IMPACT OF LEFT RENAL VEIN DIVISION DURING ABDOMINAL AORTIC ANEURYSM SURGERY ON IMMEDIATE AND LONG-TERM RENAL FUNCTION

DISSERTATION

Submitted for the partial fulfilment for the requirement of the degree of

MCh in Vascular Surgery

By

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SREE CHITRA TIRUNAL INSTITUTE FOR MEDICAL

SCIENCES AND TECHNOLOGY

THIRUVANANTHAPURAM, KERALA – 695011, INDIA

The origin of the Institute dates back to 1973 when the Royal Family of Travancore gifted a multistoried building for the people and Government of Kerala. Sri. P. N. Haksar, the then Deputy Chairman, Planning Commission, inaugurated the Sree Chitra Tirunal Medical Center in 1976, when patient services including inpatient treatment got underway. At the Satelmond Palace, Poojapura, nearly 11 km away from this Hospital Wing, the Biomedical Technology Wing followed soon, again a gift by the Royal Family.

Sree Chithira Thirunal Bala Rama Varma, the last ruling Maharaja of Travancore was a visionary beyond words, of whose name the Institute bears. Known for their munificence, the royal family of Travancore considered themselves ‘dasas’ (servants) of Lord Padmanabha, the reigning deity of Travancore. Interestingly, they wore turban instead of a crown as a mark of respect to the Lord. Their philanthropy finds expression in their countless contributions to the country, then and now.

The concept of amalgamating medical sciences and technology within a single institutional framework was regarded as sufficiently important by the Government of India to declare the center as an Institute of National Importance under the Department of Science and Technology by an Act of Parliament in 1980, and named it as Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum.

The Institute signifies the convergence of medical sciences and technology and its mission is to enable the indigenous growth of biomedical technology, besides demonstrating high standards of patient care in medical specialties and evolving postgraduate training programmes in advanced medical specialties, biomedical engineering and technology, as well as in public health – the only institution in the country to do so.


ACKNOWLEDGEMENT

I am overwhelmed and my heart is filled with immense joy and gratitude as I complete this dissertation and had the privilege to be guided and mentored in my initial days by **Prof.Dr.M.Unnikrishnan** (Retd. Head of division of Vascular Surgery) who put me on track at Sree Chitra, an ocean of knowledge and experience that he is, fine-tuned my clinical and surgical skills as I started my training.

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I should also thank **Dr.Varghese.T.Panicker** who stepped in as my Co-guide and helped and guided me throughout the conduct of the study. I would like to place on record my gratitude and thanks to **Dr.R.C.Sreekumar –** immediate past head of Division of Vascular Surgery for his guidance.

I hereby sincerely place my gratitude for the support and solace my fellow residents in the department has provided – Dr. Kiran, Dr. Vineeth, Dr.Ashutosh, Dr. Tom and all others who need not be named specifically. I should also wish to appreciate the help my fellow Cardiac anaesthesia residents especially Dr. Nayana and Dr.Don have extended in completing this.

I must also remember and appreciate the help of my statistician Mr.Jayakumar who sat with me through late nights for completion of the study.

Last but not the least, I thank God Almighty who guided me throughout this endeavour. I also express my sincere gratitude to Nursing staff and all the patients without whom this study would not be possible and whose care is my prime duty.

Harishankar.R 28/07/2019

Thiruvananthapuram

DECLARATION

I, Dr. Harishankar. R, hereby declare that the project printed in this book was undertaken and completed by me under the guidance and supervision of Dr.Varghese. T. Panicker – Addl. Professor, Dept. of CTVS, Dr. Shivanesan. P – Asst. Professor, Division of Vascular Surgery, Dept. of CTVS and Dr. Baiju. S. Dharan – Professor and Head of Dept. of CTVS, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram.

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We hereby declare that, the above statement is true and that the candidate, Harishankar.R has carried out the minimum work required for the completion of this project.

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CERTIFICATE

*Certified to be the bonafide record of **Dr.HARISHANKAR.R.** the work done in Vascular Surgery division, Department of CTVS, as part of MCh Programme in Vascular Surgery at Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram, for a period of three years from January 1st, 2017 to December 31st, 2019.*

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TITLE

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INDEX

INTRODUCTION

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Open surgical repair is the gold standard in the treatment of abdominal aortic aneurysms. The surgical technique has improved so vastly over the years, that even high risk patients can undergo the procedure with acceptable morbidity. Juxtarenal aortic aneurysms and the aneurysms with difficult or hostile neck anatomy like large aneurysm hindering clamp space or crossing of left renal vein (LRV) pose serious technical challenge to the operating surgeon. There are different techniques to tackle this and one such important method is division of left renal vein. Although described by many authors, there are contradicting reports in the literature regarding the safety of the same and need for routine reconstruction of vein. This study intends to look into the immediate post-operative and long term renal function of all patients who underwent left renal vein division during elective abdominal aortic aneurysm surgery.

Left renal vein division was employed more commonly than other methods in juxtarenal aortic aneurysms and infrarenal aortic aneurysms with difficult neck anatomy. Renal function in the LRV division group was further analysed based on aortic clamp placement (suprarenal, inter-renal or infrarenal). Blood urea, serum creatinine and estimated glomerular filtration rate (eGFR) were measured preoperatively, in the post-operative period and during follow up.

AIMS OF THE STUDY

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1) To evaluate the impact of left renal vein division on immediate and long term post-operative renal function following elective abdominal aortic aneurysm repair

2) To assess the perioperative morbidity and mortality in the above said group

3) Long term survival of patients who underwent left renal vein division

REVIEW OF LITERATURE

REVIEW OF LITERATURE

History of Aortic aneurysm surgery:

The history of the treatment of aortic aneurysm is remarkable and worthy of study because it parallels most of the great advances in medicine over the past 2,000 years. The first description of arterial aneurysms were found in the Ebers Papyrus dated 2000 B.C. In the 2nd century AD, Antyllus provided the first record of the cause and treatment of aneurysm. Osler described him as one of the most daring and accomplished surgeons in history, due to his early proximal and distal ligation of aneurysms. Ambroise Paré (1510-1590) advocated the application of a proximal ligature to aneurysms but did not believe the sac should be opened because of the danger of severe and fatal haemorrhage (1). Paré also described a ruptured aneurysm of the thoracic aorta and wrote, “The aneurysms which happen in the internal parts are incurable.” Andreas Vesalius (1514-1564) was a friend and colleague of Paré and apparently was the first to describe thoracic and abdominal aortic aneurysms in 1555 (2). Lancisi published a comprehensive text on the pathology of aneurysms, complete with case studies, in 1728 (3).

The British surgeons William and John Hunter performed a number of ligations of peripheral aneurysms, while Astley Cooper was first to ligate the abdominal aorta for a ruptured iliac aneurysm in 1817 (4,5). With John Hunter (1728-1793), surgery began to emerge as a scientific discipline on the basis of anatomy and physiology. On December 12, 1785, he ligated the superficial femoral artery high in the thigh in the area now known as Hunter's canal to treat a popliteal aneurysm. The patient did well; the aneurysm shrunk to a hard knot, and the limb survived.

A major advance in the treatment of aneurysms came in 1888, on May 6th to be exact, with Rudolf Matas's concept of endoaneurysmorrhaphy. After obtaining proximal and distal control, he obliterated the aneurysmal sac, oversewing collaterals yet preserving a lumen for blood flow (6). This operation markedly reduced the incidence of gangrene and amputation that followed the procedure in a high percentage of patients who underwent the Hunterian ligation for popliteal aneurysm. This principle is still used.

The first successful resection of abdominal aortic aneurysm with graft replacement was performed on March 29, 1951, by Charles Dubost in Paris (7). He used an extraperitoneal thoracoabdominal approach with resection of the 11th rib. The graft used was the thoracic aorta taken 3 weeks previously from a 20-year-old woman. The patient's left common iliac artery then was anastomosed to the side of the graft. After Dubost's landmark procedure, reports of successful operations appeared in quick succession by Julian, Brock, DeBakey and Cooley, and Bahnson (8,9).

In 1929, Reynaldo dos Santos, another Portuguese physician, was the first to report translumbar aortography, and he envisioned this method as valuable to studying diseases of the arteries. These pioneering achievements have evolved into today's sophisticated methods of visualizing all the vessels in the body (10).

After Dubost's report, the abdominal aortic aneurysm sac would be completely removed before the graft was placed, but this technique was sometimes difficult and hazardous. Therefore, in 1966, Oscar Creech, of Houston, combined the endoaneurysmorrhaphy technique of Matas with graft replacement that left the aneurysmal sac in place (11). This single step has greatly simplified aneurysm surgery. It is safe to say that the present day practice of open surgical repair of aneurysm has been propounded by Creech. Henry Bahnson is credited with the first successful repair of a ruptured aortic aneurysm, performed March 13, 1953 (12).

In 1952, Voorhees, Jaretski, and Blakemore reported that a tube of Vinyon-N cloth as a plastic artificial substitute for an artery would remain open in a dog's aorta (13). This observation was soon confirmed, and although Vinyon-N cloth did not prove to be satisfactory material, the principle was established. In 1954, DeBakey and his group began working on various materials for grafts. DeBakey collaborated with Professor Thomas Edman, a Philadelphia textile engineer, to build a new knitting machine to make seamless Dacron grafts of all sizes, shapes, and configurations (14). Various refinements were made in these grafts, which culminated in the standard grafts in use at the present time.

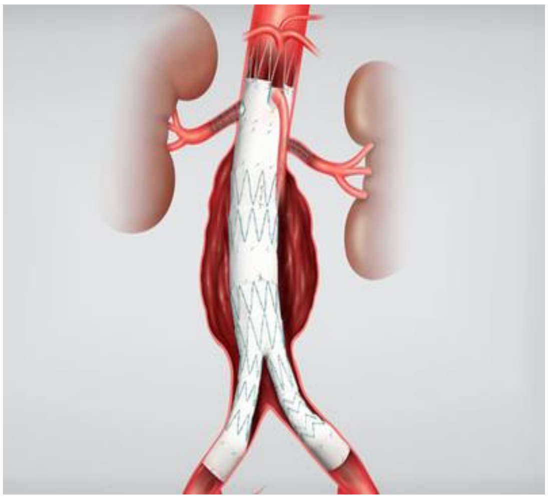
Definitions:

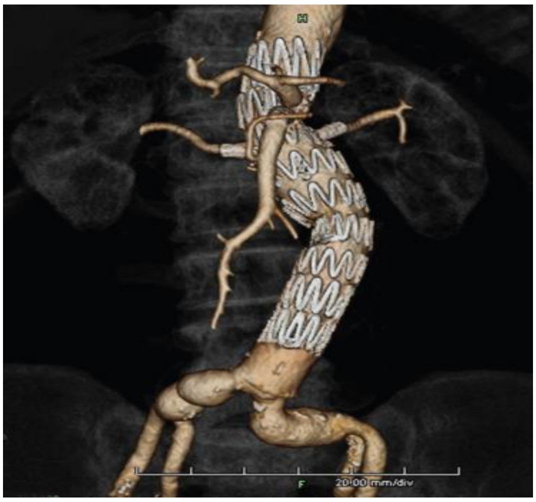
In 1963, Bergan and Trippel coined the term juxtarenal to describe atherosclerotic disease involving that segment of the abdominal aorta at, and just below, the renal arteries (15). In the 1980s, several excellent reports drew attention to aneurysms involving the juxtarenal aorta and to their incidence, diagnosis, and management (16). The incidence of the same is highly variable, from 2% to as high as 20% among all the abdominal aortic aneurysms (17,18).

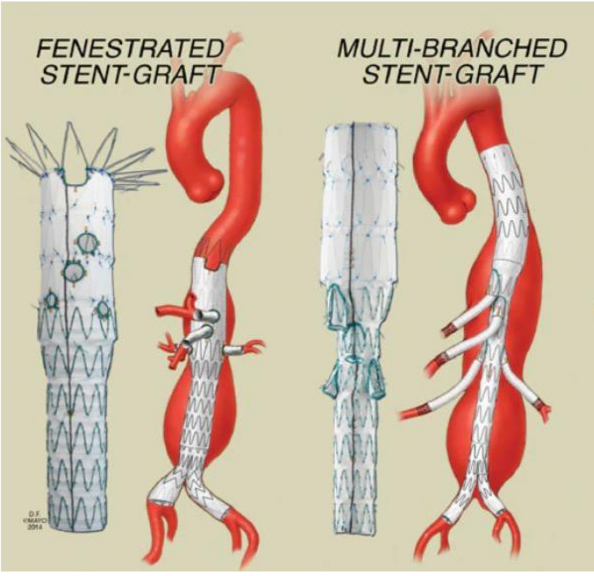
Despite description as a distinct entity, juxtarenal aortic aneurysms (JRAA) are often incorrectly diagnosed and improperly treated. These aneurysms are either downplayed as high infrarenal aortic aneurysms or overdiagnosed as complex suprarenal aortic aneurysms, resulting in either inappropriate infrarenal aortic clamping or automatic tertiary referral. The unfortunate scenario of the unsuspecting surgeon discovering juxtarenal involvement of the aneurysm and abandons resection still exists.

Open repair mandates suprarenal or supracoeliac aortic cross clamping that causes renal and visceral ischemia leading to significant morbidity and rarely mortality (19). Endovascular aneurysm repair is also not an easy proposition for lack of proximal landing zone, which mandates complex endovascular solution(s) for a successful outcome namely fenestrated or use of branched endovascular aneurysm repair device.

The common solution for JRAA is fenestrated endovascular aneurysm repair (fEVAR), where the stent graft fabric extends over the renal arteries, but perfusion to these arteries is preserved via accurately placed windows (fenestrations) within the stent graft fabric. Aortic branches such as renal arteries that would lose perfusion if not for such fenestrations are called target vessels. Customised fenestrated stent grafts with up to four openings to the target vessels (two renal arteries, superior mesenteric artery and coeliac artery) have thus been developed to allow perfusion of the target vessels. fEVAR technology is enabling an expansion of the patient population, increasing the number that may be eligible for EVAR (21,22).







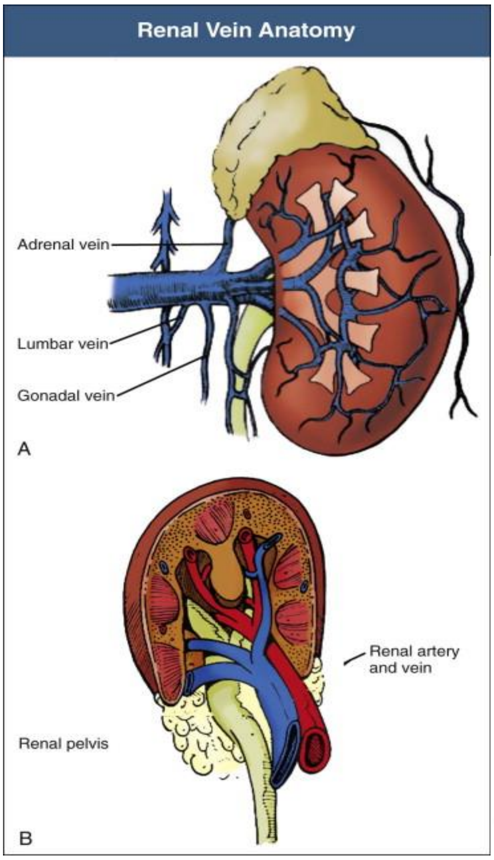
The fact that a target vessel origin is included means that the target vessel arises from the aneurysm, thus implying that a gap must be bridged from any fenestra in the stent graft within the aorta to the ostia of the target vessel. The procedure required in this population is then referred to as branched EVAR (bEVAR) (23). The term branched refers to the need to bridge the gap (created by increased diameter of aorta) between the main body of aortic stent graft and target vessels and not to any actual branch from the graft itself. Where the aneurysm is suprarenal, it involves at least one renal artery and it does not extend high enough to reach the diaphragm, thus falling short of a type IV Thoracoabdominal aortic aneurysm (TAAA). In this case, it is strictly neither a JRAA nor a TAAA, but given that it requires bEVAR it can be included within the TAAA population (24,25).

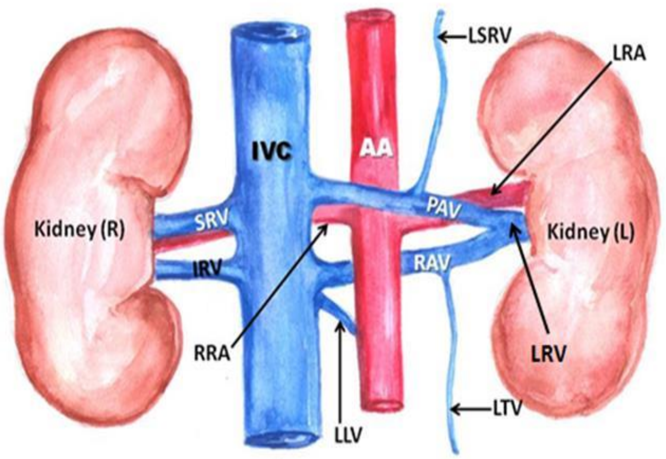
Raux M et al found that fEVAR, in a two-center study, was associated with a significantly higher risk of perioperative mortality and morbidity compared with OSR (open surgical repair) for management of Complex AAAs. These data suggest that extension of the paradigm shift comparing EVAR with OSR for routine AAAs to patients with CAAAs is not appropriate. Further study to establish proper patient selection for FEVAR instead of OSR is warranted before widespread use should be considered (26). Shahverdyan et al in their paper concluded that FEVAR and open repair have similar short-term outcomes but have diverging long-term outcomes that may be secondary to the selection bias of FEVAR being offered to high-risk patients. FEVAR is a favorable option in high-risk patients, and open repair remains viable as the gold standard. (24)

Successful adjuvants practiced during open surgical repair of JRAA include inter-renal or suprarenal clamping with frequent instillation of cold perfusate fluid at 4 degrees and placing ice slush over the kidneys to prolong the ischemia time (27). The short and long term benefits and risks of open surgical repair are well studied and has stood the test of time whereas endovascular techniques are still improving (27,28).

Anatomy of left renal vein:

Renal veins begin in the subcapsular region of the kidney. These stellate veins communicate with perirenal and cortical venous channels and empty into interlobular veins that drain into arcuate veins. The venae rectae drain the pyramids and join the arcuate veins. Arcuate veins leave the renal parenchyma through interlobar vessels, converging into four to six trunks near the hilum of the kidney (30). The main renal veins empty into the inferior vena cava; the left renal vein is three times longer than the right (7.5 cm-8.5cm versus 2.5 cm). The left renal vein traverses behind the splenic vein and body of the pancreas before it crosses in front of the aorta near its termination in the inferior vena cava at the level of L2/L3 vertebra.





