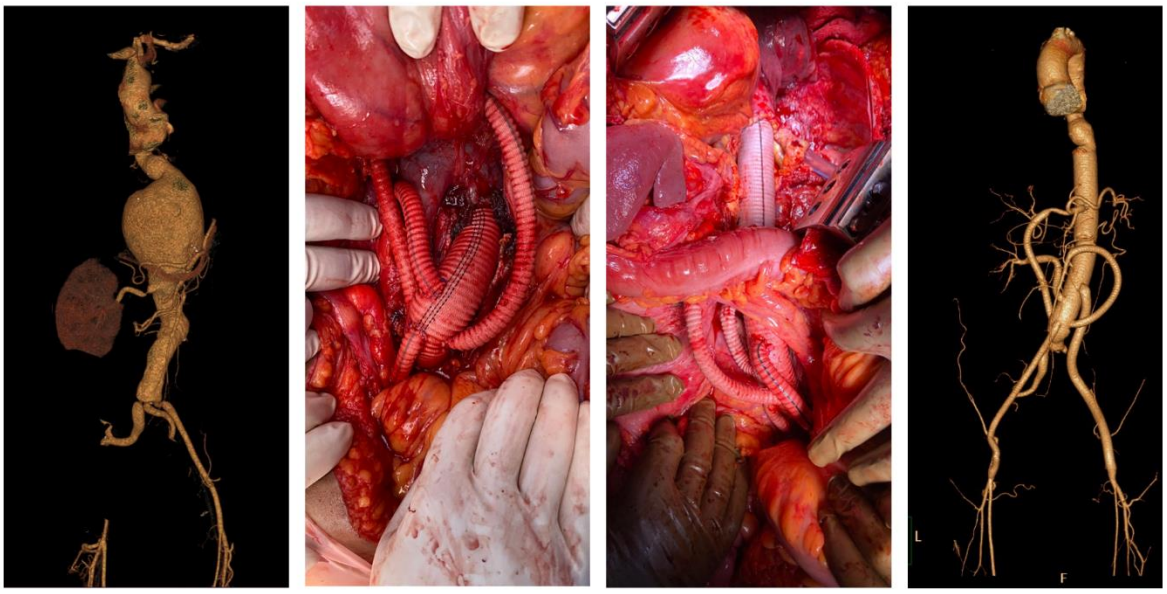

**Image 3: Type III TAAA aneurysm, post left nephrectomy, with right renal artery and left common iliac artery stenosis, right common iliac artery occlusion, underwent staged repair. (TAAA – Thoracoabdominal aortic aneurysm)**

## 3-IMMEDIATE POSTOPERATIVE OUTCOME

All patients were shifted and monitored in the ICU after the surgery. They were electively intubated for one day postoperatively and extubated on postoperative day 1. There were five patients who required prolonged intubation of more than one day and four patients who were re-intubated.

Three patients had bleeding in the postoperative period which required re-exploration – of these, two of them developed DIC.

Ten patients had acute kidney injury in the form of raised creatinine levels, and of these, two patients required hemodialysis. The remaining patients

maintained good urine output. Hence, they were managed conservatively by maintaining good hydration and monitoring of central venous pressure.

Three patients developed neurological complications – one had paraplegia, one developed mono-paresis and one had cerebellar infarct. The patient with paraplegia developed sepsis and died. The patient who developed mono-paresis with power of 0/5 in the immediate postoperative period, was managed conservatively with physiotherapy, and power improved to 4/5 at the time of discharge. One patient developed cerebellar infarct detected on postoperative imaging and was managed conservatively.

There were six patients who suffered acute respiratory distress syndrome. Three patients developed wound complications in the form of wound infection and wound gaping. All patients were managed conservatively with routine dressings, culture-based antibiotics and one patient required secondary suturing.

All patients were kept for intensive monitoring in the ICU for at least three days. Duration of ICU stay ranged from 1-20days, with a mean of 4.1days. There were five patients who required prolonged ICU stay. Duration of hospital stay in the postoperative period ranges from 1-60days. Mean duration of hospital stay in the postoperative period was 12.7 days.

| MORBIDITY | NUMBER OF CASES |
|---|---|
| Acute kidney injury<br><br>Hemodialysis | 10 (24.4%)<br><br>2 (4.8%) |
| Bleeding | 3 (7.3%) |
| ARDS | 6 (14.6%) |
| Spinal cord dysfunction | 2 (4.8%) |
| Wound infection | 3 (7.3%) |

**Table 3 – Causes of morbidity in immediate postoperative period**

There were four patients (9.7%) who expired in the early postoperative period. One patient had preoperative rupture and cardiac arrest. She was revived, resuscitated, and taken up for surgery, but she developed disseminated intravascular coagulation (DIC) in the postoperative period. Another patient also developed DIC following surgery and was taken up for re-exploration. He expired on postoperative day two. One patient developed paraplegia with sepsis, acute kidney injury and expired on postoperative day 17. One patient developed SMA embolism and right lower limb ischemia. She was taken for re-exploration, bowel resection and embolectomy, but expired due to ischemia-reperfusion injury. Of the patients who expired in the immediate postoperative period, two patients were of type III aneurysm and one each of type I and type II aneurysm.

