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The Enduring Patency of Primary Inferior Vena Cava Repair

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Abstract

Objective—Inferior vena cava (IVC) repair after planned and unplanned venotomy is performed by either interposition bypass, patch venoplasty, or lateral venorrhaphy and primary repair. Primary repair of the IVC avoids the use of foreign material and allows an all-autologous repair in an expeditious fashion. The purpose of this study was to demonstrate the utility of IVC repair, determine the degree of IVC stenosis and examine clinical outcomes after primary repair.

Methods—Single-center retrospective review of patients who underwent primary IVC repairs between January 2002 and January 2014 at a tertiary care center. Primary repair followed lateral venorrhaphy for tumor extraction or for repair of an iatrogenic IVC injury. Patient demographics, cross-sectional vena cava dimensions, and patient outcomes were tabulated.

Results—In total, 47 (30 men and 17 women) patients underwent primary IVC repair (median age 58 years, range 31–83 years). Twenty-six patients (15 men and 11 women) underwent *en bloc* radical nephrectomy, IVC tumor thrombus extraction, and primary lateral venorrhaphy (median age 61 years, range 39–83 years). The majority, 92% of these patients, had renal cell carcinoma (RCC) on final pathology, with a median follow-up period of 39 months (range 1–108 months). Twenty-one patients (15 men and 6 women) underwent primary repair for iatrogenic IVC injury (median age 54 years, range 31–82 years). Median follow-up period was 18.5 months (3–110 months). Clinic follow up with postoperative imaging was obtained in 76.9% of those undergoing tumor thrombus extraction ($n=20$) and 76.2% of those undergoing repair of an iatrogenic injury ($n=16$). Overall there was a 13% infra-renal IVC diameter loss, 17% IVC diameter loss at the level of the renal veins, and 10% supra-renal IVC diameter loss when comparing postoperative with preoperative imaging. All patients remained asymptomatic; therefore, IVC narrowing associated with primary repair was clinically insignificant.

Conclusion—Primary IVC repair is associated with less than 20% IVC diameter loss, and does not compromise venous outflow from the extremities. Primary IVC repair is a safe and expeditious technique that provides excellent clinical outcomes and long-term patency.

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INTRODUCTION

Renal cell carcinoma (RCC) is a common and lethal cancer with an incidence of 63,920 people in the United States during 2014.¹ During this time period, a predicted 14,000 people succumbed to this disease. Renal vein tumor thrombus with inferior vena cava (IVC) extension is a poor prognostic indicator, with untreated patients exhibiting a mean survival of just 5 months and a 1-year disease specific survival of merely 29%.² Current guidelines recommend radical nephrectomy with extraction of the IVC tumor thrombus to achieve any improvement in long-term survival.^{3, 4}

Iatrogenic IVC injury can occur during retroperitoneal dissection, usually during removal or debulking of a large tumor. Preoperative imaging will ideally indicate whether the vessels are at risk and a vascular surgeon can be consulted preoperatively. On occasion, intraoperative consultation is necessary after iatrogenic injury occurs.⁵

There are numerous ways to repair the IVC. Complete IVC replacement, prosthetic and autogenous patching, as well as primary lateral venorrhaphy are all described in the literature.⁶⁻⁸ Available conduits and patches are made of polytetrafluoroethylene (PTFE), autologous vein, and bovine pericardium. Vein harvest for creation of a large caliber spiral graft is time consuming, limiting its utility, especially during repair of an iatrogenic injury. Prosthetic grafts and patches expose patients to an increased risk of infection.

Direct primary repair is an alternative approach to IVC reconstruction that combines the ideal repair medium (autologous tissue) with a technique that is fast and efficacious. With this technique the theoretical risk of IVC narrowing with eventual stenosis and/or occlusion remains. The purpose of this study is to describe our experience with primary IVC repair and late outcomes of clinical and radiographic IVC stenosis or occlusion. To our knowledge, this is the largest study to date exploring this topic and the first describing primary IVC repair and the rate of late stenosis after iatrogenic injury.