In Gerota's fascia, the perirenal venous network communicates with the retroperitoneal collateral veins from the lumbar, azygos, and tributaries of the portal system. The left renal vein is typically first joined by the left adrenal vein draining into the superior aspect of the left renal vein. Shortly after, there is typically a branch of the inferior phrenic vein that joins the left renal vein on its superior aspect as well. The left gonadal vein usually joins the inferior aspect of the left renal vein before it crosses the aorta. In about 75% of the population, the posterior aspect of the left renal vein has additional tributaries such as branches from the lumbar or hemiazygos veins draining into it. These can be clinically significant in size and are highly variable (31).

Unlike the renal arterial system, the renal venous system has what anatomists refer to as a “free anastomosis” system in place. This system allows for the venous system of the kidney to communicate and freely flow throughout all the segments of the kidney allowing branches of the renal venous system to be severed or ligated without compromising the venous drainage of the renal parenchyma thus avoiding destruction of the renal tissue with the loss of minor branches of the renal venous system.

The most common left renal vein anatomic variant is a circumaortic renal vein, which occurs in 5% to 7% of the population. With this anatomic variant, the left renal vein forms a ring around the aorta (32). The anterior segment of the ring connects with the inferior vena cava at the expected level of the left renal vein, and the posterior segment connects with the inferior vena cava below the insertion of the anterior segment. Most of the time, the circumaortic branch begins as one renal vein at the hilum of the left kidney and then splits into the anterior and posterior branches; 25% of the time a circumaortic left renal vein begins as two vessels at the hilum of the left kidney. A retroaortic left renal vein is less common and occurs in 2% to 3% of people. A retro-aortic left renal vein has also rarely been known to drain into a common iliac vein instead of the inferior vena cava. About 25% of the time, there are no posterior tributaries of the left renal vein from the retroperitoneal space.

Operative assessment, technique and planning:

Even after evolving leaps and bounds with regards to technique and perioperative management, more so in the last 3 decades, open surgical repair still continues to be technically demanding especially in the setting of juxtarenal aortic aneurysms. The indication for intervention classically describes a diameter of 5.5cm or more, but in our population with relatively smaller aortic diameter, 5cm may be considered as the cutoff. Optimal patient selection is still warranted for obtaining favourable outcomes after open surgery (33,48).

Because of the physiologic derangements that occur as a result of the hemodynamic stress of an aortic cross-clamp, a detailed understanding of the patient's cardiac, pulmonary, and renal function is necessary to determine the ideal candidate for open repair. Routine measurement of serum chemistries, hematologic profile, and coagulation studies is essential, as well as electrocardiogram and chest x-ray. Additionally, carotid duplex studies, transthoracic echocardiography, and pharmacologic cardiac stress testing with nuclear imaging or conventional coronary angiogram add valuable data to help evaluate a patient's suitability for open aneurysm repair (34). In patients with a history of significant recent weight loss, nutritional parameters may be predictive of perioperative complications. Similarly, in patients with a history of liver disease and cirrhosis, appropriately tailored preoperative studies should be considered.

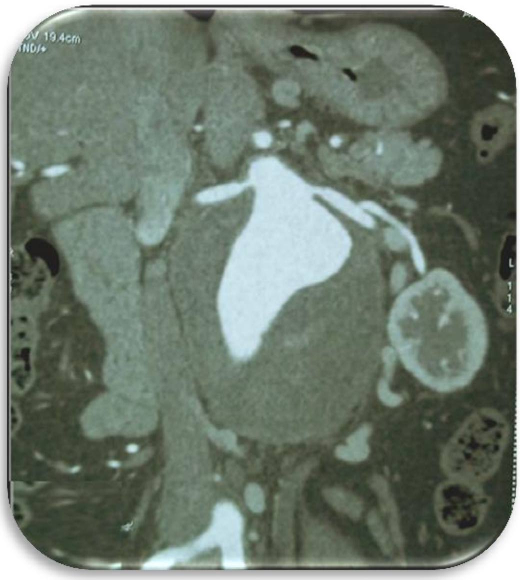
The preoperative urea and serum creatinine levels and the creatinine clearance measured using Modified Cockcroft-Gault equation ie. Sex (Male=1; Female=0.85) *

[(140-age)/ (Serum Creatinine)] * (Weight/72) are of prime importance in patients undergoing juxtarenal aortic aneurysm repair (51). These parameters are measured in the post-operative and follow up period to assess the safety of surgical adjuncts like left renal vein division and inter-/suprarenal aortic cross clamp which were performed intraoperatively. Few patients especially when presenting with acute worsening of symptoms might present with elevated serum creatinine, mostly due to prerenal dysfunction which would come back to baseline normal levels with adequate hydration and stoppage of nephrotoxic drugs. It has been proven that elevated serum creatinine or preoperative renal dysfunction is an independent risk factor for adverse post-operative outcomes (35).

Besides patient factors, a keen understanding of an individual's specific anatomy of the aneurysm and the aortic tree is necessary to adequately plan the operation and appropriately counsel the patient about the anticipated risks and benefits of the procedure. The anatomy will influence the level of the aortic cross-clamp and the complexity of the repair. Thus detailed radiographic imaging, usually in the form of contrast-enhanced computer tomography (CT) or magnetic resonance angiography (MRA) is important. These studies are necessary to understand the extent of aneurysmal, as well as occlusive, disease and to reveal any arterial or venous abnormalities that may impact the repair.

Preoperative imaging:

CT angiography (CTA) with volume-rendered three-dimensional reconstructions, which allows for accurate anatomic measurements of aorta's true cross-sectional diameter and center-line length, is mandatory for planning open repair in patients with normal renal function. CTA visualizes aneurysm angulation, arterial tortuosity, arterial wall calcification, periaortic inflammation, intravascular thrombus and suspicion of mycotic aneurysm which are useful for planning the best approach and clamp sites.



A detailed view of the proximal aneurysm neck allows the involvement of the visceral aortic segment to be accurately determined. From this, the need for a suprarenal or supraceliac clamp site can be made and potential clamp sites examined for the presence of heavy or circumferential calcification or thrombus. Concomitant occlusive disease of the visceral vessels and aortoiliac segment is also readily apparent on CTA, allowing decisions regarding the need for endarterectomy or complex reconstruction to be made preoperatively.

CTA also provides valuable information about the venous and visceral anatomy that might alter the operative plan; the presence of a retroaortic or circumaortic left renal vein has implications on selecting the surgical approach and obtaining adequate exposure. Likewise, multiple renal arteries or a horseshoe kidney can affect both clamp site selection and arterial reconstruction. Appropriate visualization of the distal anatomy is also important. Concomitant stenotic, occlusive, or aneurysmal disease will influence the site of distal reconstruction, as well as the need for additional procedures. For example, additional graft limbs may be needed to preserve IMA or hypogastric flow. In addition, severe stenotic or occlusive disease can be bypassed at the time of the reconstruction (35).

Finally, the rate of incidental findings on CTs obtained for AAA is not inconsequential, and in certain circumstances, such as the diagnosis of an advanced malignancy, may take precedence over aneurysm repair.

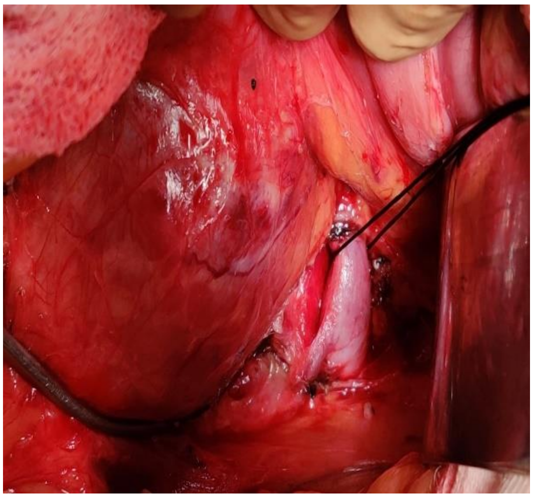
Magnetic Resonance Angiography:

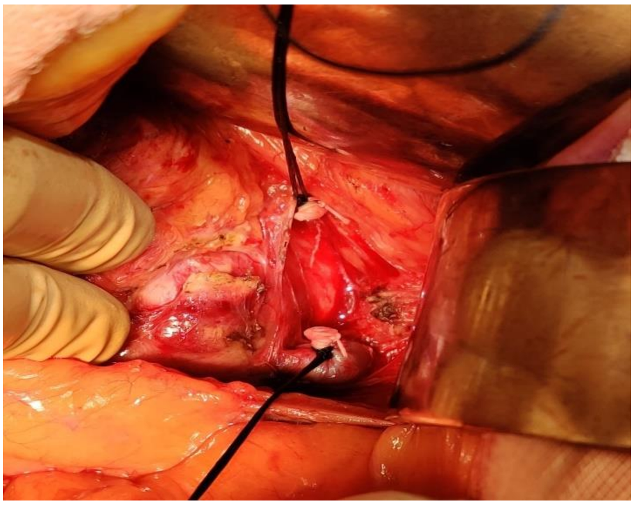
Magnetic resonance angiography (MRA) may also be used for preoperative planning especially in patients with renal dysfunction. It has been shown to be just as accurate as CT in the determination of aneurysm size and extent, as well as in the evaluation of concomitant occlusive disease. In patients with inflammatory aneurysms it may offer more information regarding the extent of the inflammatory process. MRA, however, does not offer information on the extent of calcification and sometimes can overestimate stenotic disease.

Concept and basis of Left renal vein division:

With the advent of EVAR, it is a well-known fact that the open surgical repair is being performed more and more for complex aortic aneurysms with unfavourable anatomy and short or absent neck for infrarenal aortic cross-clamp. According to the literature, LRVD rate ranges from 1.3% to 18.8%. Adequate exposure of viscerorenal aortic segment is of paramount importance in the management of juxtarenal aortic aneurysms especially due to the need for suprarenal clamping and renal artery reconstruction as the case maybe.

Left renal vein division and ligation (LRVDAL) is a technique employed for the same and was first described by Neal and Shearburn in 1967 (36). Left renal vein division and subsequent re-anastomosis (LRVDAR) in order to facilitate such exposure was originally described by Szilagyi et al in 1969, and have been practiced by many surgeons (37). But subsequent studies showed that although there is transient but significant rise in post-operative serum creatinine in patients undergoing LRVDAL, with ensuing venous hypertension, the creatinine levels would fall back to normal by 30 days post-operatively, negating the need for routine reconstruction of the same (38, 39).



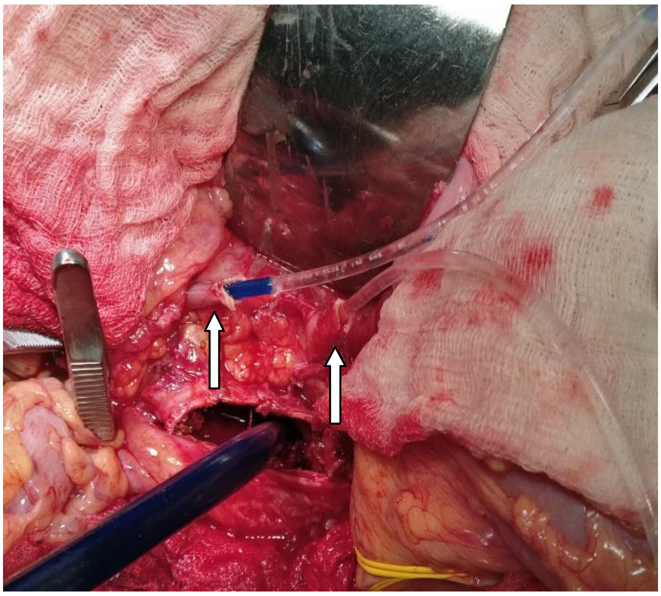


In order to determine whether the vein could be divided and safely ligated, Calligaro et al described “test clamping” the renal vein to check stump pressures (40). They suggested that when the LRV is distended and stump pressure is >50 cm water, renal vein ligation and division should not be attempted, rather relying on re-anastomosis or retraction of the vein which can be mobilized more readily by ligating the gonadal vein. Absolute LRV pressure has been reported to be unreliable, however, and a renal-caval pressure gradient of 1 to 3 mm Hg or greater was recommended instead to assess for LRV hypertension. Huber et al demonstrated that a distended LRV does not necessary imply a significantly increased pressure gradient. Prospective randomized studies comprising routine LRVDAL and intact vein groups would be unethical and hence there are no studies looking into the safety and benefits/risks of the same in that aspect.

Effect of aortic cross-clamp and renal perfusion strategy:

The morbidity associated with LRV division has been found to be sure but transient, as, in published literature, most of the patients attained their baseline normal creatinine and creatinine clearance by 30 days. But, an important factor not to be overlooked in this aspect is aortic cross-clamp position and its duration and use of renoplegia to decrease the effects of renal ischemia. Although an infrarenal aortic cross-clamp is well tolerated in most patients, supraceliac or suprarenal clamping produces profound alterations in splanchnic and renal blood flow and significant associated physiologic derangement (43).

The overall rate of renal complication after surgery on the suprarenal aorta remains high and may reach 17% with 5% chance of hemodialysis in infrarenal clamp. Infrarenal aortic cross-clamping is associated with a large increase in renal vascular resistance and as much as 30% decrease in renal blood flow and persists even after unclamping. The renin-angiotensin system is apparently involved in the pathogenesis of renal hemodynamic disturbances during aortic cross-clamping (44).



Renal perfusion with cold hyperosmolar crystalloid, histidine-tryptophan-ketoglutarate (HTK) solution, or saline with mannitol and methylprednisolone, results in renal hypothermia and prolongs tolerance to ischemia. The use of mannitol, furosemide, dopamine and fenoldopam have shown renoprotective effect in experimental settings (27). For every degree Celsius that the kidney is cooled, there is a 7% reduction in renal metabolism, such that by cooling the kidney to 30%, its metabolic demands are cut in half. Ultimately, reducing ischemic times to the kidneys likely has the greatest beneficial effects on renal protection (45).

Complications of renal vein division:

Acute complications of LRV ligation are rare and mainly reported in patients with a ruptured AAA. These include increased mortality, massive hemorrhage requiring nephrectomy, venous renal infarction, and loss of left renal function. During open surgical repair of pararenal aortic aneurysms, LRV ligation was also found to be an independent determinant of postoperative renal insufficiency and was also associated with cardiopulmonary complications and prolonged hospital stay (28).

Among chronic sequelae, subclinical or clinical deterioration of renal function is the most common. In case of insufficient drainage through LRV tributaries, renal venous pressure significantly increases, resulting in a reduction of renal blood flow and GFR (glomerular filtration rate) with activation of the renin-angiotensin-aldosterone system, which further decreases both renal perfusion and GFR. Finally, an increase in LRV pressure may produce the pelvic congestion syndrome, which consists of dysmenorrhea, dyspareunia, dysuria, and vulvar and pelvic varices in women, and varicocele in men (38).

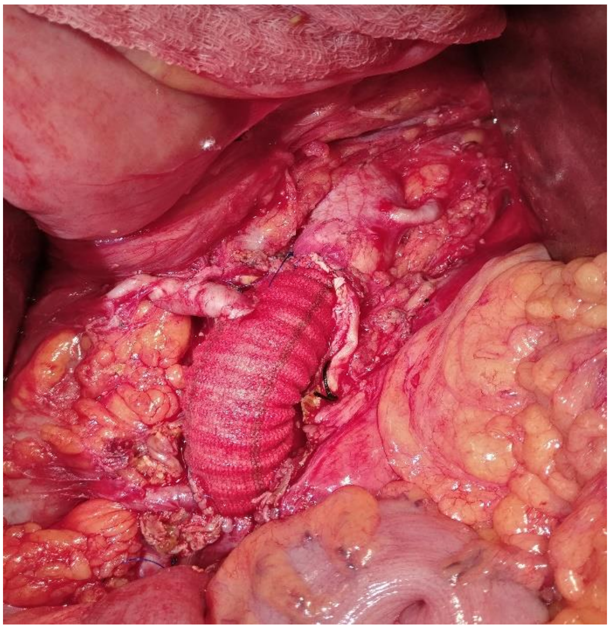
Marrocco-Trischitta et al found that if collateral circulation is adequate, LRV ligation may not adversely affect renal function in many cases; however, based on preoperative and intraoperative findings, the occurrence of renal venous hypertension seems to be unpredictable (46).

Stenstrom and colleagues reported a higher mortality in patients after ruptured abdominal aortic aneurysms who required LRV division. However, as in the previous series concerning ruptured aneurysms, this result may reflect a greater degree of prolonged, severe hypotension resulting in relatively diminished arterial inflow in patients who had LRV division compared with patients not requiring this maneuver (50).

Repair of juxtarenal and suprarenal AAAs remains a significant surgical challenge. There have been numerous reports regarding JAA repair, and a recent review showed that the perioperative mortality rate was 2.9% (95% CI: 1.8-4.6%) for nonruptured JAAs requiring suprarenal clamping. It has been reported that common early postoperative complications after abdominal aortic surgery include myocardial infarction, acute pulmonary decompensation resulting in pneumonia or reintubation, and renal dysfunction.

Renal artery revascularization:

There is a subset of patients who present with concomitant renal artery stenosis, some being symptomatic while others critical but asymptomatic. Society of Vascular Surgery guidelines clearly state the need for intervention in only those who are symptomatic and have uncontrolled hypertension with optimal medication and recent worsening of renal function.



Options in open surgery include bypass graft to the affected renal artery from the aortic graft or the iliac vessels and direct reimplantation of the renal artery onto the graft. The long term results of both options are good. Endovascular options include renal artery angioplasty with or without stenting which has been proposed to be the first option in these patients or use of fEVAR or bEVAR (28,29).

So far, the safety of LRVD without re-anastomosis is still controversial. Some studies showed that the LRVD did not influence the in-hospital renal function or associated complications of aortic surgery. Samson and colleagues investigated the long-term renal function of 36 LRVD patients, and found that all patients had a stable creatinine and GFR level except for two, who had insufficient preoperative renal function and experienced deterioration more than a year after surgery. These findings demonstrated that LRVD was a safe adjunct for aortic surgery (41).