The presence of disease activity in the preoperative period was evaluated and analysed with morbidity and mortality. On comparison of data variables, it was found that the p-value for morbidity was 0.75 and immediate mortality was 0.27, which was statistically insignificant. However, all the patients who expired in the immediate postoperative period had raised inflammatory markers prior to surgery.

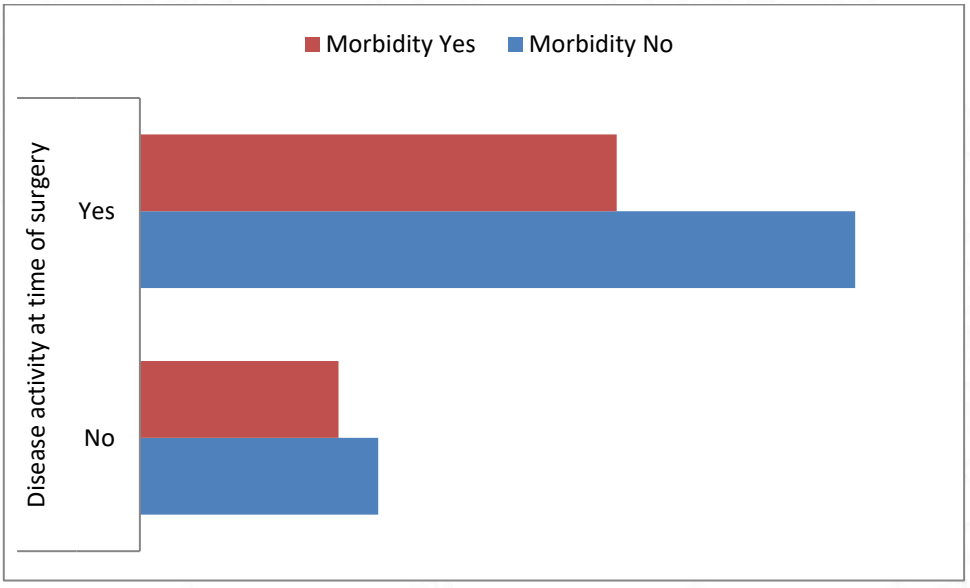


**Figure 3 - Relation between morbidity and disease activity at the time of surgery**

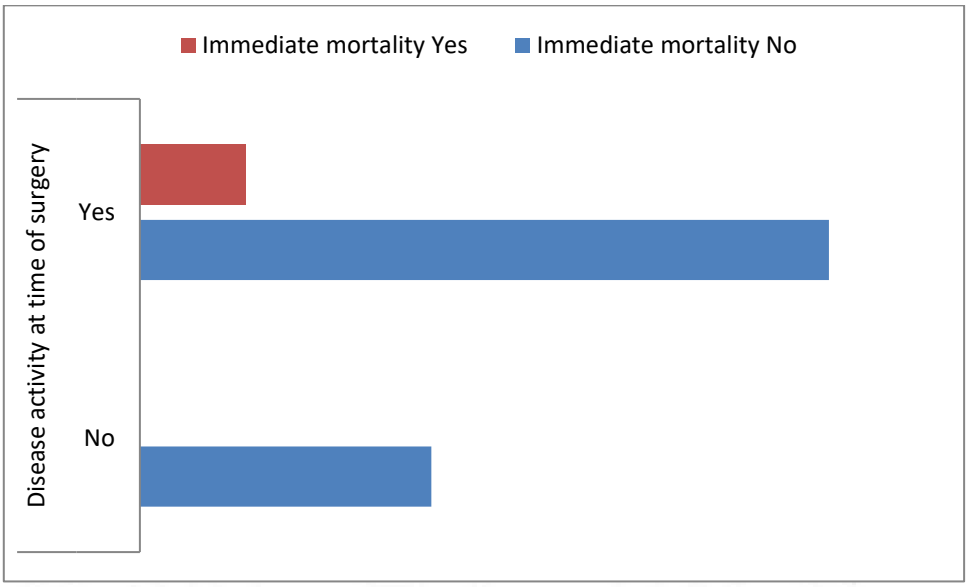


**Figure 4 - Relation between immediate mortality and disease activity at the time of surgery**

## 4-LONG TERM OUTCOMES

Of the 37patients who were discharged, patients have been on follow-up for six months to 19years, with a mean follow up of 41.02±43.91 months and median follow up of 24months.

Over the period of follow-up, four patients expired. One patient developed necrotising pancreatitis and expired at 6months. One patient developed graft infection at 17 months, while one patient developed anastomotic pseudoaneurysm after three years which ruptured. One patient died of renal failure three years after surgery. Analysis with the presence of disease activity in the preoperative period in patients with late mortality showed a p value of 0.27, and was statistically insignificant.