METHODS

Data Collection

Data was retrospectively collected on 47 consecutive patients undergoing primary repair of an IVC venotomy at a single tertiary care center between January 2002 and January 2014. Only patients undergoing primary repair were included. Exclusion criteria included patients undergoing IVC repair using synthetic or autogenous patches, interposition bypass, complete IVC replacement, or who required IVC repair due to injuries sustained during blunt or penetrating trauma. During the study period there were fewer than 5 cases in which IVC replacement was utilized and these were for primary sarcomas of the IVC or if patch repair was performed. There were fewer than 4 cases of patch repair, which were performed if there was an estimated 50% diameter reduction of the IVC at the time of surgery. Patients were categorized according to whether the venotomy occurred in the context of radical nephrectomy for RCC and planned IVC tumor thrombus extraction or if primary venotomy repair was required due to an intraoperative iatrogenic IVC injury. Patient demographics, preoperative and postoperative imaging, and patient outcomes were tabulated. Computed

tomography (CT) and magnetic resonance imaging (MRI) allowed for measurements of the infrarenal, renal, and suprarenal IVC along its minor axis. Comparisons of the IVC at each level were made pre- and postoperatively. This study was approved by our Institutional Review Board and a waiver of consent was obtained.

For those patients undergoing venotomy to facilitate removal of an RCC tumor thrombus, the Neves classification was used to describe the extent of intracaval tumor propagation: Level 1 (renal involvement), Level 2 (extension into the infrahepatic IVC), Level 3 (retrohepatic caval extension), and Level 4 (suprahepatic or atrial thrombus extension). For those patients undergoing venotomy repair in the context of iatrogenic injury, the primary reason for surgery was recorded.

Surgical Technique

Surgical exposure for patients undergoing radical nephrectomy was obtained through a transabdominal incision. A standard radical nephrectomy was performed after confirming the absence of intra-abdominal metastatic disease. Proximal control of the IVC was obtained with either a suprahepatic ($n=4$) or infrahepatic ($n=21$) clamp. Sternotomy and cardiopulmonary bypass was required in one case with tumor extension into the right atrium (Neves Level 4). Control of all pertinent IVC branches was obtained with vessel loops and vascular clamps, and posterior lumbar branches were ligated and divided providing a bloodless field during repair. A venotomy was performed on the anterior surface of the renal vein-IVC confluence and extended cephalad along the lateral aspect of the IVC. Incising in this location allows for complete extraction of the tumor thrombus and excision of any IVC wall tumor involvement (Figure 1). Also, this is a patulous location in the IVC that minimizes narrowing after primary repair. Proximal control and a generous lateral venotomy allow uncomplicated tumor thrombus extraction with negative tumor margins. Suprahepatic clamp time was minimized by transitioning to an infrahepatic position once tumor removal was complete. In these cases, hepatic venous outflow was maintained while primary IVC repair was performed. IVC specimens were resected to grossly negative intra-operative margins and specimens were sent for pathology analysis. IVC repair was completed using a 3-0 or 4-0 monofilament polypropylene suture (Prolene, Ethicon, Somerville, NJ). Systemic low-dose heparinization was used only for prolonged reconstructions, and not for primary repair. All patients were observed in the surgical intensive care unit (SICU) prior to transfer to the general surgical floor.

Primary repair of iatrogenic IVC injuries were all performed in patients undergoing retroperitoneal dissection for newly diagnosed or metastatic cancer. Injury to the IVC occurred during nephrectomy for renal cancer without IVC tumor extension, retroperitoneal debulking for non-renal cancers, and skeletonization of the IVC and aorta during cancer resection. Proximal control of the IVC was obtained with an infrahepatic ($n=18$) clamp. In 3 cases, no IVC clamp was necessary. Suture repair was performed using 3-0, 4-0, or 5-0 monofilament polypropylene suture. Systemic heparinization was not used. In every case patients were monitored in the SICU postoperatively.

Follow-Up and Imaging

Outpatient follow-up occurred at 3, 6, 9, and 12 months postoperatively for cancer resection imaging and assessment. Patients were seen yearly thereafter. Imaging (CT or MRI) obtained to evaluate for tumor recurrence was used to measure and compare IVC diameter. The patients were assessed clinically for signs and symptoms consistent with IVC stenosis or occlusion. Diameters of the IVC were calculated using the measuring tool on the institutional picture archiving and communication system (PACS, General Electric, Fairfield, CT). All measurements were taken in the minor axis orientation of the IVC, most commonly in the anterior-posterior direction. Measurements were taken from sections in which the IVC was the most clearly identifiable as infrarenal, at the confluence of the renal veins with the IVC, and suprarenal in each patient; bony landmarks were used to ensure that measurements were taken at the same location pre-operatively and post-operatively. Since measurements were taken of the IVC at the most clearly identifiable locations in three anatomic regions there was no area of the IVC that was consistently available as an index reference point to normalize the measurements to other patient factors such as hydration status, overall size, and anatomic variation.