With rapid strides of advancements made in the endovascular techniques and advent of newer stent grafts, surgeons are tackling most of the abdominal aortic aneurysms through EVAR – even those with hostile neck. But the long term safety and durability of the same still remain unproven with some studies showing reintervention rates of about 38%. In the era of endovascular aortic repair, surgeons still encounter complicated cases that are better handled by open repair.

MATERIALS AND METHODS

MATERIALS AND METHODS

A total of 255 patients who underwent elective open surgical repair of abdominal aortic aneurysms from January 2009 to April 2019 (a period of 10 years) were included in the study. This included symptomatic and asymptomatic infrarenal and juxtarenal aortic aneurysms. Data regarding demographics, preoperative, perioperative and postoperative details were collected from inhospital patient electronic medical records.

All patients undergoing elective open aneurysm surgery would undergo complete haemogram including coagulation profile, ESR (erythrocyte sedimentation rate) and CRP (C-Reactive Protein, as the case maybe), serum biochemistry panel – blood urea, serum creatinine, liver function, electrolytes, chest X-ray, 12- lead electrocardiogram and 2D- echocardiogram (Echo). Pulmonary function test would be done for active smokers and known COPD patients. Institute protocol includes coronary angiogram (Computed tomographic or Conventional) for cardiac risk stratification and if the patient could be waited for the aneurysm repair and had significant coronary artery disease, coronary revascularization was performed prior to the aneurysm surgery after explaining the potential risk of aneurysm rupture.

There were 48 patients (including juxta- and infrarenal aneurysms) who underwent elective LRVDAL. Data from these patients were retrospectively analyzed for immediate and long term effects of the same on their renal function. They were called to the outpatient department telephonically and latest blood urea, serum creatinine and body weight were measured and creatinine clearance calculated; which were entered in a restructured data collection form and compared to perioperative and immediate postoperative values. The original cohort also contained 56 juxtarenal aortic aneurysm patients who underwent LRVDAL or had their left renal vein intact, but underwent the surgery under various positions of aortic cross-clamp – namely inter-renal, suprarenal and infrarenal. These patients were compared for renal function and creatinine clearance till 30 days post operatively. Complications that occurred in this time period also were analyzed.

Patient demographics, comorbidities and post-operative complications were analyzed in detail and comparison made in the juxtarenal aortic aneurysm cohort with intact and divided left renal vein.

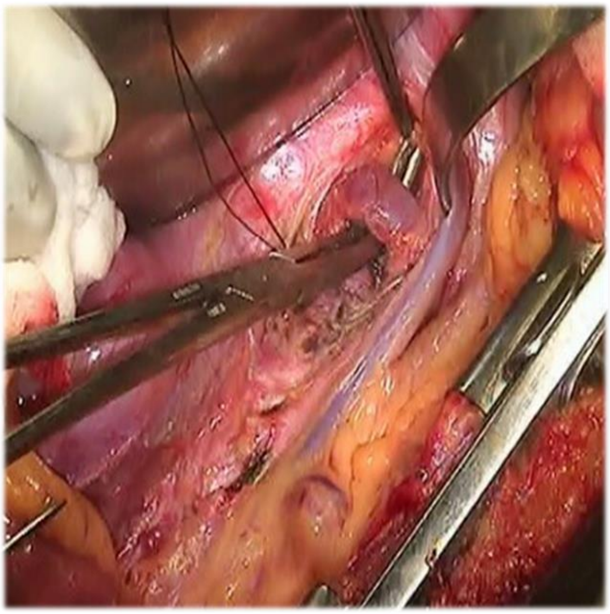
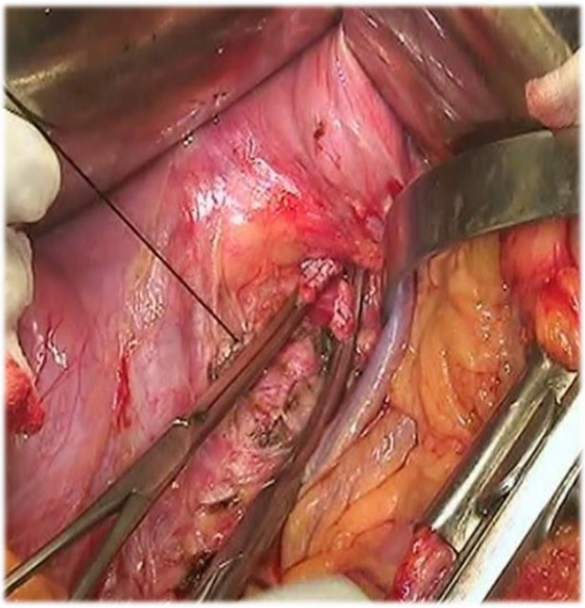
Suprarenal, Type 4 Thoracoabdominal aortic aneurysms, ruptured abdominal aortic aneurysms and isolated iliac artery aneurysms were ***excluded*** from the study. Approval was obtained from the Technical Advisory Committee (TAC) and Institutional Ethics Committee (IEC) for the conduct of the study.

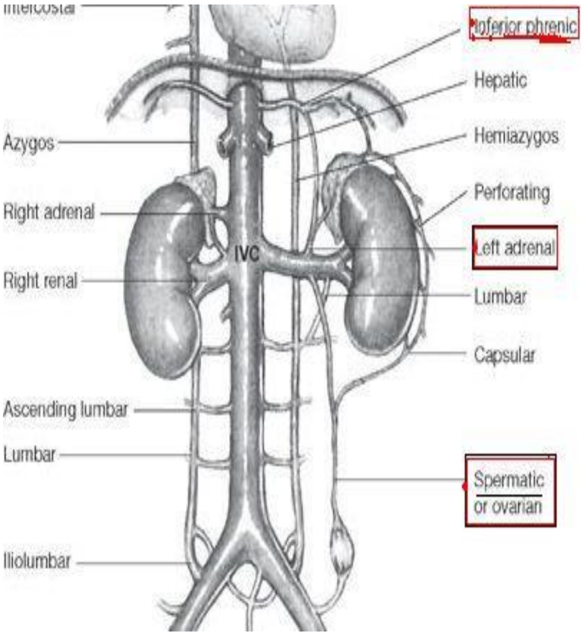
Renal dysfunction was defined as serum creatinine greater than or equal to 1.5mg/dl and increase of >0.5mg% in postoperative period. Coronary artery disease was defined as history of acute coronary syndrome, prior coronary angioplasty or coronary artery bypass or indirect evidence of myocardial ischemic damage in ECG or Echo or coronary lesion confirmed on CAG.

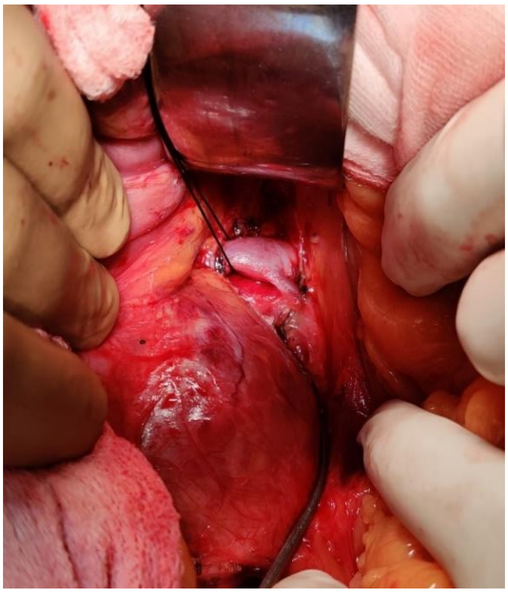
Juxtarenal AAA:

The management of patients with juxtarenal AAA involved the same steps of a standard infrarenal AAA with a few modifications. In most of these cases, the LRV was anterior to the aorta. Patients with a normal renal function and eGFR (estimated

Glomerular Filtration Rate), we adequately mobilized the LRV and created space for aortic cross clamping. In case this was not successful, the LRV was ligated and divided close to where it joined the Inferior Vena Cava (IVC). The tributaries of the LRV were preserved as these channels would later work as the draining pathways of the left kidney especially suprarenal, gonadal and lumbar veins which were consistently found joining the LRV. Hence, preserving the tributaries was an important step in the initial mobilisation of the LRV. Division of these tributaries and later division of the LRV would be detrimental to the left renal venous drainage as it produced venous hypertension and renal venous congestion and hence glomerular damage.

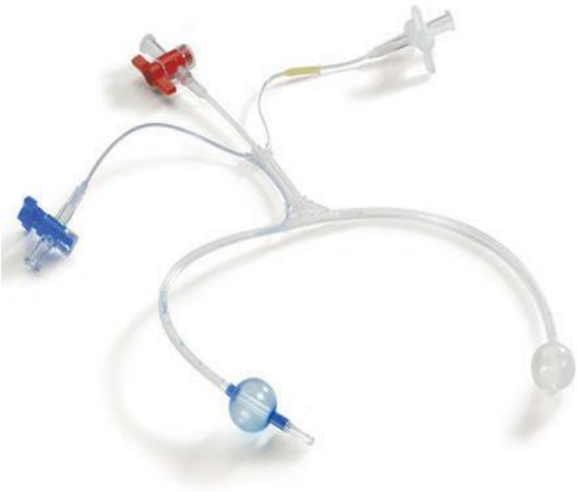
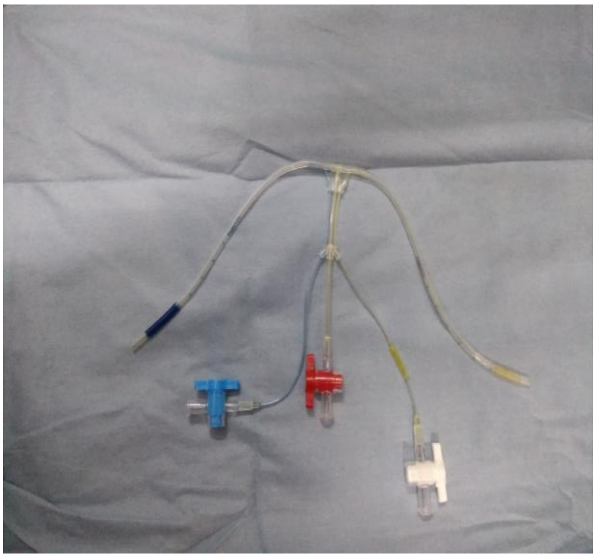







Aortic cross-clamping:

The clamp position most commonly employed in open surgical repair of juxtarenal aortic aneurysms was inter-renal clamp wherein there was some space between the renal arteries on CT angiogram, the aorta was clamped in the inter-renal area with the lower renal artery being temporarily perfused during the clamp time with cold renoplegia solution to reduce the renal ischemia time and make kidney tolerate the ischemic insult better. Renoplegia solution was prepared at the start of the procedure with ice cold saline, Sodium bicarbonate, Hydrocortisone, Heparin and papaverine and initially 500ml of the solution given rapidly and then the next 500ml of the solution slowly over the duration of the aortic cross clamp. We used 9F Pruitt - Inahara shunt for selective renal perfusion during this procedure. In case, the clamp time prolonged, we used ice slush for cooling the kidneys and ice cold saline/Ringer's lactate solution to perfuse the kidney.

"**<u>RENOPLEGIA" (COLD RENAL PERFUSATE) SOLUTION</u>**:

N. Saline	400cc
Mannitol	40cc
Soda bicarbonate	40cc
Heparin	2000 I U
Papavarine	30mg
Hydrocortisone	100mg

At times, the aortic neck would be heavily diseased and friable making it mandatory to get clamp space above both renal arteries – suprarenal clamping, followed by renoplegia and proximal anastomosis.

Operative technique - Transperitoneal Approach:

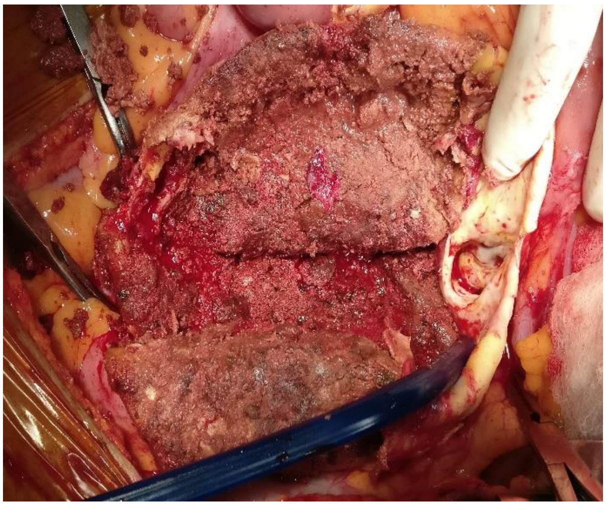
Open repair of abdominal aortic aneurysm aneurysm was done under general anaesthesia and epidural catheter inserted for analgesia. Second or third generation cephalosporin (Cefuroxime/ Cefoperazone) antibiotic was always given during induction of anaesthesia and repeated at 4 hours of open surgery. Central venous pressure monitoring line either in internal jugular vein or subclavian vein, radial artery for proximal Mean Arterial Pressure (MAP) monitoring were placed in all patients.

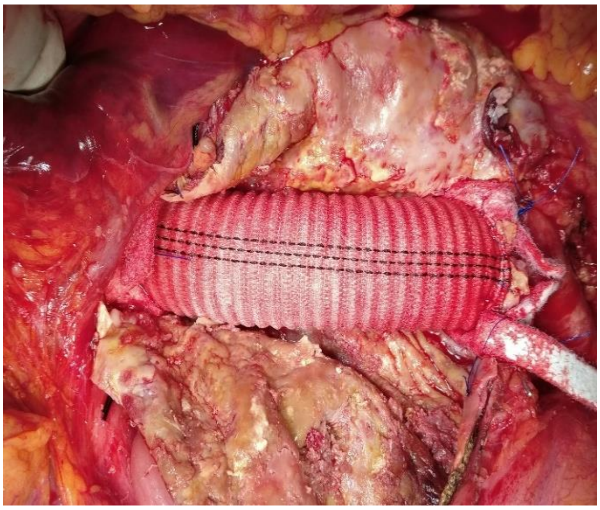
After scrubbing and painting, the area was draped from nipple to mid-thigh level. Vertical midline xipho-pubic laparotomy incision was done. Ryle's tube position in stomach was confirmed and stomach deflated.

The small bowel loops were packed in a moist towel and placed outside the abdominal cavity. The retroperitoneum was opened by dividing the posterior peritoneum along the right border of the aorta, between the duodenum and the inferior mesenteric vein, taking care not to injure the nervi erigentes at the bifurcation. Lymphatics crossing in this area were ligated and divided. The left renal vein was identified and retracted cephalad with an IVC retractor. The lower renal artery was identified and the infrarenal aorta was dissected and clamp space created. Distally, the right CIA was dissected and looped. The retroperitoneal tissue at the aortic bifurcation was preserved and a flap raised on the left side to identify the Left CIA and clamp space created. The iliac veins were identified and then the CIAs were dissected taking care not to injure the common iliac veins. In case a bifurcated graft was planned then the tunnels were created to the groin or external iliac arteries posterior to the ureter and anterior to the iliac artery.

After heparinisation with 1mg/kg of unfractionated heparin (UFH), the CIAs were clamped first and then the infrarenal abdominal aorta was clamped. The aneurysm was opened preserving the IMA and the thrombus evacuated. The lumbar back bleeders were suture closed usually with 3-0 Polyester (TICRON) sutures. The inferior mesenteric artery (IMA) was managed as per the preoperative CT findings. IMA was usually ligated in most cases, but IMA reimplantation was done if needed.

Proximally, the aneurysm was opened and a T-cut was made at the proximal end just below the neck of the aneurysm. Distally the T-cut was made again similar to the proximal end.





The proximal anastomosis was fashioned with Polypropylene sutures with the anastomosis reinforced with a PTFE (Polytetrafluoroethylene) felt if the aortic wall was friable and unhealthy or deficient. The graft was clamped distal to the anastomosis and the aortic clamp was released to check for any loose sutures or areas of bleeding at the proximal anastomosis. After checking the anastomosis, the clamps were released sequentially, one iliac after the other. Femoral pulses were checked and adequate flow confirmed.

Partial heparin reversal done with Protamine sulphate and hemostasis achieved. The wall of the aneurysm was cauterized and wrapped around the graft and then the retroperitoneum was closed. Abdomen was closed in layers after replacing the bowel in the peritoneal cavity.

Data recording and analysis:

Data regarding perioperative events, parameters and 30-day renal function were collected from inhospital patient electronic medical records. Long term follow up was done in the outpatient department with renal function assessed at the time of follow up visit. All-cause mortality and mortality secondary to renal dysfunction were analysed. Statistical analysis was done using Chi-Square test, Log Rank test and Kaplan-Meyer Survival curve with the aid of Windows Excel 2013 and IBM-SPSS statistical analysis software.

OUTCOMES:

Primary:

1) Immediate and long term renal function after left renal vein division

2) Long term survival after left renal vein division

Secondary:

1) Variation in renal function in juxtarenal aortic aneurysms according to position of aortic cross-clamp and comparison between intact and divided left renal vein groups

2) All-cause mortality and complications

Renal function was calculated by measuring urea, creatinine and creatinine clearance till discharge, at 30 days and the last follow up visit. Disease-specific mortality was attributed if the patient died secondary to renal dysfunction and acute kidney injury or if the patient developed chronic kidney disease with or without maintenance hemodialysis. All patients who underwent left renal vein division were followed up till 1month prior and renal function reassessed. Those patients with juxtarenal aortic aneurysms were compared till 30 days post operatively for variation in renal function in two groups i.e., with intact and divided left renal vein. Mortality due to any other cause – mainly cardiac, pulmonary or neurological was considered in all-cause mortality group.