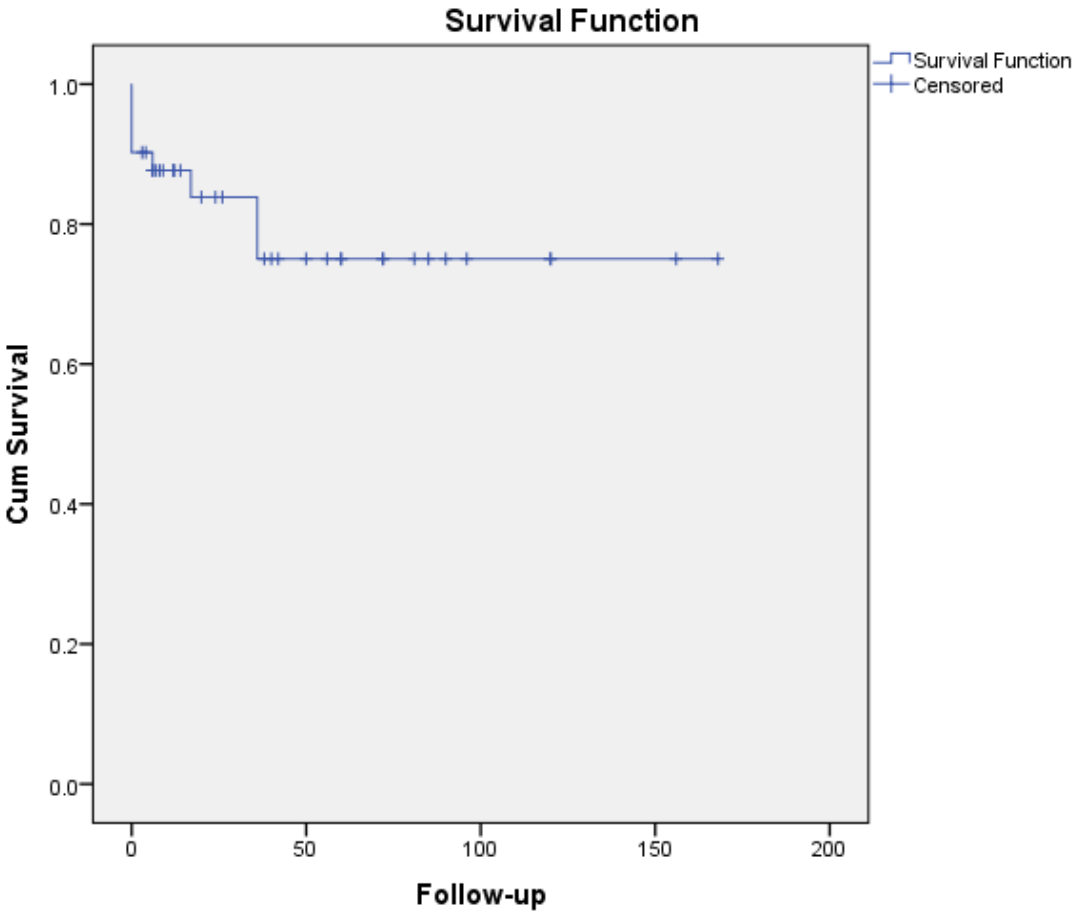


**Figure 5 - Kaplan Meier curve on these patients indicate a low event rate and a good survival rate**

According to the Kaplan Meier survival curve, the mean survival period ranges from 130.026 ± 12.020 months. The 5year survival rate is 84.4%. The curve also indicates a low event rate and good survival, after the immediate postoperative period.

There were patients who developed arteritis related complications and morbidity on follow-up. Four patients developed anastomotic pseudoaneurysm, of whom one patient underwent TEVAR and three underwent open repair (Image 4). Four patients had renal artery stenosis and two underwent renal

artery angioplasty. One patient developed renal artery aneurysm and one had celiac artery stenosis, who were managed conservatively. Two patients developed carotid ectasia and two patients had optic atrophy. These long-term complications were more common in patients with type III aneurysm.

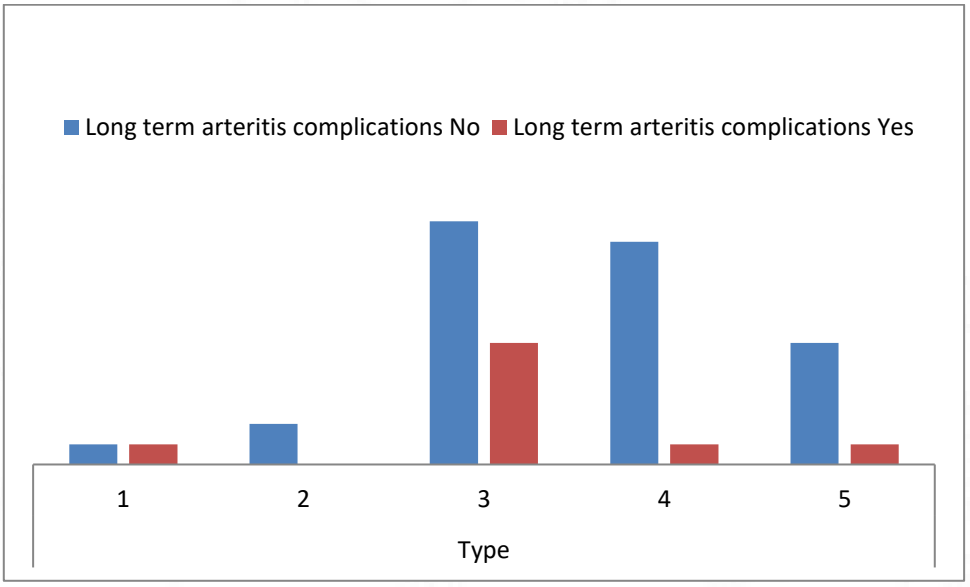


**Figure 6 – Distribution of arteritis related complications among different types of thoracoabdominal aortic aneurysm**


**Image 4: Post TAAA aneurysm repair with anastomotic pseudoaneurysm 6years postoperatively, underwent thoracic endovascular repair (TEVAR)**

On comparing the disease activity at the time of surgery with the long-term arteritis related complications that require intervention, the p-value was 0.59 and hence statistically not significant.