Statistical Analysis

Categorical variables were reported as frequencies and percentages and compared between groups using Fisher's exact test. Continuous variables (IVC diameters) were reported as medians and ranges and compared between groups using the Wilcoxon rank sum test. Post-surgical versus pre-surgical values for continuous variables in all patients and within groups were assessed using the signed rank test.

RESULTS

Total Cohort

A total of 47 patients (30 men, 17 women) underwent primary repair of the IVC between January 2002 and January 2014 and had a median age of 58 years (range 31-83 years). Overall, 43% were hypertensive (HTN, $n=20$), 17% had hyperlipidemia (HL, $n=8$), 30% had chronic renal insufficiency (CRI, creatinine > 1.2 , $n=14$), 11% had diabetes (DM, $n=5$), 15% were hypothyroid ($n=7$), and 19% smoked ($n=9$). Of this group, 26 required IVC primary repair after extraction of an IVC tumor thrombus. The remaining 21 patients sustained iatrogenic injury requiring IVC repair during the course of an operation being performed, in the majority of cases, to remove or debulk cancer (Table I). All patients included in this study were at increased risk for thrombotic events such as caval thrombosis and venous thromboembolism because they were undergoing major open abdominal surgery, or had a history malignancy, or both.

Postoperative imaging was available for 36/47 patients, with a median follow-up of 33 months (range 1-110 months). There was a postoperative loss in IVC diameter noted at the infrarenal (12.6%), renal (17.1%), and suprarenal (9.7%) locations (Table II). All patients remain asymptomatic at follow-up. Radiographic pre- and postoperative IVC diameter loss is depicted in Figure 2. Postoperative prophylactic anticoagulation with subcutaneous heparin and intermittent pneumatic compression boots was routinely used, except for two

patients being treated with therapeutic anticoagulation for newly diagnosed pulmonary embolism. All patients were on 325_mg aspirin after primary IVC repair.

Tumor Thrombus Extraction

Patient Demographics—The 26 patients undergoing surgery for tumor thrombus removal (15 men, 11 women) had a median age of 61 years (range 39-83 years). Co-morbidities included 50% with HTN ($n=13$), 19% with HL ($n=5$), 31% with CRI ($n=8$), 15% with DM ($n=4$), 15% were hypothyroid ($n=4$), and 12% smoked ($n=3$).

Patient Operative Course—The 26 patients' Neves classifications were: 4% Level 1 ($n=1$), 60% Level 2 ($n=15$), 24% Level 3 ($n=6$), 12% Level 4 ($n=3$), and no preoperative imaging was available for one patient. Clamp positioning was infrahepatic in 21 patients and suprahepatic in 4 patients. Median sternotomy and cardiopulmonary bypass (CPB) was necessary for 1 patient due to tumor thrombus extension into the right atrium. In patients with a more extensive tumor thrombus there was a tendency to a more dilated, patulous IVC. This was noted subjectively by the operating surgeon at the time of repair and not objectively measured. Median SICU stay was 2 days, and median overall length of stay of 8 days. Complications involved pulmonary edema effectively treated with diuresis ($n=1$), postoperative pulmonary embolism treated with therapeutic anticoagulation ($n=2$), small bowel obstruction requiring lysis of adhesions and small bowel resection ($n=1$), and ureteral obstruction and anuria requiring reoperation ($n=1$). Mean preoperative creatinine level was 1.08 with an insignificant increase to 1.31 on the day of discharge.

Patient Follow-up—Postoperative imaging was available for 20/26 patients, with a median follow-up of 39 months (range 1-108 months). Adjuvant chemotherapy was necessary in 50% ($n=10$) of patients who followed up due to metastatic disease or positive microscopic resection margins. There was a postoperative loss of IVC diameter noted at the infrarenal (14.9%), renal (8.6%), and suprarenal (9.7%) locations (Table III). No patients required re-intervention, none of the patients were affected by caval thrombosis, and none of the patients with IVC stenosis post repair were symptomatic.