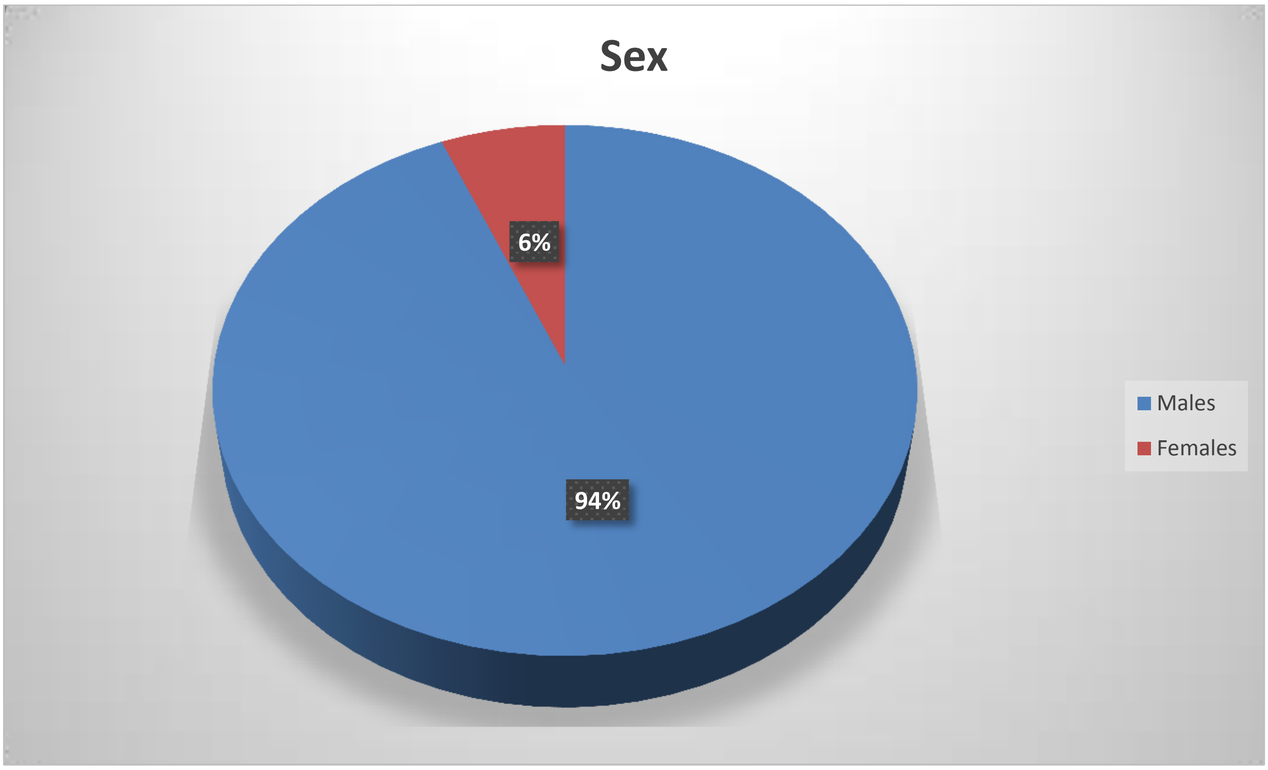
RESULTS

RESULTS

1) Demographics:

A total of 255 patients underwent elective open surgical repair of abdominal aortic aneurysm from 2009 – 2019.

Out of these, **48 patients** underwent Left renal vein division and ligation including juxta- and infrarenal aneurysms. This was a predominantly male cohort with 45 male patients (93.8%) and 3 female patients (6.3%).



Pie diagram -1: Sex distribution

The mean age of the cohort was 63.81 ± 9.81 (SD) ranging from 35-82 years. The maximum number of patients were in the 61-70 age group (n=20) while there was only 1 patient in > 80 years group.

Table-1: Age group of the cohort

Age	**Frequency (n)**	**Percent (%)**
≤ 50.0	5	10.4
51.0 - 60.0	11	22.9
61.0 - 70.0	**20**	**41.7**
71.0 - 80.0	11	22.9
>80	1	2.1
Total	48	100

The patients were followed up from a minimum of 2 months to maximum 96 months with mean period of 28 months (± 8.98)

2) Risk factors:

Table-2: Risk factors in the study group

Comorbidities	**Frequency (n)**	**Percent (%)**
Hypertension	42	87.5
Type-2 Diabetes	9	18.8
Chronic Kidney disease	2	4.2
COPD	7	14.5
Coronary artery disease	32	66.7
Smoking	40	83.3

As high as 87.5 % patients (n=42) had hypertension and 83.3% (n=40) were smokers (either actively smoking or recently reformed).

We found 32 patients had coronary artery disease while 7 patients were diagnosed to have COPD. All patients were optimized as much as possible prior to the surgical procedure. 6 patients had significant coronary disease and had undergone revascularization prior to aneurysm surgery.

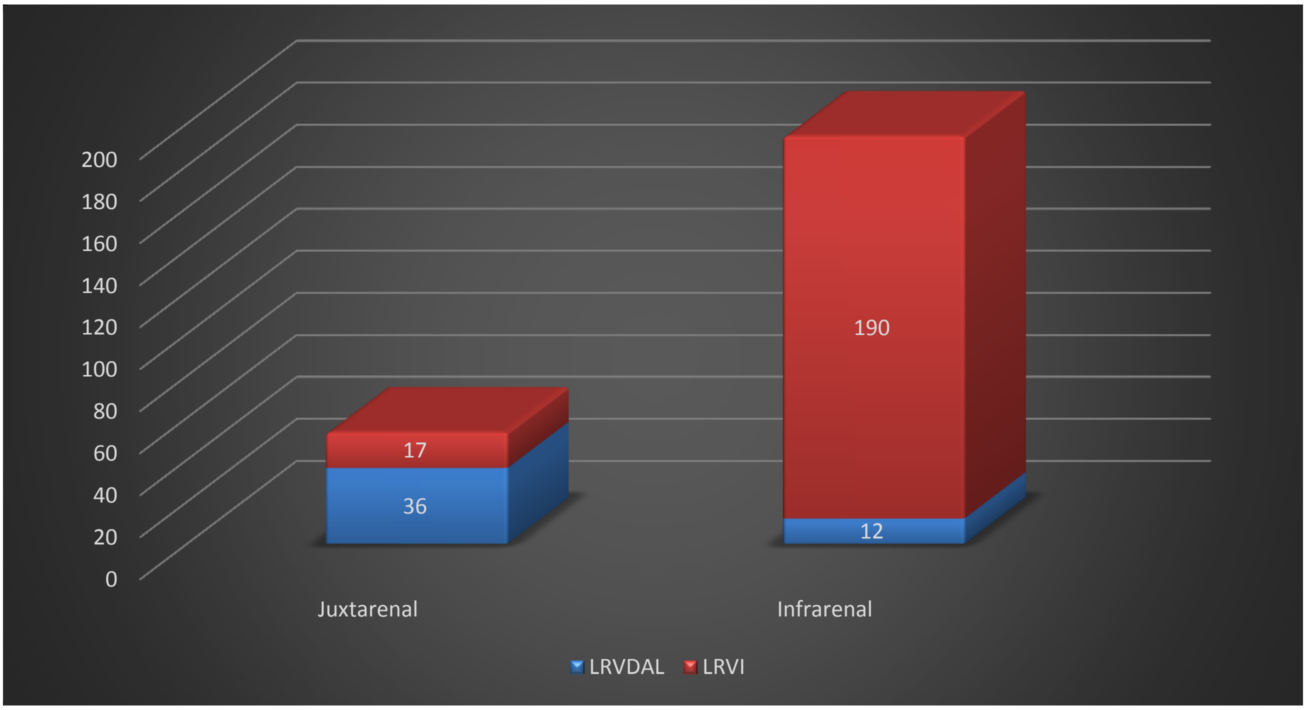
Preoperative renal dysfunction due to existing chronic kidney disease was noted in 2 patients and it was worthwhile to see the impact of LRVDAL in that group.

3) Type of aneurysm:

There were 36 juxtarenal aneurysms (75%) and 12 infrarenal aneurysms (25%) in the LRVDAL group. (n=48)

Further, there were 17 juxtarenal aneurysms who underwent surgery without division of left renal vein in the total number of 255 patients.

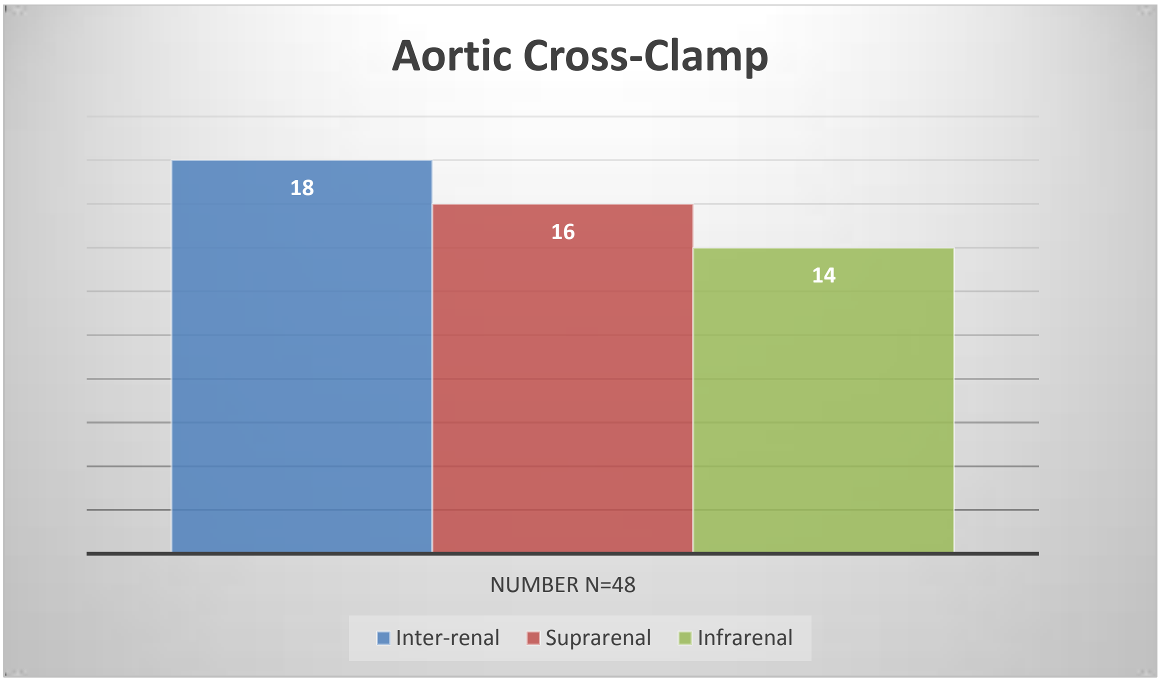
17 of the 48 patients (35.4%) who underwent left renal vein division and ligation had associated unilateral or bilateral common iliac artery aneurysm and underwent repair using bifurcated graft to either iliacs or common femoral artery in the groin.



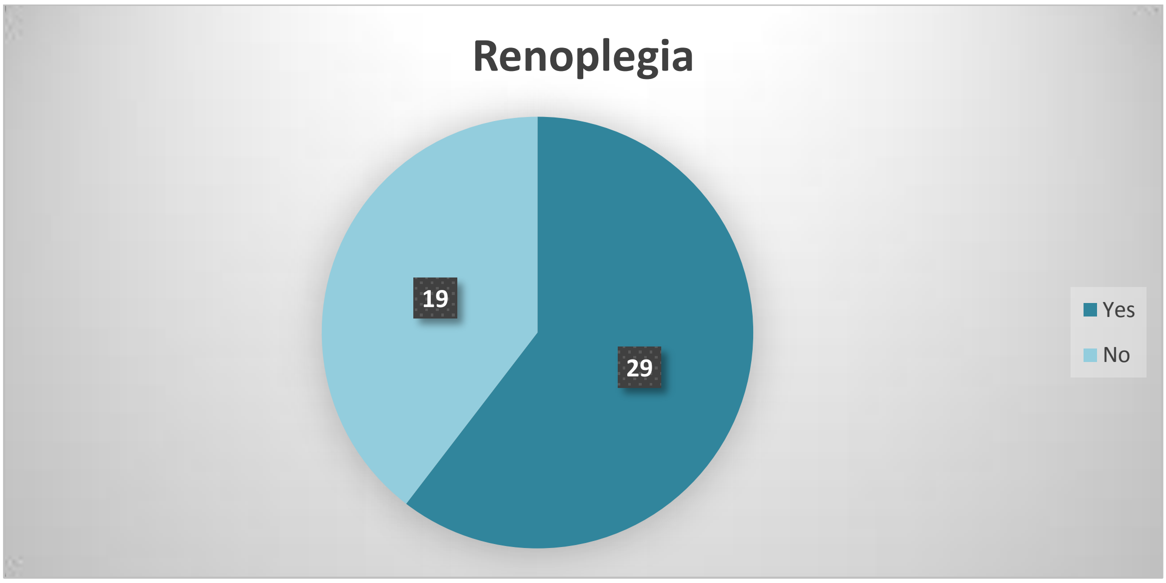
Bar diagram-1: Type of aneurysm and status of left renal vein

4) Aortic cross-clamp position and status of renoplegia:

Position of aortic cross-clamp was divided into inter-renal, suprarenal and infrarenal. Once clamp was applied and aneurysm opened, renoplegia solution (ice-cold) was infused through the exposed lower renal artery – one or both.



Bar diagram-2: Aortic clamp position



Pie diagram-2: Status of renoplegia

5) Renal function assessment on a timeline:

Renal function was assessed in the form of serum creatinine preoperatively and on post-operative days (POD) 0, 1, 3, at discharge and later during last follow up;

creatinine clearance was calculated using body weight and serum creatinine. The mean values of creatinine and creatinine clearance are given in the tables.

Table-3: Mean serum creatinine values over time

Time period	Serum Creatinine (mg/dl)	
	Mean	SD
Pre op	1.16	0.24
Day 0	1.37	0.36
Day 1	1.80	0.58
Day 3	1.95	0.85
at Discharge	1.80	1.06
At follow up	**1.42**	0.81

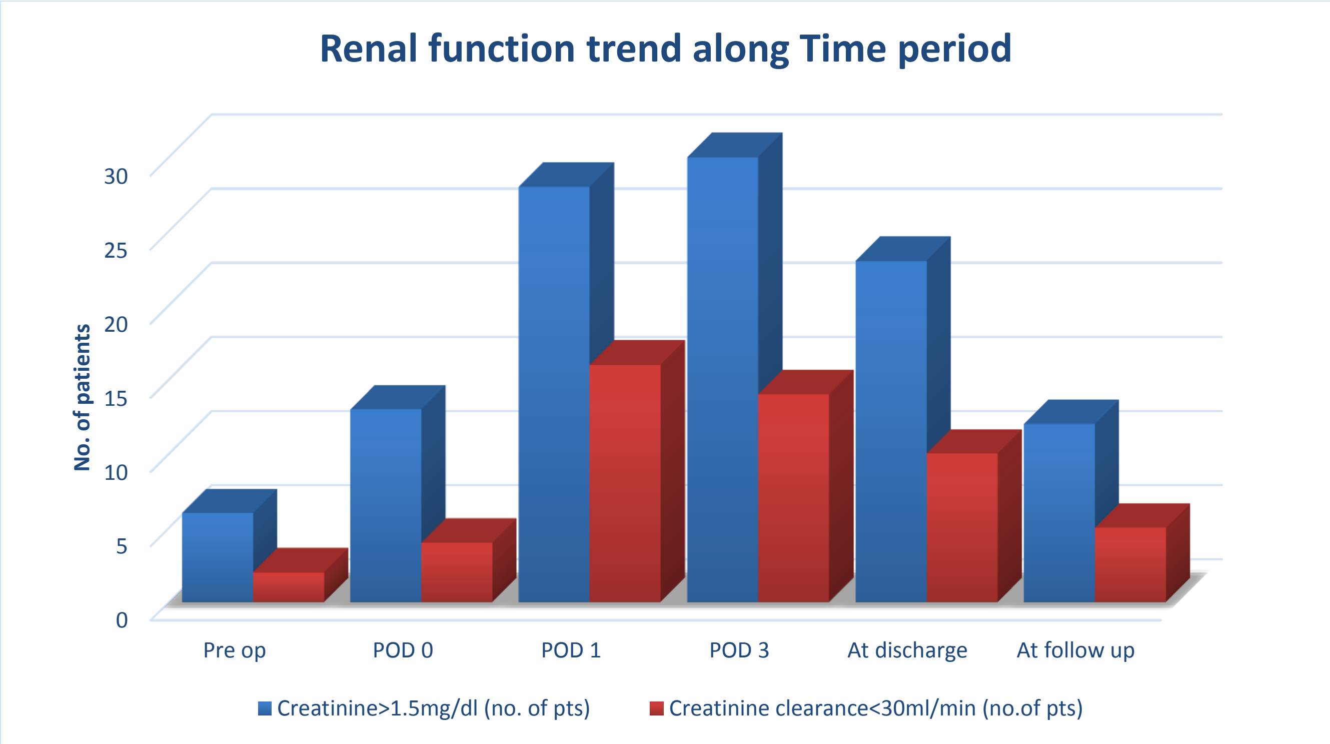
Table-4: Mean creatinine clearance values over time

Time period	**Creatinine clearance**	
	Mean	SD
Pre op	58.27	18.04
Day 0	50.46	18.50
Day 1	41.07	17.41
Day 3	38.22	16.06
at Discharge	43.16	16.91
At follow up	**52.51**	18.96

a) Comparison based on time period – preoperative, post-operative and follow up:

Most of the patients had mildly elevated creatinine at the time of discharge, but the creatinine value tended to touch baseline at 1 month and remained so at follow up also.

Creatinine clearance which is a more sensitive parameter of renal function was more on the lower side and again improved during follow up visit, mostly by 30 days post-operatively.



Bar diagram-3: Creatinine and creatinine clearance values against time period

Tables showing no. of patients with renal dysfunction i.e, creatinine >1.5 mg% and creatinine clearance <30ml/min along a timeline – preoperative vs postoperative period are given below.

Table–5: No. of patients with renal dysfunction as a factor of mean serum creatinine value over time

Renal dysfunction (>1.5mg %)	Frequency	Percent (%)
Pre op	6	12.5
Day 0	13	27.1
Day 1	28	58.3
Day 3	30	62.5
at Discharge	23	47.9
At follow up	12	25

Table–6: Renal dysfunction as a factor of mean serum creatinine clearance value over time (no. of patients)

Creatinine Clearance (<30ml/min)	Frequency	Percent
Pre op	2	4.2
Day 0	4	8.3
Day 1	14	29.2
Day 3	16	33.3
at Discharge	10	20.8
At follow up	5	10.4

b) Comparison based on Aortic cross-clamp position:

There was statistically significant elevation of serum creatinine in all clamp positions on POD 1. Although the values came towards normal at discharge and follow up, this was not significant.