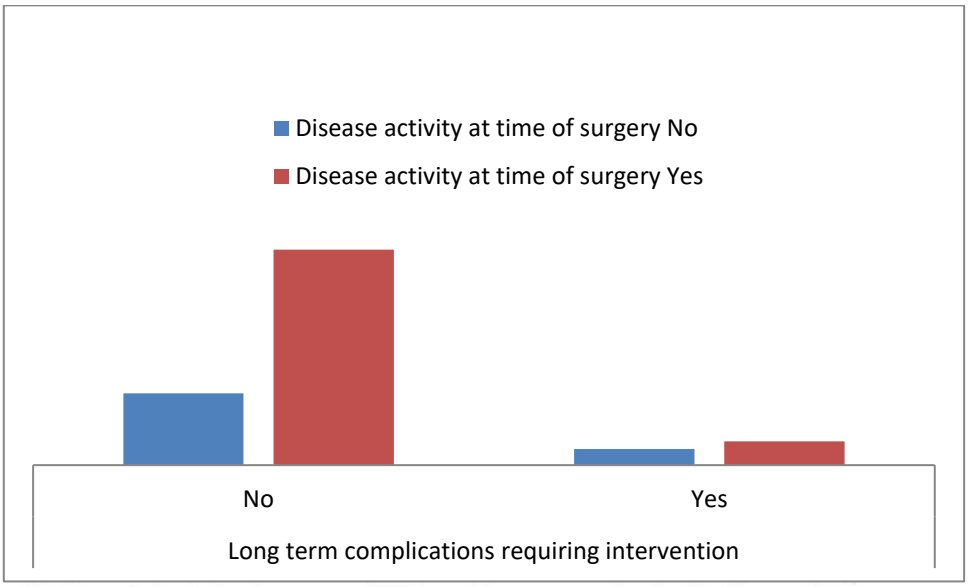


**Figure 7 – Long term complications requiring intervention in patients who had disease activity at the time of surgery**

# DISCUSSION

Takayasu arteritis is a chronic inflammatory arteritis of aorta and its branches[1,2]. It commonly presents as stenotic or occlusive lesions, while aortic aneurysms are rare with incidence ranging from 10-30%[7-9]. The main concerns with the disease are the extensive involvement of blood vessels, especially branch vessel occlusion, and vessel wall calcification. The progressive nature of the disease also necessitates the need of regular follow-up.

As aneurysms in TA is rare, literature reports are limited to small case series and retrospective analysis. We attempted to analyze the outcome of operative repair in TA patients with TAAA in the immediate and long-term period, spanning over 20years. We also highlight the need and importance of follow-up in TA patients owing to the disease activity.

Our study on TAAA in TA patients showed predominant female cohort in their second decade of life, which has been reported in other case series[3-5]. In our study, the most common type of thoracoabdominal aortic aneurysm is type III. However, in the study by Kieffer et al, type I TAAA was most common with an incidence of 24%[10].

No major comorbidities were present in much of our study population, except for hypertension which was seen in 48% of patients. More than half of TA patients with aneurysms in a study done by Yang et al had hypertension[20]. This underscores the importance of open surgical repair as the best modality of managing these patients, because they are young and surgically fit.

Involvement of the ascending aorta has been reported in upto 30-50% of patients[25]. Although we did not include these patients in our study, cardiac involvement was reported in some patients in the form of aortic and mitral valve regurgitation, and one patient was post aortic valve

replacement.

Prosthetic replacement of aneurysm repair was performed for all patients, along with addressing of visceral branches. Visceral branches revascularization has also been reported, most commonly performed for the renal artery. One of the concerns in our patients was addressing the stenotic and occlusive lesions in the visceral branches. Especially difficult is the need to address right renal artery origin stenosis when the patient is in the right semi-lateral/lateral decubitus position for performing the aortic replacement.

Four of our patients underwent staged repair, wherein the patients underwent surgery in two stages. In the first stage of surgery, visceral debranching was done and in the second stage, the main aneurysm was tackled. This staged repair was done for patients who required bypass to multiple visceral branches – renal arteries, superior mesenteric and celiac arteries. By performing the procedure in stages, it allowed resuscitation overnight and reduced the total heparin requirement by reducing the amount of CPB duration.

Morbidity in immediate postoperative period included bleeding, acute kidney injury, respiratory complications, wound complications, with the most tragic being paraplegia. Studies have shown reports of 9% paraplegia and 12% respiratory related complications[10]. Our study showed 4.8% patients had spinal cord dysfunction, of whom only one patient had paraplegia. ARDS was present in 14.6% of patients, with four patients requiring re-intubation. Despite the morbidities, patients maintain good outcomes and this can be attributed to their age as well as general fitness and lack of co-morbidities.