Table-7: Comparison of no. of patients with high mean serum creatinine values over time at various clamp positions

Renal dysfunction (Creatinine>1.5mg/dl)	Clamp								p
	Inter		Supra		Infra		Total		
	N	%	N	%	N	%	N	%	
Pre op	3	16.7	2	12.5	1	7.1	6	12.5	0.721
Day 0	3	16.7	4	25	6	42.9	13	27.1	0.248
Day 1	**7**	**41.2**	**13**	**86.7**	**8**	**57.1**	**28**	**60.9**	**0.030**
Day 3	11	61.1	12	80	7	53.8	30	65.2	0.314
at Discharge	9	50	10	71.4	4	30.8	23	51.1	0.107
At follow up	3	16.7	6	40	3	21.4	12	25.5	0.284

When creatinine clearance was compared, there was statistically significant improvement in the values at the time of discharge and at follow up showing the normalization of renal function following the initial insult.

Table-8: Comparison of no. of patients with mean creatinine clearance values over time at various clamp positions

Renal failure (Creatinine Clearance<30ml/min)	Clamp								p
	Inter		Supra		Infra		Total		
	N	%	N	%	N	%	N	%	
Pre op	0	0	2	12.5	0	0	2	4.2	0.124
Day 0	0	0	3	18.8	1	7.1	4	8.3	0.140
Day 1	3	16.7	7	50	4	28.6	14	31.1	0.396
Day 3	5	29.4	7	50	4	30.8	16	35.6	0.130
at Discharge	**2**	11.1	**7**	50	**1**	7.7	**10**	**22.2**	**0.010**
At follow up	**1**	5.6	**4**	26.7	**0**	0	**5**	**10.6**	**0.045**

c) Comparison of Renal function between POD 3 and at discharge and follow up:

Renal dysfunction was most severe in majority of the patients by 3rd post-operative day and started to normalize at the time of discharge. Hence POD 3 values were compared with values at discharge and later at follow up visit.

The renal dysfunction improved to statistically significant levels at discharge and at follow up.

Table-9: Mean serum creatinine values compared between POD 3 and discharge and follow up

	Creatinine		Paired difference from POD 3		p
	Mean	SD	Mean	SD	
POD 3	1.796	0.250			
At Discharge	**1.536**	**1.055**	**-0.630**	**1.059**	**<0.001**
Last follow up	**1.318**	**0.806**	**-0.257**	**0.818**	**0.037**

Table-10: Mean creatinine clearance values compared between POD 3 and discharge and follow up

	Creatinine clearance		Paired difference from POD 3		p
	Mean	SD	Mean	SD	
POD 3	44.51	15.08			
At Discharge	**48.16**	**16.91**	**15.29**	**15.01**	**<0.001**
Last follow up	**58.44**	**18.96**	**5.68**	**14.70**	**0.011**

d) Renal function at discharge and follow up according to aortic cross-clamp:

When the mean serum creatinine values at discharge and follow up were compared among various aortic cross-clamp levels, although they were normalizing did not show statistical significance.

Meanwhile, increase in creatinine clearance values which is the more sensitive parameter of renal function, were statistically significant.

Table-11: Mean serum creatinine across clamp positions vs time

Clamp	Creatinine			
	At Discharge		Last follow up	
	Mean	SD	Mean	SD
Inter	1.74	1.19	1.27	0.40
Supra	2.25	1.22	1.75	1.32
Infra	1.39	0.25	1.26	0.19
p	0.100		0.162	

Table-12: Mean creatinine clearance across clamp positions vs time

Clamp	Creatinine clearance			
	At Discharge		Last follow up	
	Mean	SD	Mean	SD
Inter	46.39	16.36	58.83	20.19
Supra	33.64	18.21	43.07	17.97
Infra	48.92	12.35	54.50	15.13
p		**0.033**		**0.049**

6) Juxtarenal aneurysms with LRVDAL and LRVI:

The mean creatinine and creatinine clearance values at POD 1, at discharge and at 30 days post-operatively were assessed according to various aortic cross-clamp positions i.e, suprarenal, inter-renal and infrarenal and compared between left renal vein division group and those with intact left renal vein.

The mean creatinine values in LRVI group showed statistical significance only in infrarenal clamp at discharge whereas the improvement was not significant in inter-renal and suprarenal clamps across the same timeline.

Table-13: Mean serum creatinine across various clamp positions at POD1, discharge and 30 days in LRVD vs LRVI groups

Clamp	**Creatinine**	**LRVD**		**LRVI**		p
		Mean	SD	Mean	SD	
Inter	POD 1	1.26	0.37	1.38	0.29	0.566
	at Discharge	1.76	1.26	1.32	0.34	0.508
	At 30 days	1.20	0.31	1.26	0.43	0.726
Supra	POD 1	1.44	0.35	1.41	0.34	0.839
	at Discharge	2.25	1.22	1.47	0.44	0.122
	At 30 days	1.75	1.32	1.39	0.42	0.500
Infra	POD 1	1.31	0.27	1.26	0.21	0.750
	at Discharge	1.50	0.26	1.05	0.15	**0.045**
	At 30 days	1.20	0.16	0.96	0.12	0.085

The improvement in mean creatinine clearance values was noted to be significant in LRVI group with suprarenal clamp as compared to LRVDAL group. The same was NOT found in inter-renal and infrarenal clamp positions.

Table-14: Mean creatinine clearance across various clamp positions at POD1, discharge and 30 days in LRVD vs LRVI groups

Clamp	Creat clearance	LRVD		LRVI		p
		Mean	SD	Mean	SD	
Inter	POD 1	59.25	19.90	46.50	10.38	0.237
	at Discharge	47.88	16.77	49.50	13.67	0.860
	At 30 days	62.06	18.74	53.25	16.26	0.402
Supra	POD 1	42.81	14.28	55.22	12.20	**0.039**
	at Discharge	33.64	18.21	55.71	17.00	**0.015**
	At 30 days	43.07	17.97	61.17	16.31	**0.046**
Infra	POD 1	65.50	16.42	47.50	14.53	0.152
	at Discharge	57.25	13.38	56.00	13.86	0.909
	At 30 days	70.25	11.93	59.67	2.08	0.198

7) MORTALITY:

Table-15: No. of patients expired/survived

Status	Frequency	Percent (%)
Expired	8	16.7
Survived	40	83.3
Total	48	100

A total of 4 (8.3%) patients died in the immediate post-operative period attributable to acute kidney injury following left renal vein division and its related complications.

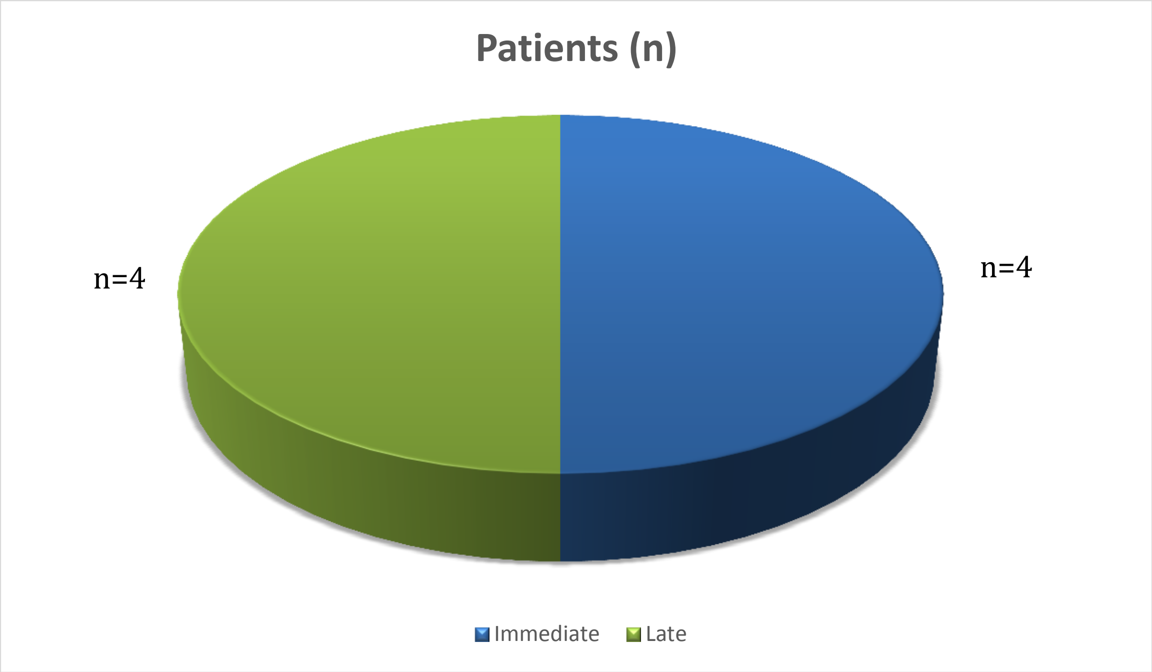
Cause of mortality in other 4 patients:

i) Patient developed type-3 equivalent thoracoabdominal aneurysm after 6 years of index surgery and underwent surgical repair for the same. He died following complications of the same.

ii) Patient developed distal anastomotic pseudoaneurysm after 3 years of surgery and presented with rupture of the same.

iii) Known Takayasu arteritis patient developed deep surgical site infection and graft thrombosis 15 months after first surgery. He underwent graft explantation followed by stormy post-operative period due to enteric perforation and repair of the same. 1 more year later, he had persistent aortic-stump infection and developed stump-enteric fistula and presented with massive malena. He died following the same.

iv) Patient had coronary artery disease (triple vessel disease) with left ventricular dysfunction and died 6 months post-surgery following acute coronary syndrome.



Pie diagram-3: No. of patients who died in immediate/late mortality group

Out of the 48 patients, a total of 44 were followed up for long term survival as 4 of them died in the immediate post-operative period.

4 more died in the follow up period, making cumulative mortality of 8. (16.7%)

Maximum follow up duration was 96 months and minimum was 2 months.

Renal function tests were done periodically during follow up visits.

A total of 5 patients required hemodialysis in the cohort; which included 3 in the mortality group.

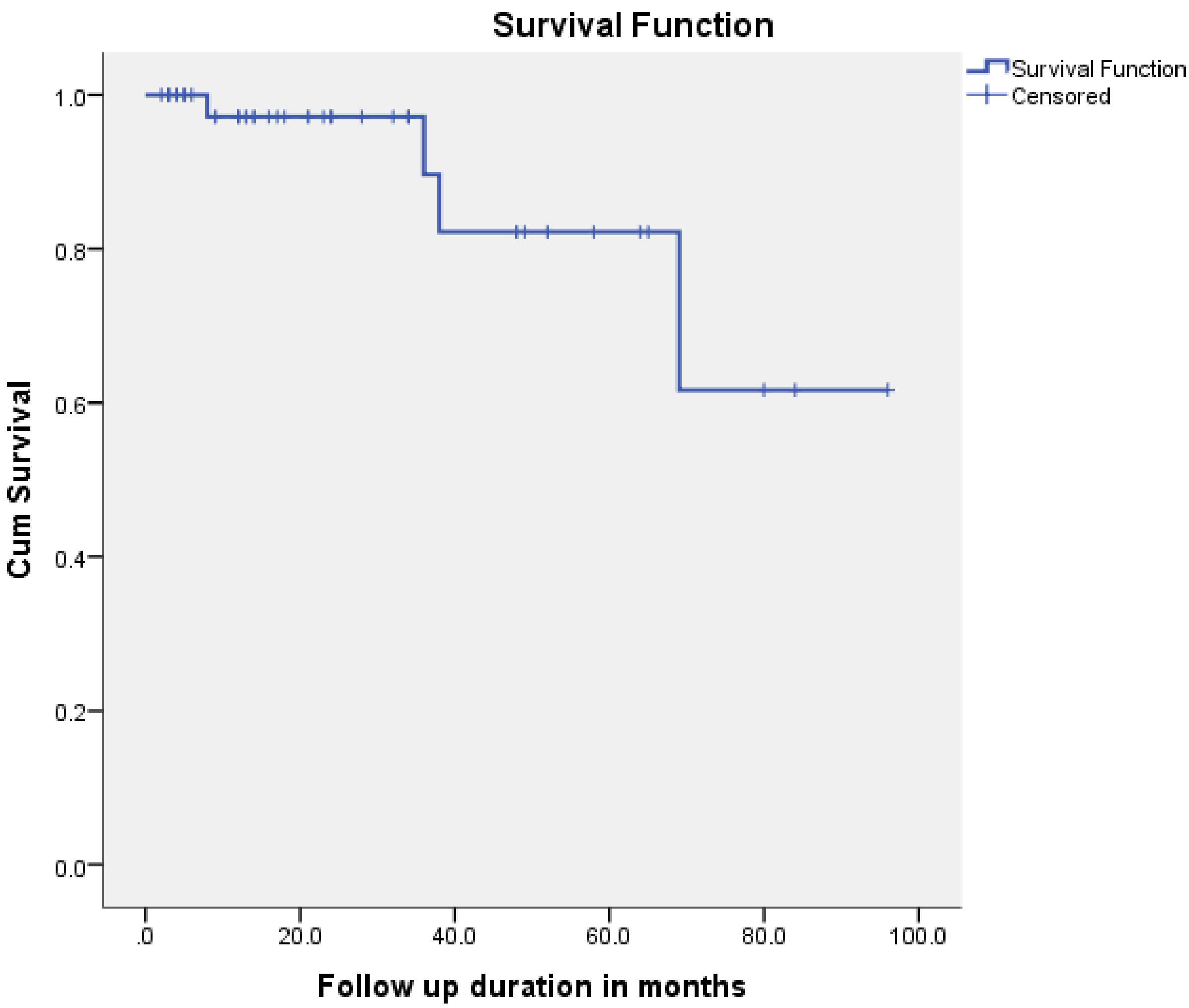
One patient (2%) became chronic kidney disease and was initiated on maintenance hemodialysis.

Mean duration of survival in months was calculated and was found to be **79.1 months** with standard error of 7.3 (95% CI of 64.8-93.4 months) and 5-year survival rate of 83%.

Table-16: Mean duration of expected survival in months

Mean Duration of survival in months			
		95% Confidence Interval	
Estimate	Std. Error	Lower Bound	Upper Bound
79.120	7.290	64.831	93.409

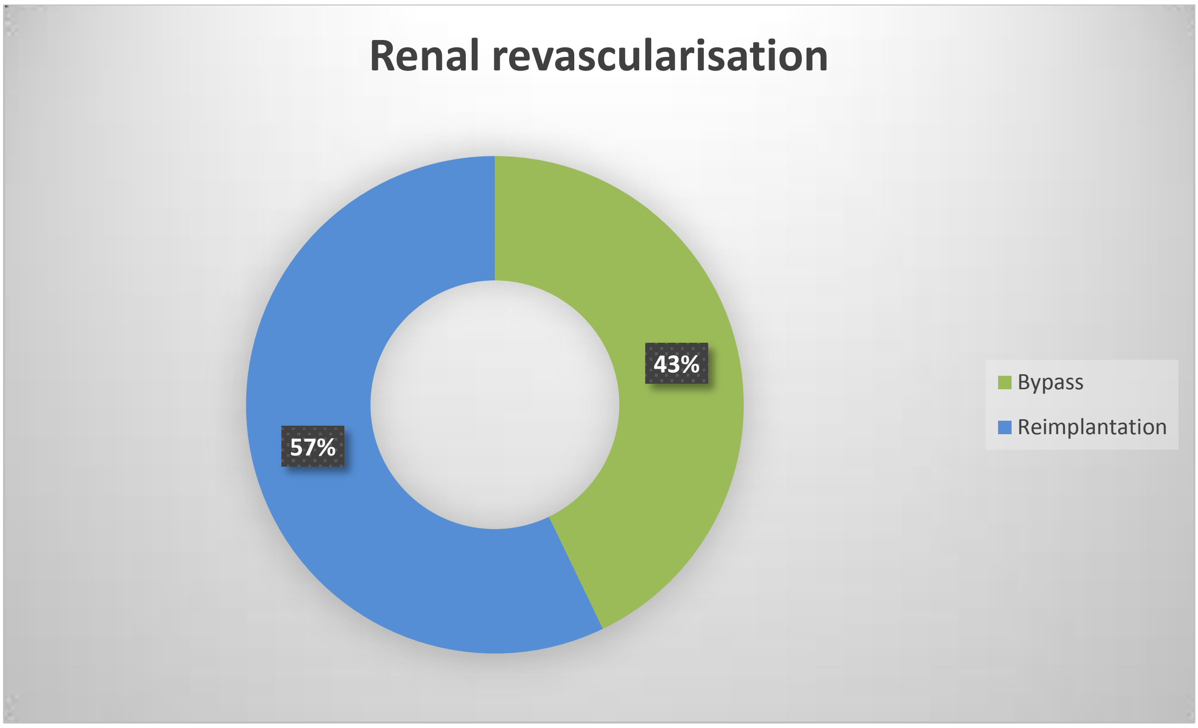
Kaplan-Meyer Survival curve for the patients who underwent left renal vein division and ligation is given below:



8) Renal revascularization:

In this cohort, 8 patients had concomitant unilateral or bilateral renal artery stenosis; out of which only 2 were symptomatic for the same.

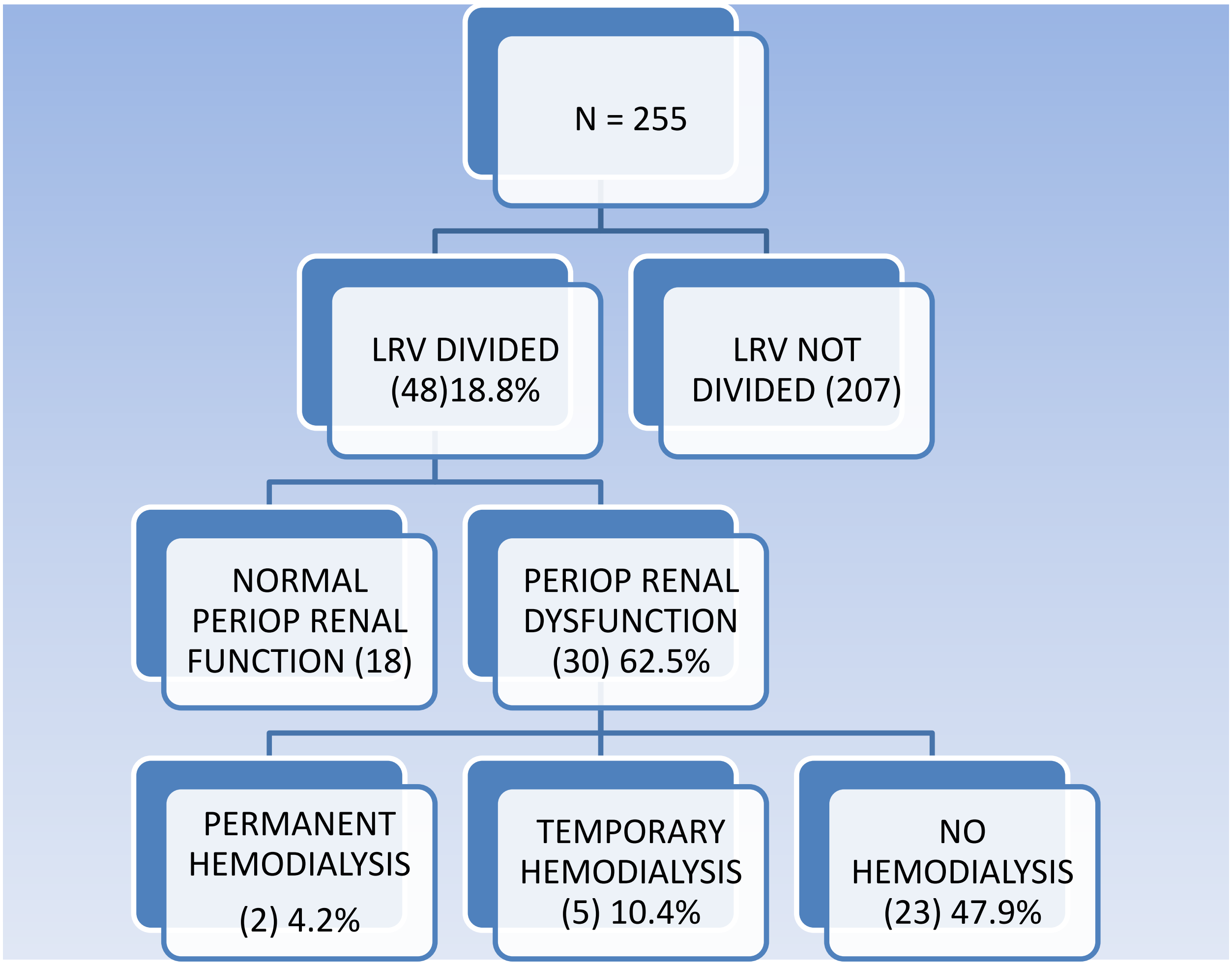
Seven patients underwent renal revascularization - 3 patients underwent bypasses using polyester graft from the aortic graft and 4 underwent direct reimplantation of artery itself.



Pie diagram – 4: Renal artery revascularisation

9) COMPLICATIONS:

a) Need for haemodialysis:



In the LRVDAL group, 5 (10.4%) patients needed temporary hemodialysis due to worsening renal function and anuria.

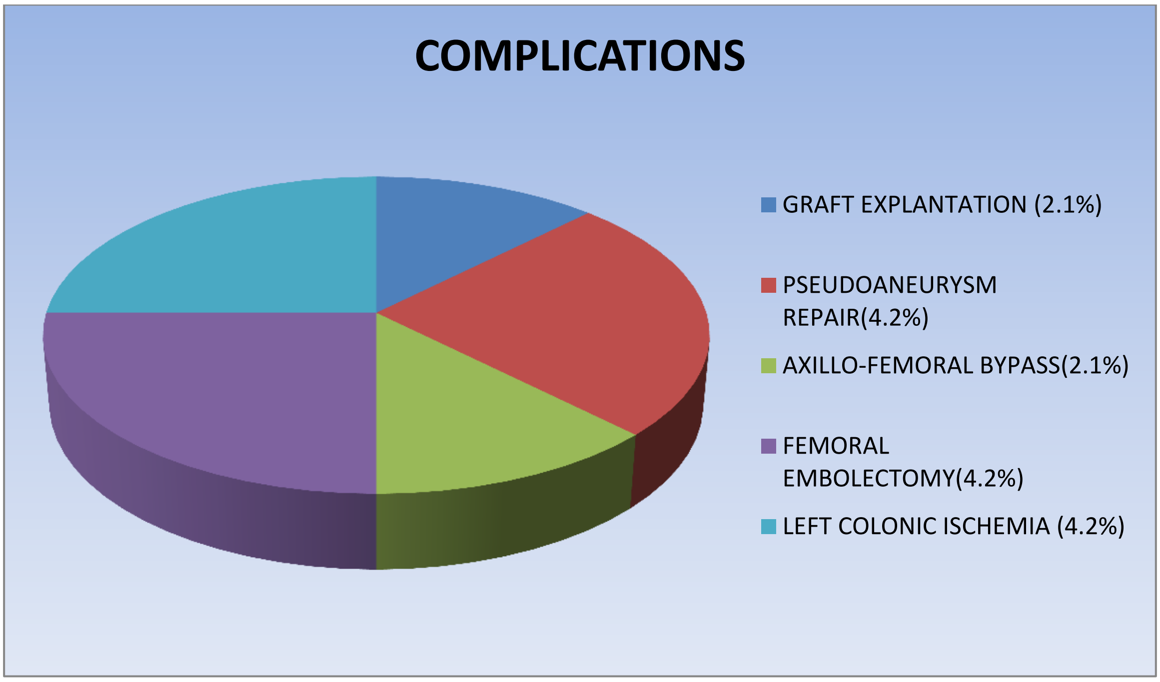
Two (4.2%) patients developed chronic kidney disease needing lifelong renal replacement therapy; both of them had mild renal dysfunction at the outset of surgery itself.

b) Worsening of COPD and adverse cardiac events:

Exacerbation of COPD was encountered in 3 (6.3%) out of 7 patients needing reintubation and prolonged mechanical ventilation.

Among the 32 patients who had coronary artery disease, 1 patient with triple vessel disease underwent concomitant aneurysm repair and died on POD 5 whereas 1 patient had acute coronary event in immediate post-op period and died by POD 9, even after revascularisation.

c) Others:



Pie diagram – 5: Complications

DISCUSSION

DISCUSSION

Our study analysed the long term safety of left renal vein division in elective abdominal aortic aneurysm surgery for adequate exposure of neck. This is one of the surgical adjuncts which can be safely employed for aiding proximal anastomosis in aneurysms with difficult neck anatomy more so in juxtarenal aortic aneurysms which have the inherent property of short or absent neck and close proximity of aneurysm sac to the renal arteries. One of the first reports of safe and successful left renal vein division came from Neal et al (36). But contradicting reports existed till recently over the need for routine re-anastomosis of the divided left renal vein. One of the first studies in this aspect came from Szilagyi et al and many surgeons following him stressed routine left renal vein reconstruction (37). The long term renal function in routine abdominal aortic aneurysm surgery with intact left renal vein has been well documented (41,48). That pushed us to look into the long term survival in left renal vein division patients.

Mayo clinic group came with their experience with 126 patients and reiterated the safety of LRVD without reconstruction as long as the major draining channels namely gonadal, lumbar and suprarenal veins were preserved (48). Immediate effect of left renal vein division is renal venous congestion with hypertension which follows a crescendo pattern till 3rd or 4th day with rising renal parameters i.e., creatinine and falling creatinine clearance following which the collaterals take over the venous drainage adequately. Serum creatinine falls from then on, and majority of the patients tend to have near normal creatinine at the time of discharge or by 7th day. By post-operative day 30, most patients in our study had a normal function similar to the Mayo Clinic group.

Marrocco-Trischitta et al., reporting on a group of AAAs who underwent LRVD and reconstruction during open repair, concluded that left renal vein reconstruction maintained renal function and was not associated with lengthening operative time and increasing complications (46). However, re-anastomosis of the vein can only be completed safely and quickly by a well-trained surgeon.

Another important factor deciding on post-operative renal dysfunction is the placement of aortic cross-clamp. Huber et al in their study showed that there was persistently high serum creatinine in suprarenal clamp as compared to inter-renal or infrarenal clamping (42). We also found that creatinine clearance had decreased in suprarenal clamp group and tended to stay so for long although in long term follow up there was no difference. This might probably be due to the added insult of acute renal ischemia due to the cross-clamp. In our study we did not find any statistically significant correlation in serum creatinine values in different clamp positions.

Dubois et al in their series found that postoperative transient renal dysfunction occurred in 37.3% of patients after open juxtarenal AAA repair, with a low incidence of dialysis and a low rate of permanent dysfunction with in-hospital mortality of 9.5% (28). We found that 56.3% patients had renal dysfunction which peaked by POD 3, came towards normal at discharge in 45.8 % and had touched baseline on long term follow up in 77.1% patients. Technical factors including renal ischemia time, aortic clamp position, and left renal vein division were the strongest predictors of renal dysfunction. Our study also had similar disease-specific in-hospital mortality of 8.3%.

Use of renoplegia solution to increase renal tolerance to ischemia was practiced and perfected by renal transplant surgeons especially for cadaveric donor kidney harvest. We used custom-made solution with heparin, papaverine, mannitol, hydrocortisone and sodabicarbonate in ice cold saline or ringer's lactate solution in our patients. The definitive protection offered by this has been well documented by studies by Allen et al, and Tshomba et al, in their series of repair of juxtarenal and pararenal aortic aneurysms (27,45).

Juxtarenal aortic aneurysms pose serious technical challenge as compared to infrarenal aortic aneurysms in three aspects: addressal of the viscerorenal segment with need for renal revascularization, aortic cross-clamping with one or both renal arteries under the clamp, and avoiding renal ischemia as much as possible. The intricacies of surgical repair exemplify when there is concomitant iliac artery aneurysm or when there is need for renal artery revascularization. Allen B et al in their large series found that careful consideration of the route of exposure, location of the proximal aortic clamp, and the preservation of renal function with renal hypothermia and with the repair of significant renal artery lesions will result in minimal morbidity and mortality in patients requiring surgery for juxtarenal or suprarenal abdominal aortic aneurysms (27).

The morbidity associated with open surgical repair of juxtarenal aortic aneurysms still remains acceptably high as presently, the indication for intervention in most centres are due to failed endovascular option or due to the complex anatomy of the aneurysm. With advent and evolution of more complex aortic stent graft devices in the last decade, EVAR (fenestrated or branched) has become the procedure of choice in this group of patients, extending the limits of usage of aortic endograft devices (29).

A Dutch meta- analysis on repair of JRAAA, including 21 non-randomized cohort studies from 1986 to 2008, involving 1256 patients, had shown perioperative mortality 2.9% and new onset of dialysis of 3.3% (49). Immediate mortality in our study group was slightly higher 8% - 3 out of 4 were due to acute kidney injury and related complications whereas another patient died due to sepsis. It was significant to note that 2 patients had preoperative renal dysfunction at the time of surgery and needed hemodialysis in the post-operative period. We also found that we had higher number of patients with significant coronary artery disease adding to the morbidity and ensuing long term mortality.

As things stand today, endovascular technique is the first option even for complex aortic aneurysms with the evolution of newer aortic stent grafts. Open surgery hence has become even more technically challenging as more and more complex aneurysms which are not amenable to EVAR are chosen for open surgical repair. Available literature is still insufficient to substantiate whether LRVDAL is a marker for complexity of the surgery and has caused the morbidity in those patients. Randomised controlled trial in this regard would be unethical to compare patients with LRVD to those with intact LRV. There should be more good surgical risk patients with juxtarenal aortic aneurysms who need to undergo open surgical repair so that more details can be known regarding effects of the surgical adjuncts required for easing the surgical procedure.

CONCLUSION

CONCLUSION

Left renal vein division and ligation can be safely employed in juxtarenal aortic aneurysms and infrarenal aortic aneurysms with hostile neck anatomy for favour of adequate exposure of the underlying aorta. Long term survival is comparable to patients who have not undergone division. Renal function in these patients deteriorated in the immediate post-operative period but normalised towards discharge and tended to remain stable in long term. Renoplegia offers protection from ischemic renal damage to some extent. According to our results, we advocate routine division of left renal vein without reconstruction. As aortic aneurysms with favourable anatomy are being managed with endovascular techniques, open surgery would be performed for even more complex aneurysms, warranting techniques like left renal vein division for optimal surgical exposure.

LIMITATIONS:

1) There was no randomisation in our study and no direct comparison was made between all patients who had intact left renal vein and left renal vein division.

2) Details into the effects of risk factors and individual clamp time were not analysed in detail.

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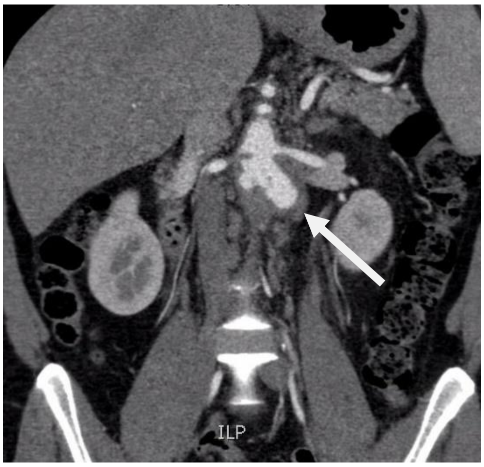
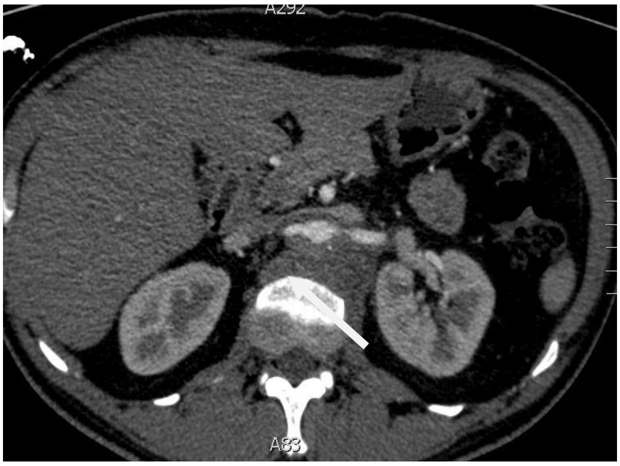
UNIQUE CASES

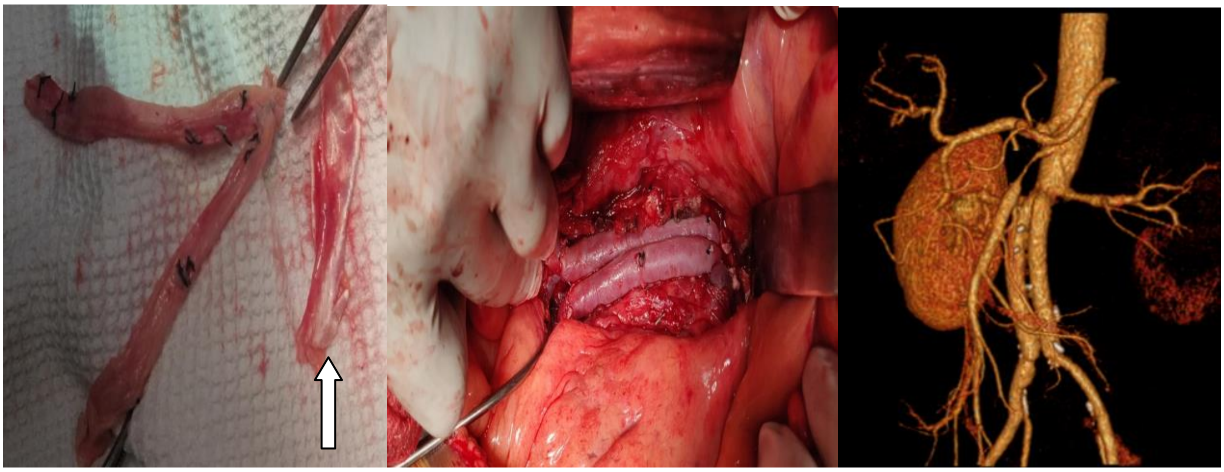
1) MYCOTIC JUXTARENAL AORTIC ANEURYSM

- 50-year old gentleman presented with complaints of worsening abdominal pain for 3 months with recurrent high grade fever.
- He was a diabetic hypertensive on treatment
- CT Angiogram revealed saccular juxtarenal aortic aneurysm with possible contained rupture and normal looking distal aorta and iliac arteries and asymptomatic SMA stenosis.



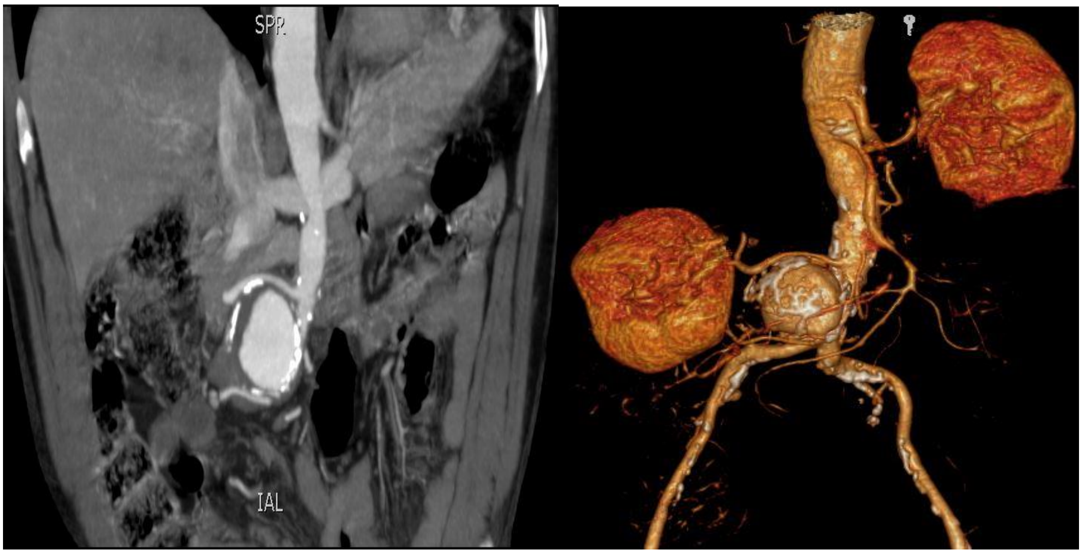


- Blood and Urine culture grew Group D Salmonella sp. and Widal test was positive.
- He underwent aneurysm repair with Neo-Aorto-Iliac System using bilateral superficial femoral veins made into a pantaloon graft buttressed posteriorly with tensor fascia lata.