Early mortality has been reported in the range of 5-10% of patients and late mortality in the range of 6-17%[10,22]. Our study has shown an early mortality rate of 9.7% and late mortality rate of 9.7%. Ando et al reported a

9year survival rate of 74%, while Miyata et al reported a 20year survival of 73% for 45 patients[12,22,23]. Our study gives a 5year survival rate of 84.4%. A longer study period is required for reporting longer survival rates in our patient cohort, but patients have a good survival rate and long-term outcomes of surgery.

The importance of long-term follow-up is more pronounced in patients who undergo operative repairs of aneurysms. Anastomotic pseudoaneurysms can develop at any time following surgery, with a reported incidence of upto 12-20%, even at 15 years postoperative period[23]. Our study showed an incidence of 10%, detected at 6-7years postoperative period.

Disease activity and steroid use prior to surgery is a topic of controversy, but studies have shown favorable outcome when disease is quiescent[19]. Our study has shown that 30 patients had raised inflammatory markers at the time of surgery. Ando et al reported that 45% of patients had raised inflammatory markers in preoperative evaluation and steroids were started accordingly[22]. Steroid therapy has been shown to have a positive impact on the overall prognosis[19,22]. In our study, even though the immediate post operative mortality was more in the patients with active disease, it was not statistically significant. Additionally, comparison of the immediate post op morbidity and long-term outcomes of surgical repair with disease activity at the time of surgery was not statistically significant. It is possible that the disease activity may not have been adequately indicated by raised inflammatory markers. Similar to our result, a study done by Fields et al on performing surgeries in patients with occlusive disease have shown that patients with active disease had a good term survival, but required more reintervention[19].

The study has some limitations. Firstly, it is a retrospective study with small study cohort. Secondly, postoperative intake of anti-inflammatory

medications and its correlation with arteritis related issues is not studied due to lacking data. We recommend a closer observation on the impact of anti-inflammatory medications on the late complications of TAAA repair in TA.

# CONCLUSION

Patients with Takayasu arteritis associated thoracoabdominal aortic aneurysms are young individuals, displaying relatively prolonged survival rates. The complexity of the aneurysms demands meticulous surgical planning. However, surgical repair can lead to favorable and satisfying outcomes, with notable low morbidity and mortality rates. Our study revealed that the presence of disease activity at the time of surgery does not necessarily correlate with poor postoperative outcomes. The tendency of Takayasu arteritis to progress at any stage of its course, highlights the importance of diligent, lifelong vigilance. Consequently, a robust regimen of long-term follow-up and frequent imaging is essential to detect and manage potential disease advancement promptly.

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# ANNEXURES

Format for CV of the Investigators

| | | |
|---|---|---|
| SUN | NEELAMJINGBHA | |
| Last Name | First Name | Middle Name |
| Date of Birth (dd/mm/yy) 21/04/1992 | | Sex FEMALE |
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| PDCC Vascular surgery | 2020 | SCTIMST, India |
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| Details of professional registration : (MCI/State Registration/Bar Council/DCI/etc including Registration Number and Year of Registration): TCMC - 74214 | | |
| Current and previous positions (most recent position first) | | |
| Month and Year | Title | Institution/Company, Country |
| | | |
| | | |
| Brief summary of relevant research experience: | | |
| Current project/s at hand: | | |
| Signature: | | Date: 09/03/2022<br>Place: Thiruvananthapuram |

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Format for CV of the Investigators

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| PITCHAI | SHIVANESAN | |
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| MCh Vascular surgery | 2016 | SCTIMST, India |
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| MBBS | 2009 | PSGIMSR Coimbatore, India |

Details of professional registration : (MCI/State Registration/Bar Council/DCI/etc including Registration Number and Year of Registration): TCMC – 64489, Year 2017

Current and previous positions (most recent position first)

| Month and Year | Title | Institution/Company, Country |
|---|---|---|
| 2022 onwards | Associate professor | SCTIMST, India |
| 2018 - 2022 | Assistant professor | SCTIMST, India |
| 2017-2018 | Adhoc Assistant professor | SCTIMST, India |

Brief summary of relevant research experience:

Current project/s at hand:

| | |
|---|---|
| Signature: | Date: 16/11/2022<br>Place: Thiruvananthapuram |

Format for CV of the Investigators

| | | |
|---|---|---|
| PILLAI | VIVEK | P |
| Last Name | First Name | Middle Name |
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| MCh CVTS | 2007 | SCTIMST, India |
| MS General surgery | 2004 | MCH Thiruvananthapuram, India |
| MBBS | 1998 | MCH Thiruvananthapuram, India |
| Details of professional registration : (MCI/State Registration/Bar Council/DCI/etc including Registration Number and Year of Registration): TCMC - 28070 | | |
| Current and previous positions (most recent position first) | | |
| Month and Year | Title | Institution/Company, Country |
| 2020 onwards | Professor | Department of CVTS, SCTIMST, India |
| 2015-2020 | Additional professor | Department of CVTS, SCTIMST, India |
| 2012-2015 | Associate professor | Department of CVTS, SCTIMST, India |
| 2009-2012 | Assistant professor | Department of CVTS, SCTIMST, India |

Brief summary of relevant research experience:

Adult Cardiac Surgery - Coronary Artery Surgery and MICS

Current project/s at hand:

1. Co-investigator for 'SIRS' Trial - International Trial, McMaster University,Canada
2. Co-investigator for 'Mitochondrial Metabolism and Function in Type 2 Diabetes Heart'-along with Dept.of Biochemistry
3. Participation in the animal trials for LVAD and Bovine Pericardium - with BMT, Poojapura
4. Intra operative flow dynamics of TTK-Chitra valve - with Dept.of Anaesthesia

Signature:

Date: 16/11/2021
Place: Thiruvananthapuram

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# Institutional Ethics Committee

**(IEC Regn No. ECR/189/Inst/KL/2013/RR-21)**

14.09.2022

SCT/IEC/1878/MAY/2022

**Dr. Neelamjingbha Sun**
Senior Resident
Department of CVTS
SCTIMST, Thiruvananthapuram

*Dear Dr. Neelamjingbha Sun,*

*The Institutional Ethics Committee* held on 13th May, 2022, reviewed and discussed your application to conduct the study titled "**OUTCOME OF OPEN REPAIR OF THORACOABDOMINAL AORTIC ANEURYSM IN TAKAYASU ARTERITIS: A RETROSPECTIVE ANALYSIS"** (IEC/1878).

**The following members of the Ethics Sub-committee were present at the meeting held on 13th May, 2022.**

| SL. No. | Member Name | Highest Degree | Gender | Scientific /Non Scientific | Affiliation with Institution(s) |
|---|---|---|---|---|---|
| 1. | Dr. Pradeep S | MBBS, MD | Male | Basic Medical Scientist | No |
| 2. | Smt. Sathi Nair | MA (English Literature) | Female | Lay Person | No |
| 3. | Dr. Christina George | MD Psychiatry | Female | Clinician | No |
| 4. | Dr. P. Manickam | BSMS, MSc (Epid)., PhD | Male | Health Science Expert/ Social Scientist | No |
| 5. | Adv. Priya Kaimal | LLM, MBL | Female | Legal Expert | No |
| 6. | Dr. Manikandan.S | MBBS,MD,PDCC | Male | Clinician | Yes |
| 7. | Dr. Srinivas G | PhD | Male | Basic Medical Scientist (Member Secretary) | Yes |

**The following documents were reviewed:**

Original submission

1. Checklist Form
2. Covering letter addressed to the Chairman, IEC, SCTIMST dated 05.01.2022
3. Research Proposal
4. Proforma
5. IEC Application Form
6. CV of PI and Co –PIs
7. Declaration form
8. SRC Recommendation

Revised submission

1. Checklist Form
2. Covering letter addressed to the Chairman, IEC, SCTIMST dated 12.09.2022
3. Research Proposal
4. Proforma
5. IEC Application Form
6. CV of PI and Co–PIs
7. Declaration form

**IEC Decision**

The IEC approved the conduct of the study in the present form.

***Remarks:***

The Institutional Ethics Committee expects to be informed about the progress of the study, any SAE occurring in the course of the study, any changes in the protocol and patient information/informed consent and asks to be provided a copy of the final report.

There was no member of the study team who participated in voting / decision making process. The ethics committee is organized and operated according to the requirements of Good Clinical Practice and the requirements of the Indian Council of Medical Research (ICMR).

Sincerely,

**Dr. G. Srinivas**
Member Secretary, IEC

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE (IEC)
SCTIMST, THIRUVANANTHAPURAM

INSTITUTIONAL ETHICS COMMITTEE (IEC) SCTIMST THIRUVANANTHAPURAM

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## Document Information

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## Sources included in the report

## Entire Document

INTRODUCTION

Takayasu disease is an immune mediated arteritis causing inflammation of the aorta and its branches. It commonly affects women, in the second or third decade of life. The disease is more common in Asians, with an incidence of 200-300 per million in India. Aneurysmal disease in Takayasu arteritis ranges between 30-45% and varies with geographical location, India having reports of 13.7% incidence, while 60% patients from Thailand have aortic aneurysm. Descending aortic and thoracoabdominal aneurysms are common aortic aneurysms associated with Takayasu disease, although the incidence of rupture is low.

Aneurysms are extensive, with studies showing 70% cases involving the entire descending thoracic aorta and most of the thoracoabdominal aorta. The aneurysms are commonly fusiform and calcified. However, there is paucity of data on the natural history of thoracoabdominal aneurysms associated with Takayasu. There are few small case series and mostly case reports on the surgical management and outcome of these patients.

Surgical intervention of these aneurysms is indicated in large, complicated, symptomatic or rapidly expanding aneurysms. Standard technique used is prosthetic graft replacement. The procedure can be done by cross clamping alone or using partial cardiopulmonary bypass. A notable aspect of surgical repair in Takayasu disease is the need for separate reimplantation of visceral arteries, intercostals, lumbar arteries and the need for spinal protection.

Most patients affected fall in the younger age groups with better surgical fitness and less co-morbidities. Kieffer et al reported satisfactory outcome following open repair of thoracoabdominal aneurysm in 33 patients with Takayasu disease between 1974-2001. In their investigation on the natural history of Takayasu arteritis, Ishikawa and Maetani et al reported a 43% survival at 15 years in patients with major complications, like aneurysm, retinopathy, hypertension. Miyata et al also reported an increase in the long term survival after surgical management in these patients.