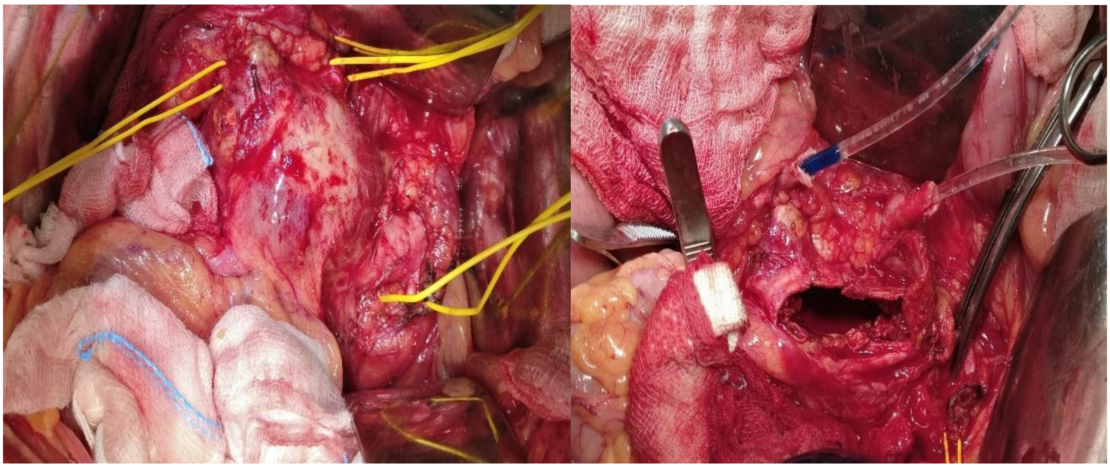


2) AORTIC ANEURYSM IN A SETTING OF CONGENITAL RENAL VASCULAR ANOMALY

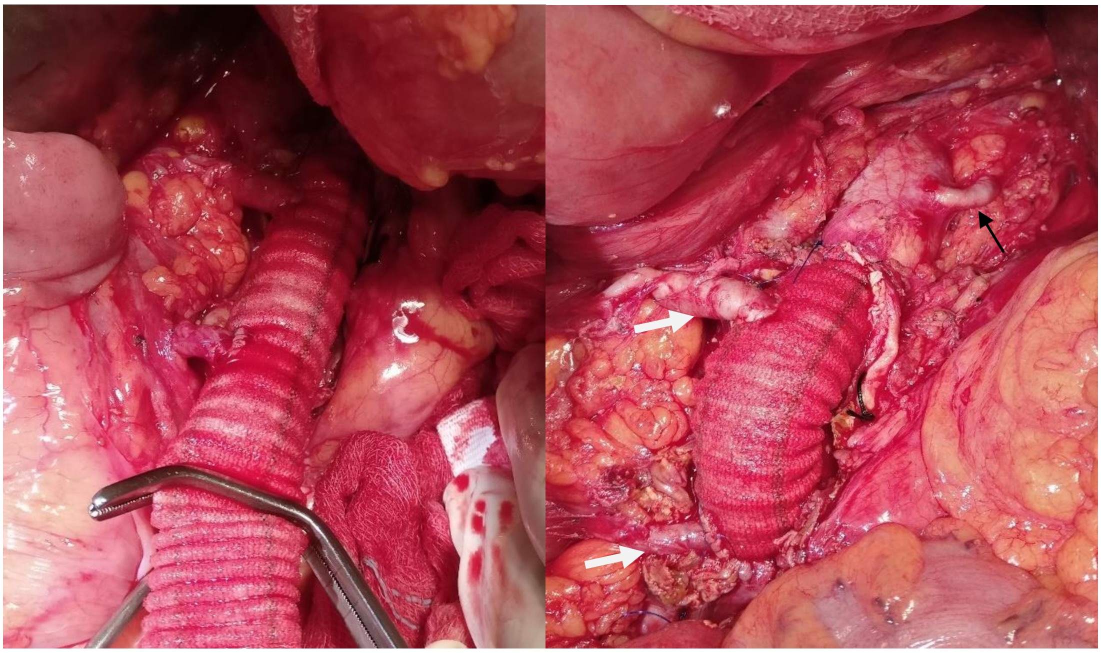
- 72-year old hypertensive presented with low back pain for 3 months



CT Aortogram shows unascended rotated right kidney with double renal arteries and adjoining saccular aortic aneurysm



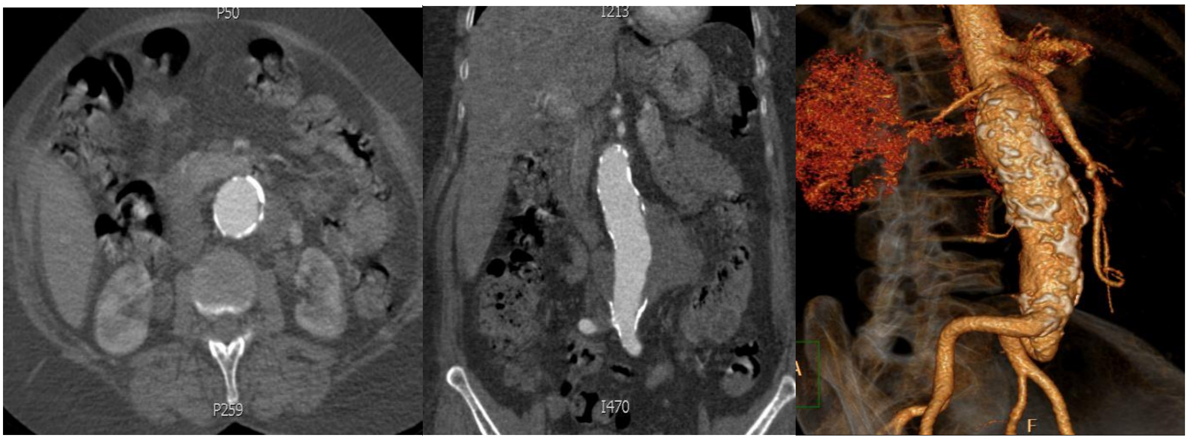
Intraoperative pictures showing anueysm and renal arteries being looped; Cold renoplegia being administered to renal arteries



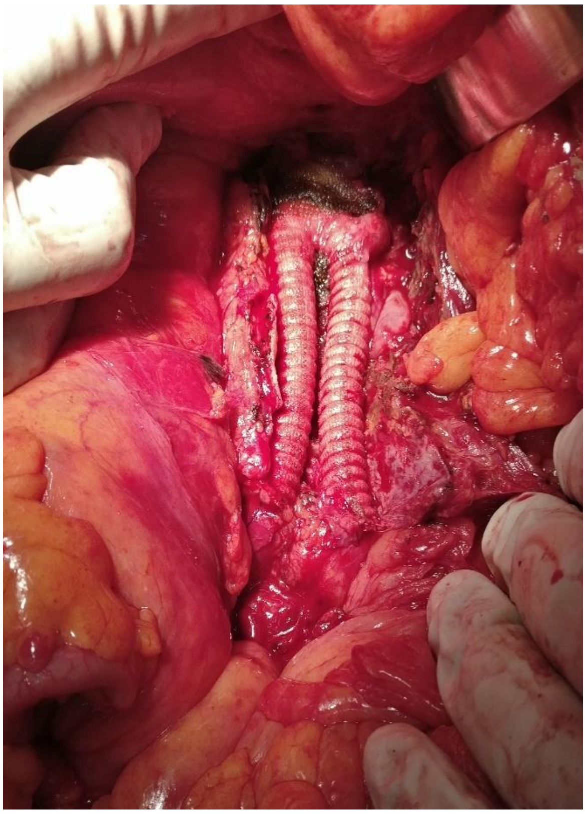
Renal arteries being implanted onto the aortic polyester graft; Completed anastomosis showing implanted renal arteries and higher left renal artery.

3) JUXTARENAL AORTIC ANEURYSM IN TAKAYASU'S ARTERITIS

- 52-year old female presented with recurrent joint pain and low back pain.



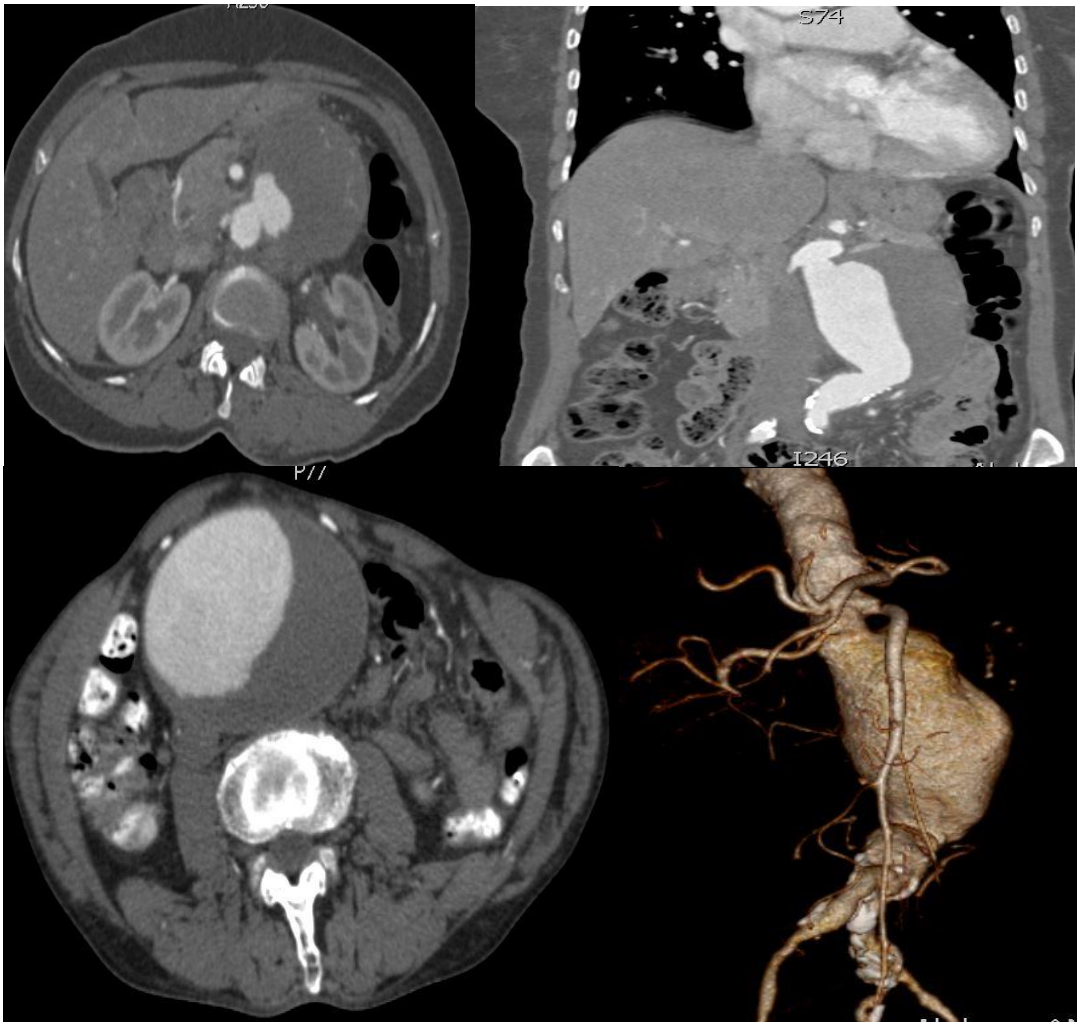
CT aortogram showing circumferential aortic calcification



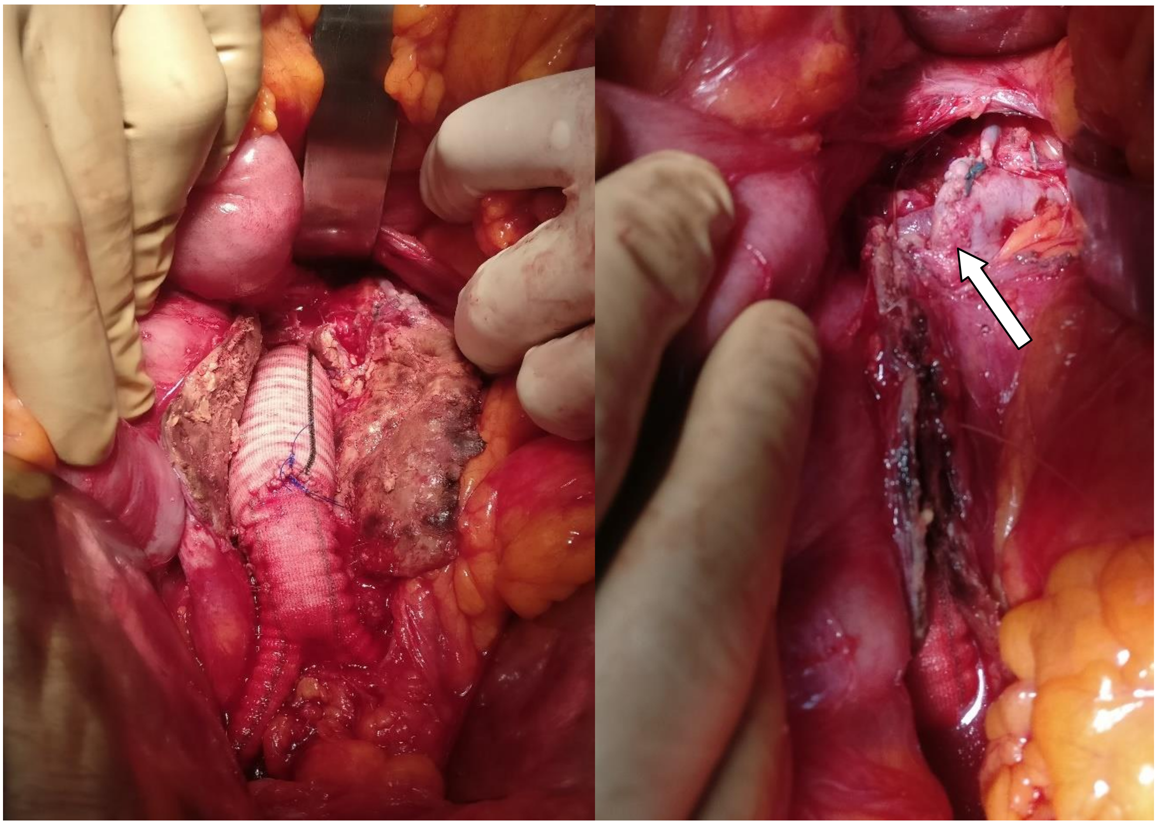
Intraoperative picture showing bifurcated graft to both common iliac arteries with left renal artery reimplanted onto the distal part of themain body of the graft.

4) JUXTARENAL AORTIC ANEURYSM WITH BILATERAL COMMON ILIAC ARTERY ANEURYSMS

- 72-year old diabetic hypertensive patient with triple vessel coronary artery disease presented with acute worsening of abdominal and low back pain and history of bilateral thigh claudication pain for 3 months



CT Aortogram showing diseased aorta with a large juxtarenal aortic aneurysm extending into b/l CIAs



Intraoperative picture showing bifurcated aortofemoral graft; divided left renal vein stump.

ABBREVIATIONS

AAA – abdominal aortic aneurysm

bEVAR – branched endovascular aneurysm repair

CAAA – complex abdominal aortic aneurysm

CAD – coronary artery disease

CIA – common iliac artery

COPD – chronic obstructive pulmonary disease

CKD – chronic kidney disease

CTA – computed tomographic angiogram

EVAR – endovascular aneurysm repair

fEVAR – fenestrated endovascular aneurysm repair

GFR/eGFR – glomerular filtration rate/estimated

HTN – hypertension

IMA – inferior mesenteric artery

JRAA – juxtarenal aortic aneurysm

LRV – left renal vein

LRVI – left renal vein intact

LRVDAL – left renal vein division and ligation

MRA – magnetic resonance angiography

OSR – open surgical repair

POD – post-operative day

TAAA – thoracoabdominal aortic aneurysm

ANNEXURES

ANNEXURE - I

PATIENT INFORMATION PROFORMA

Sl No:

AGE/SEX Weight BSA

RISK FACTORS:

Hypertension

Diabetes

Coronary Artery disease

Peripheral Arterial disease

Chronic kidney disease

Dyslipidemia

Smoker

Parameters:

1) Preoperative:

Blood urea/Serum creatinine/eGFR/ Urine routine & micro

2) Intraoperative:

Aortic clamp: a) Infrarenal b) Inter-renal c) Suprarenal d) Supracoeliac

Aortic clamp time:

Renal protection: Yes/No

Left renal vein division: Yes/No

2) Post-operative:

Blood Urea / Serum Creatinine POD 0; POD 1; POD 3; 30 days; At Discharge; Follow up visit

Hemodialysis: Yes/No (If Yes- No. of sittings)

eGFR: At discharge; Follow up visits

3) Complications: Immediate post-operative/ Long term

ANNEXURE - II

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ANNEXURE - III

Technical Advisory Committee (Clinical Studies)

SREE CHITRA TIRUNAL INSTITUTE FOR MEDICAL SCIENCES & TECHNOLOGY
THIRUVANANTHAPURAM – 695011, INDIA

TAC Registration No: SCT-/S/2018/858 **Date: 22.01.2019**

Project title: IMPACT OF LEFT RENAL VEIN DIVISION DURING ABDOMINAL AORTIC ANEURYSM REPAIR ON IMMEDIATE AND LONG-TERM RENAL FUNCTION

Principal Investigator:	
Dr. Harishankar R Senior Resident, Division of Vascular Surgery, Department of CVTS, SCTIMST	Degree: MS, MRCSEd
Co-Principal Investigator(s)	
Dr,Varghese.T.Panicker Additional Professor, Division of Vascular Surgery, Department of CVTS, SCTIMST	Degree: MS, MCh (CVTS)
Dr. Shivanesan.P, Assistant Professor, Division of Vascular Surgery, Department of CVTS, SCTIMST	Degree: MS, MCh (Vascular Surgery)

Members who participated in the TAC meeting on 16/01/2019
Dr. Rupa Sreedhar (Chairperson)
Dr. Prasantakumar Dash
Dr. Krishna Kumar K
Dr. Sankara Sarma P
Dr. Sylaja. P.N
Dr. Bijulal S
Dr. Sanjay G
Dr. Varghese T. Panicker
Dr. K. Shivakumar (Member Secretary)

Dr. Sylaja. P.N, Dr. Sanjay G, Dr. Rupa Sreedhar Dr. Bijulal S and Dr. K. Shivakumar stayed away from the proceedings when the projects in which they are involved as investigator were discussed (# 861,874, 876,877, 879).

Risk Classification of the project (Minimum/ Moderate/ High): Minimum
Requirement of DSMB: No
Recommended members of DSMB: Not applicable

Recommendations of TAC:
Recommended for consideration of IEC in the light of the responses received from the investigator

The PI may note that there can be no additions / alterations in the documents approved by TAC when they are submitted to the IEC.

Signature of the Member Secretary, TAC (Clinical Studies)

Note for IEC
Copy of the investigator's responses to questions/suggestions from TAC is attached (Appendix-1).

ANNEXURE - IV

श्री चित्रा तिरुनाल आयुर्विज्ञान और प्रौद्योगिकी संस्थान, त्रिवेन्द्रम
तिरुवनन्तपुरम - ६९५०११, केरल, इंडिया
SREE CHITRA TIRUNAL INSTITUTE FOR MEDICAL SCIENCES AND TECHNOLOGY, TRIVANDRUM
Thiruvananthapuram - 695 011, Kerala, India
(An Institute of National Importance under Govt. of India)
Grams : Chitramet, Phone : +91-471-2443152, Fax : +91-471-2550728 / 2446433, E-mail : sct@sctimst.ac.in, Website : www.sctimst.ac.in

Institutional Ethics Committee

(IEC Regn No. ECR/189/Inst/KL/2013/RR-16)

SCT/IEC/1352/FEBRUARY-2019 18.02.2019

Dr. Harishankar R
Senior Resident
Department of CVTS
SCTIMST, Thiruvananthapuram

Dear Dr. Harishankar,

The Institutional Ethics Committee reviewed and discussed your application to conduct the study entitled "IMPACT OF LEFT RENAL VEIN DIVISION DURING ABDOMINAL AORTIC ANEURYSM REPAIR ON IMMEDIATE AND LONG-TERM RENAL FUNCTION (IEC/1352)" on 16th February, 2019.

The following documents were reviewed:

1. *Covering Letter addressed to the Chairman, IEC, SCTIMST with checklist*
2. *Forwarding Letter from the HOD*
3. *TAC Approval Letter*
4. *IEC Application Form*
5. *Project Proposal*
6. *Proforma*
7. *CV of Principal Investigator and Co-Principal Investigators*

Page 1 of 2

The following members of the Ethics Committee were present at the meeting held on 16th February, 2019 at G. Parthasarathi Board Room, AMCHSS, SCTIMST

SL. No.	Member Name	Highest Degree	Gender	Scientific /Non Scientific	Affiliation with Institution(s)
1.	Dr. R V G Menon	M Tech, PhD	Male	Lay Person (Chairman)	No
2.	Dr. Rema M. N	MD	Female	Basic Medical Scientist	No
3.	Dr. Kala Kesavan. P	MBBS, MD	Female	Basic Medical Scientist	No
4.	Dr. Harikrishna Varma PR	Ph.D(Materials Science)	Male	Medical Technology	Yes
5.	Dr. Christina George	MD Psychiatry	Female	Clinician	No
6.	Dr. S S Giri Sankar	LL.M. Ph.D.	Male	Legal Expert	No
7.	Dr. Aneesh V Pillai	BA. LLB (Hons.), LLM, Ph. D, SET (Law)	Male	Legal Expert	No
8.	Dr. P. Manickam	BSMS, MSc (Epid).,PhD	Male	Health Science Expert/ Social Scientist	No
9.	Mr. Satheesh Chandran	MSW, PGDPM	Male	Lay person/ NGO/ Social Scientist	No
10.	Dr. Harikrishnan S	MD, DM (Cardiology) DNB (Cardiology)	Male	Clinician	Yes
11.	Dr. Mala Ramanathan	PhD	Female	Social Scientist (Member Secretary)	Yes

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,

Mala Ramanathan
Member Secretary, IEC

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ANNEXURE - V

Name	Age	Sex	Aneurysm	Hosp No	Surgery Date	HTN	DM	CAD	CKD	V Divis	nterenal Clam	enopleg	arenal c	renal cl	op Creatin	Wt	Cr Cl	POD 0 Creatinine
Nair S.R	78	M	Infra	280126	07-10-13	+	-	+	+	+	-	-	-	+	1.6	71	38	2
Kesavan Nair B	59	M	Juxta	281004	15-07-09	+	-	+	-	+	+	+	-	-	1.5	71	53	1.4
Rajan	52	M	Juxta	287108	23-10-08	+	-	-	-	+	+	+	-	-	1.1	66	73	2.1
Yatheendran.N	65	M	Juxta	304388	24-11-09	-	-	+	-	+	-	-	+	-	1.5	50	35	2
Chandran C	53	M	Juxta	322293	19-02-11	-	+	+	-	+	+	+	-	-	0.8	55	83	0.9
Abdul Rahman	62	M	Juxta	323266	03-03-11	+	-	+	-	+	+	+	-	-	0.9	64	77	1.1
Cletus	35	M	Juxta	330549	19-07-11	+	-	-	-	+	+	+	-	-	0.7	70	100	0.9
Stanislavos	75	M	Infra	334956	25-10-11	+	-	+	-	+	-	-	-	+	1.3	63	44	1.8
Pathrose	73	M	Juxta	336345	29-11-11	+	-	-	-	+	-	-	+	-	1.4	43	30	1.4
Krishnan M	60	M	Infra	340101	31-07-12	-	-	-	-	+	-	-	-	+	1.3	68	58	2
Koshy PA	77	M	Juxta	341655	27-03-12	+	-	+	-	+	+	+	-	-	1.7	71	37	1.8
Nanu M	56	M	Juxta	345746	31-07-12	+	-	+	-	+	+	+	-	-	1.3	56	54	1.4
Rajan E G	64	M	Juxta	352235	28-04-14	-	-	-	-	+	+	+	-	-	1	65	73	1.1
Retnakaran Nair	63	M	Juxta	354344	03-06-15	+	+	-	-	+	+	+	-	-	1.4	55	42	1.4
Sasidharan Nair K	60	M	Juxta	357764	15-03-13	-	-	-	-	+	+	+	-	-	1.1	57	58	1.1
Damodaran N	82	M	Infra	359782	29-04-13	+	+	+	-	+	-	-	-	+	1.3	48	31	1.9
Narayana Pillai	68	M	Juxta	365498	13-11-13	+	-	-	-	+	-	+	+	-	1.1	59	54	1.2
Nasim Banu	46	F	Juxta	366352	17-01-14	+	-	-	-	+	+	+	-	-	0.8	52	72	0.8
Ramachandran Pillai	64	M	Juxta	371004	04-12-13	-	-	+	-	+	+	+	-	-	1.1	57	55	1.4
Velayudhan Nair	69	M	Juxta	371815	01-02-14	+	-	+	-	+	-	+	+	-	1.1	69	62	1.6
Alex F	51	M	Infra	377015	05-08-14	+	-	+	-	+	-	-	-	+	1	40	62	1
Varghese	60	M	Infra	394275	25-07-16	+	+	+	-	+	-	-	-	+	0.97	64	73	0.89
Anandh Rao	55	M	Juxta	403145	20-10-15	+	-	+	-	+	-	+	+	-	1.2	55	54	1.3
Muhammed Kutty	63	M	Juxta	408981	01-03-16	+	-	+	+	+	+	+	-	-	1.8	58	34	1.6
Chandrasekhar	80	M	Infra	410730	10-03-16	+	+	+	-	+	+	+	-	-	1.1	65	49	1.4
Sathya Narayana	46	M	Juxta	411712	30-03-16	+	-	-	-	+	-	-	-	+	1.1	65	77	1.7
Jayamohana Kumar	61	M	Juxta	415901	20-06-16	+	-	-	-	+	-	-	-	+	0.9	85	104	1.1
Varughese	67	M	Infra	417804	28-07-16	+	-	-	-	+	-	-	-	+	1.2	64	54	1.1
Abraham	66	M	Juxta	418483	21-09-16	+	-	+	-	+	-	-	-	+	1.16	68	60	1.29
Alavikutty	60	M	Juxta	429159	20-03-17	+	+	+	-	+	+	-	-	-	1.15	70	68	1.04
Unnikrishnan.V	50	M	Juxta	433417	15-06-17	+	-	+	-	+	-	-	-	+	0.95	68	90	1.16
Salim Ummer	66	M	Juxta	433510	16-06-17	+	-	+	-	+	-	+	+	-	1.2	58	50	1.4
Chendoor Pandian	70	M	Infra	440131	16-10-17	+	-	-	-	+	-	-	-	+	1.05	65	60	1.35
Sulaiman	61	M	Juxta	442582	13-12-17	+	-	+	-	+	-	+	+	-	0.95	72	83	1.28
Vasudevan	72	M	Juxta	447605	25-05-18	+	-	+	-	+	-	+	+	-	1.12	60	51	1.69
Hussain	70	M	Infra	448527	12-04-18	+	-	+	-	+	-	-	-	+	1.3	62	46	1.53
Krishnan Chettiyar	70	M	Infra	450189	10-05-18	+	-	+	-	+	+	+	-	-	0.83	57	67	1.03
Sairandhri	76	F	Juxta	450700	09-05-18	+	-	+	-	+	-	+	+	-	1.16	49	32	1.15
Joseph C	66	M	Juxta	451435	21-05-18	+	-	+	-	+	+	+	-	-	0.95	56	61	0.8
Jaffer	64	M	Juxta	452307	21-06-18	+	+	+	-	+	+	-	-	-	0.95	62	69	1.31
Sukhwantin Bai	54	F	Juxta	453780	12-02-19	+	-	-	-	+	-	+	+	-	1.26	66	53	1.23
Ashraf	50	M	Juxta	456111	03-09-18	+	-	-	-	+	-	+	+	-	1.11	72	82	1.26
Krishnan C	70	M	Juxta	456931	15-10-18	+	+	+	-	+	-	+	+	-	1.01	68	66	1.09
Podiyan	75	M	Juxta	457312	11-10-18	+	-	-	-	+	-	+	+	-	1.18	46	35	1.14
Podiyan Y	67	M	Juxta	461864	03-01-19	+	-	+	-	+	-	+	+	-	0.87	49	57	1.34
Gopalan Sankaran	71	M	Juxta	464453	11-02-19	+	+	+	-	+	-	+	+	-	1.29	71	53	1.48
Md mustafa kunju	72	M	Infra	467245	01-04-19	+	-	+	-	+	-	-	-	+	1.2	63	50	1.47
Sambhu Nair	71	M	Juxta	9601542	21-10-13	+	-	+	-	+	-	-	+	-	1.7	50	28	2.4
	61.3YR					Interrenal C		18							1.23			Mean
						Supra renal C		16									19.45066	SD
			Juxta	36		Infra renal C		14										n
			Infra	12														Mean
																		SD
																		n
															Inter	61.42		
															Supra	41.8		
															Infra	58.42		

e	S Creat POD1		S-creat POD3		Creatinine at Discharge		Last S-Creatinine	Cr Cl	Follow up	Post op complications	
31	2.3	27		25	1.8	34	1.5	41	12		
57	1.4	57	1.8	44	1.6	50	1.4	53	69	fter 6 years post type 3 TAAA repair	
38	1.4	58	1.4	58	1.4	58	1.1	73	48		
26	2.3	23	2.6	20	3.6	14	1.2	43	3		
74	1.1	60	1.1	60	1.1	60	0.9	74	65		
63	1.3	53	2	35	1.8	39	1.3	59	96		
113	1.4	73	1.5	68	1.4	73	1	102	36	after 3 years due to ruptured PSA	
31	1.9	30	2.1	27	1	57	1.05	54	84		
29	2.1	19	2	20	2	20	1.8	30	3		
37	1.9	39	1.4	53	1.4	53	1.6	47	2		
35	2.2	28	3.6	17	2.1	30	1.9	33	48		
50	1.7	41	2	35	1.5	47	1.3	54	80		
67	2.9	26	4.4	17	6.3	12	1.66	41	24	Renal Failure	
42	2.1	28	1.9	31	1.8	33	1.1	53	14		
58	1.3	49	1.4	45	1.2	53	0.7	90	14		
20	2.6	15	1.4	28	1.5	26	1.5	32	18		
49	1.9	31	3.5	17	4.7	13	1.8	33	58	Renal Failure	
72	1.1	52	1.1	52	1.1	52	0.8	85	49	Pelvic ectopia	
43	2.5	24	1.7	35	1.5	40	1.1	55	52		
36	2		2							Mortality	
49	1.1	45	1.4	35	1.2	41	1.3	33	24		
80	0.81	88					1	71	21		
50	2.8	23	2.4	27	1.9	34	1.4	46	4	Single right kidney	
39	2	31	2	31	2	31	1.45	46	34		
39	2.2	25	1.9	29	1.7	32	1.3	42	34	ft RAS with reimplantation	
50	1.5	57	1.4	61	1.4	61	1.1	77	38	Mortality	
85	1.3	72	1.4	67	1.6	58	1.4	67	23		
59	1.3	50	1.5	43	1.3	50	1.2	54	12		
54	2.29	31	2.54	28	1.8	39	1.27	55	32		
75	1.34	58	1.08	72	1.15	68	1.1	70	28		
73	1.44	59	1.6	53	1.2	71	1.04	82	8	Mortality	
41	1.58	37	1.9	31	1.62	36	1.4	41	9	COPD	
47	1.41	45	1.91	33	1.25	51	1.2	53	21		
62	2.15	37	1.9	42	1.38	57	1.15	69	17		
34	3.62	16	4.76	12	4.8	12	6.41	9		Mortality	
39	1.7	35	1.1	55	1.1	55	1.2	50	16	COPD	
54	1.08	55	1.1	50	1.48	37	2.36	24		Mortality	
32			1.19	31			1.05	35	13		
72			1.08	53	0.79	73	1.18	49	13		
50	1.49	44	2.14	31	1.38	47	1.16	56	12		
55	1.5	45			1.25	54	1.2	56	5	Vasculitis	
71	1.23	73	1.5	60	1.25	72	1.09	83	9	Mycotic/NAIS	
61	1.19	56	1.13	59	1.5	44	1.17	57	5	Ca left colon	
36	1.58	26	1.35	31	1.41	30	1.4	30	5		
37	2.18	23	2.62	19	2.16	23	1.7	29	6	ht Renal art reimplantat	COPD
46	1.87	36	2.13	32	1.7	40	1.52	45		Mortality	n/CAD-TVD
41	1.97	30	1.77	34	1.48	40	1.28	47	3	Myeloma/Hypothyroid	
20	2.7	18	3.5	14	2.2	22	1.9	40	64	Right solitary kidney	
49.04			Mean	37.69230769			Mean	53.76			
20.65475847			SD	15.9744026			SD	19.0814717			
48			n	48			n	48			
1.48			Mean	2			Mean	1.34			
0.389149629			SD	0.796076919			SD	0.3039779			
48			n	48			n	48			
					inter		60.5				
					supra		39.75				
					infra		47.47				

Name					Clamp	Renop	Preop crea	Weight	CrCl	POD0	CrCl	POD3	CrCl	At discharg	CrCl	At 30days	CrCl			
Vincent	58	M	219843	21-09-03	Suprarenal	-	1.1	64	66	1.8	41	2.4	30					Mortality/Aortoduodenal fistula/Sepsis		
Musthafa	39	M	254728	21-06-06	Suprarenal	-	0.95	66	98	1.2	77	1.4	66	1.1	84	1.1	84			
Ramachanc	71	M	247415	30-07-06	Infrarenal	-	1.2	60	48	1.1	60	1.6	36	1.2	48	0.9	62	Post CABG	Retroaortic	HTN
Surendran	58	M	253437	19-05-06	Suprarenal	-	1.1	62	67	1.3	56	1.45	51	1.3	56	1.41	51			
Habeebulla	54	M	300160	18-08-09	Suprarenal	-	1	68	81	1.25	65	1.5	54	1.22	67	1.1	73	B/L CIAA		
Thank	77	M	370588	12-12-13	Infrarenal	-	1.3	58	39	1.54	33	1.3	39	1.05	48	0.88	59	B/L CIAA	HTN/T2DM/CAD/Post op LTB	
Damodarar	68	M	379295	26-05-14	Interrenal	+	0.85	64	75	1.2	53	1.1	58	1	64	1.1	59	Right CIAA/Left EIA occlusion		
Abdul Salar	69	M	389362	17-12-14	Suprarenal	-	0.9	67	73	1.1	60	1.4	47	1.38	48	1.18	52	B/L CIAA	HTN/CAD	
Hussainkut	70	M	395054	28-05-15	Interrenal	+	0.95	63	65	1.2	51	1.3	47	1.18	52	1	62	HTN/CAD		
Ahamedku	67	M	408123	31-08-16	Interrenal	+	1.1	65	60	1.3	51	1.54	43	1.3	51	1.05	63	HTN/CAD/I	Left colon ischemia/Left hemicolectomy	
Ramasamy	65	M	445832	06-02-18	Suprarenal	+	1.04	52		1.37		1.67		1.35		1.55		Mortality		
Surendran	61	M	446075	24-04-18	Interrenal	-														
Vasudevan	61	M	455349	13-08-18	Suprarenal	+	1.94	72	41	2.1	38	2.4	33	2	40	1.95	40	HTN/CKD-3		Retroaortic LRV
Asanaru Pil	73		459180	18-11-19	Suprarenal	-														
Dharmaraji	73	M	446312	16-04-18	Suprarenal	+	1.3	80	57	1.5	50	2.1	36	2.2	34	20		Left RCC/H	Post op MHD	
Raveendra	70	M	430949	16-04-17	Suprarenal	-	1.1	66	58	1.3	49	1.4	46					Contained	HTN/T2DM	
Philipose	82	M	437461	19-08-17	Infrarenal	-	1.2	60	44	1.3	37	2	24					HTN/COPD/MODS		
Palagan	64	M	376733	31-10-14	Suprarenal	+	0.85	64	80	1.1	61	1.3	52	1.1	61	1	67	B/L CIAA	Cabrol technique	
Janardhan	69	M	332380	02-09-11	Infrarenal	-	1.1	66	59	1.08	60	1.2	54	0.9	72	1.1	58	HTN/CAD	carotid stenosis	
Koshy	77	M	341655	27-03-12	Interrenal	+	1.7	63	32	1.8	31	2.1	26	1.8	31	1.9	29	B/L CIAA	HTN/CKD-4	

Suprarenal	10
Interrenal	4
Infrarenal	4
Renoplegia	7