The incidence of postoperative complications in these patients has reduced and outcome has improved owing to the advances in surgical techniques and perioperative management. However, most of the information on surgical repair come from case reports or small case series. A retrospective study on the outcome of patients from this single centre over the past 19 years can contribute to the operative management of thoracoabdominal aneurysms in patients with Takayasu disease.

MATERIALS AND METHODS

A retrospective observational study was done in patients with Takayasu arteritis operated for thoracoabdominal aortic aneurysm at our centre from January 2004 to June 2023. The perioperative and long-term outcomes were studied in these patients.

Inclusion criteria:

Patients with:

1) Takayasu arteritis with Thoracoabdominal aortic aneurysm who underwent open repair in the study period

| Patient nu | Age | Gender | Type | Max diame | Multiple st | Comorbidities |
|---|---|---|---|---|---|---|
| 1 | 26 | F | 4 | 6 | Yes | HTN, abortion, post right renal angioplas |
| 2 | 35 | F | 3 | 7.2 | No | Right brachial embolectomy |
| 3 | 35 | M | 4 | 14.7 | No | |
| 4 | 39 | M | 5 | 6.3 | No | HTN, abandoned left nephrectomy |
| 5 | 29 | F | 4 | 5.7 | Yes | HTN, abortion |
| 6 | 32 | F | 5 | 6.5 | Yes | |
| 7 | 21 | F | 4 | 5.2 | Yes | |
| 8 | 25 | F | 3 | 3.35 | Yes | HTN, TB, appendectomy |
| 9 | 39 | F | 5 | 7.5 | No | TB, asthma |
| 10 | 49 | M | 4 | 5.9 | No | |
| 11 | 32 | F | 5 | 8 | No | HTN, abortion |
| 12 | 26 | F | 3 | 5 | No | HTN |
| 13 | 31 | F | 3 | 5.5 | Yes | Incidentally detected during pregnancyw |
| 14 | 33 | M | 3 | 10.6 | Yes | TIA, HTN |
| 15 | 25 | F | 3 | 6 | Yes | Abortion, htn |
| 16 | 19 | F | 3 | 6 | Yes | Balloon angioplasty of bilateral renal art |
| 17 | 32 | M | 1 | 5.3 | No | Right cca aneurysm excision and graft (1 |
| 18 | 33 | F | 3 | 6.1 | No | AR, MR, HTN, abortion |
| 19 | 30 | M | 5 | 7 | No | |
| 20 | 46 | M | 3 | 20 | Yes | HTN, diagnosed with taaa 3years prior to |
| 21 | 42 | F | 3 | 6.8 | Yes | HTN |
| 22 | 46 | M | 4 | 6.4 | No | |
| 23 | 29 | M | 5 | 6.1 | Yes | Inguinal hernia |
| 24 | 50 | F | 4 | 6.5 | No | HTN |
| 25 | 44 | F | 3 | 6.8 | Yes | HTN |
| 26 | 27 | M | 3 | 6.5 | No | HTN |
| 27 | 43 | M | 4 | 7 | No | HTN, incisional hernia repsir post 2lscs |
| 28 | 53 | M | 3 | 7.8 | No | |
| 29 | 19 | F | 3 | 5.8 | Yes | HTN, optic atrophy |
| 30 | 33 | M | 1 | 6.1 | No | s/p AVR (2015) |
| 31 | 38 | F | 3 | 6.2 | No | s/p Left nephrectomy for atrophic nfk wi |
| 32 | 33 | F | 2 | 6 | No | |
| 33 | 32 | F | 2 | 5.5 | Yes | HTN, Type B dissection |
| 34 | 23 | F | 3 | 6.1 | Yes | |
| 35 | 47 | F | 3 | 5.5 | Yes | |
| 36 | 34 | M | 4 | 7.7 | Yes | Right nephrectomy for NFK, stenting of l |
| 37 | 47 | F | 3 | 9 | Yes | Type B dissection, HTN, Pulmonary TB, C |
| 38 | 45 | F | 4 | 8.6 | Yes | Bilateral renal artery angioplasty for Ren |
| 39 | 51 | M | 4 | 9.4 | Yes | Posterior circulation stroke |
| 40 | 23 | F | 4 | 6.2 | No | Abortion |
| 41 | 25 | M | 5 | 6.5 | No | HTN |

| Albumin | Creat | Disease ac | Immediate | Morbidity | Acute kidn | Wound inf | ARDS | Bleeding | Spinal cord |
|---|---|---|---|---|---|---|---|---|---|
| 3.8 | 1.6 | Yes | No | No | No | No | No | No | No |
| 3.2 | 1.1 | Yes | Yes | Yes | Yes | No | Yes | No | Yes |
| 3.8 | 0.7 | Yes | No | No | No | No | No | No | No |
| 3 | 1.4 | No | No | Yes | Yes | No | Yes | No | No |
| 3.2 | 1.6 | Yes | No | No | No | No | No | No | No |
| 3 | 0.8 | Yes | No | No | No | No | No | No | No |
| 3.5 | 0.9 | Yes | No | No | No | No | No | No | No |
| 4.3 | 0.8 | No | No | Yes | No | No | No | No | Yes |
| 4.3 | 0.5 | Yes | No | No | No | No | No | No | No |
| 4.8 | 0.9 | No | No | No | No | No | No | No | No |
| 3.1 | 1.3 | Yes | No | Yes | Yes | No | No | No | No |
| 3.2 | 1.8 | Yes | No | Yes | No | No | No | Yes | No |
| 3.6 | 0.6 | Yes | No | Yes | Yes | No | No | No | No |
| 3.8 | 1.6 | Yes | No | Yes | Yes | Yes | No | No | No |
| 3.5 | 0.9 | Yes | No | Yes | No | No | No | No | Yes ( cereb |
| 4 | 1 | Yes | No | No | No | No | No | No | No |
| 3.6 | 1 | No | No | No | No | No | No | No | No |
| 4 | 1 | No | No | No | No | No | No | No | No |
| 3.1 | 0.9 | No | No | Yes | Yes | No | No | No | No |
| 3.9 | 1.2 | No | No | No | No | No | No | No | No |
| 4.2 | 0.9 | No | No | No | No | No | No | No | No |
| 2.9 | 1.1 | Yes | No | No | No | No | No | No | No |
| 4.7 | 1.1 | Yes | No | No | No | No | No | No | No |
| 3.6 | 0.9 | Yes | No | No | No | No | No | No | No |
| 4.2 | 0.8 | No | No | Yes | No | Yes | Yes | No | No |
| 4.7 | 1.19 | Yes | No | Yes | No | No | Yes | No | No |
| 3.6 | 0.5 | Yes | No | No | No | No | No | No | No |
| 2.1 | 0.82 | No | No | Yes | No | Yes | Yes | No | No |
| 2.9 | 2.1 | Yes | No | No | No | No | No | No | No |
| 4.2 | 0.89 | Yes | Yes | Yes | Yes | No | No | Yes | No |
| 3 | 0.79 | Yes | No | Yes | No | No | Yes | No | No |
| 3.2 | 1.4 | Yes | Yes | Yes | Yes | No | No | Yes | No |
| 3.5 | 0.73 | Yes | No | No | No | No | No | No | No |
| 2.4 | 1.34 | Yes | Yes | Yes | Yes | No | No | No | No |
| 3.3 | 0.74 | Yes | No | No | No | No | No | No | No |
| 4 | 0.96 | Yes | No | Yes | Yes | No | No | No | No |
| 3 | 1.4 | Yes | No | No | No | No | No | No | No |
| 3.4 | 1.2 | Yes | No | No | No | No | No | No | No |
| 3.1 | 1.2 | Yes | No | No | No | No | No | No | No |
| 3 | 0.7 | No | No | No | No | No | No | No | No |
| 3.8 | 0.77 | Yes | No | No | No | No | No | No | No |

| Sepsis | Long term | ICU stay | Total hospi | Long term | Long term | Follow-up | Long term followup death |
|---|---|---|---|---|---|---|---|
| No | No | 3 | 11 | No | No | 72months | No |
| Yes | Yes | 17 | 17 | No | No | Died immediate postop | |
| No | No | 1 | 5 | Yes | Yes | 36months | died 36mths pseudoan rupture |
| Yes | Yes | 15 | 35 | No | No | 26months | |
| No | No | 2 | 8 | No | No | 60months | |
| No | No | 2 | 8 | Yes | No | 90months | |
| No | No | 2 | 15 | No | No | 81months | |
| No | Yes | 7 | 15 | No | No | 85months | |
| No | No | 2 | 7 | No | No | 38months | |
| No | No | 1 | 7 | No | No | 96months | |
| No | No | 3 | 14 | No | No | 12months | |
| No | No | 4 | 10 | Yes | No | 12months | |
| No | Yes | 20 | 60 | No | No | 3months | |
| No | No | 3 | 12 | No | No | 36months | died at 36months with CKD |
| No | No | 3 | 12 | Yes | Yes | 72months | |
| No | No | 3 | 9 | Yes | Yes | 168months | |
| No | No | 3 | 9 | Yes | Yes | 120months | |
| No | No | 3 | 7 | Yes | No | 156months | |
| No | No | 5 | 11 | No | No | 12months | |
| No | No | 5 | 20 | Yes | Yes | 120months | |
| No | No | 3 | 9 | No | No | 9months | |
| No | No | 2 | 12 | No | No | 17months | died 36mths with graft infection |
| No | No | 3 | 10 | No | No | 12months | |
| No | No | 1 | 7 | No | No | 60months | |
| No | Yes | 10 | 18 | Yes | No | 56months | |
| No | No | 3 | 23 | No | No | 42months | |
| No | No | 1 | 7 | No | No | 50months | |
| No | No | 18 | 35 | No | No | 40months | |
| No | No | 4 | 14 | No | No | 20months | |
| No | No | 2 | 2 | No | No | Died immediate postop | |
| No | No | 3 | 10 | No | No | 24months | |
| No | No | 1 | 1 | No | No | Died immediate postop | |
| No | No | 3 | 14 | No | No | 14months | |
| No | No | 3 | 3 | No | No | Died immediate postop | |
| No | No | 3 | 20 | No | No | 6months | died at 6months |
| No | No | 1 | 7 | No | No | 8months | |
| No | No | 3 | 14 | No | No | 7months | |
| No | No | 2 | 7 | No | No | 6months | |
| No | No | 2 | 6 | No | No | 6months | |
| No | No | 2 | 5 | No | No | 6months | |
| No | No | 2 | 5 | No | No | 4months | |