Iatrogenic Injury Repair

Patient Demographics—The 21 patients (15 men, 6 women) who required primary repair of an iatrogenic IVC injury had a median age of 54 years (range 31-82 years). Co-morbidities included 33% with HTN ($n=7$), 14% with HL ($n=3$), 29% with CRI ($n=6$), 4% with DM ($n=1$), 14% with hypothyroidism ($n=3$), and 29% smoked ($n=6$).

Patient Operative Course—IVC injury was sustained during retroperitoneal dissection for a variety of indications, the majority were associated with a primary or metastatic cancer: renal cell carcinoma without IVC tumor thrombus ($n=10$), duodenal carcinoma ($n=2$), germ cell tumor ($n=2$), sarcoma ($n=1$), uterine cancer ($n=1$), teratoma ($n=1$), seminoma ($n=1$), urothelial carcinoma ($n=1$), and transitional cell carcinoma ($n=1$). One patient sustained an IVC injury during a nephrectomy for a nonfunctional kidney associated with recurrent urinary tract infections. If iatrogenic injury occurred, the same criteria were applied as all other IVC repairs – if there was an estimated 50% or greater diameter loss of the IVC after

injury, then patch repair was used. However, due to the patulous nature of the IVC at the renal vein confluences, this was rarely necessary. Clamp positioning was infrahepatic in 18 patients. No patients required a suprahepatic clamp or median sternotomy and CPB. No clamp was necessary during the repair of 3 (14%) IVC injuries. Median SICU stay was 0.5 days, and overall length of stay was 7 days. Complications included reoperation for drain removal ($n=1$), delayed gastric emptying and infection with *Clostridium difficile* ($n=1$), portal vein thrombosis requiring anticoagulation ($n=1$), and atrial fibrillation with rapid ventricular response ($n=1$). Mean preoperative creatinine level was 1.13 with an insignificant rise by the day of discharge to 1.22.

Patient Follow-Up—Postoperative imaging was available for 16/21 patients, with a median follow-up of 18.5 months (range 3-110 months). Adjuvant chemotherapy was necessary in 31% ($n=5$), while radiation therapy was used in 6% ($n=1$). Preoperative and postoperative IVC measurements are included in Table IV. There was a loss of IVC diameter (stenosis) noted at the infrarenal (9.2%), renal (22.4%), and suprarenal (4.4%) locations. No patients required re-intervention, none of the patients were affected by caval thrombosis, and none of the patients with IVC stenosis post repair were symptomatic.

DISCUSSION

Our Experience with Primary Repair

To our knowledge, our study is the largest to measure luminal diameter pre-operatively and post-operatively at multiple levels to calculate degree of IVC narrowing and correlate the extent of IVC narrowing to clinical symptoms. Our cohort is larger (47 patients) with a longer duration of follow-up than any other study to date (39 months for the tumor thrombus extraction group, 18.5 months for the iatrogenic injury group). Postoperative imaging revealed a decrease in IVC diameter at all measured levels (infrarenal, renal, and suprarenal) compared to preoperative imaging. We can extrapolate these measurements to an objective parameter, which surgeons can measure intra-operatively at the time of IVC repair to determine reconstruction options.

The decrease in size was most notable at the infrarenal IVC in the tumor thrombus group (14.9% reduction) and at the level of the renal vein confluence in the iatrogenic injury group (22.4% reduction). There were no postoperative IVC thromboses detected on postoperative imaging. Regardless of IVC diameter, all patients were clinically asymptomatic during follow-up rendering any loss of IVC diameter clinically insignificant.

Neither Neves classification nor IVC clamp position had any bearing on complications, IVC stenosis, or IVC occlusion in our RCC tumor thrombus group. Pulmonary embolism ($n=2$) occurred in the RCC tumor thrombus group but it is unclear whether this was associated with intraoperative tumor embolization or was a postoperative venous thromboembolic event. These patients were treated with systemic anticoagulation, as was one patient after iatrogenic injury that developed portal venous thrombosis.

Renal Cell Carcinoma

An estimated 63,920 patients were diagnosed with renal cell carcinoma in 2014, and RCC was responsible for almost 14,000 deaths.¹ Up to 25% of people harbor metastatic disease at the time of diagnosis and as high as 10% exhibit tumor thrombus extension into the IVC.^{9, 3} Traditionally studies have favored treating patients with RCC and venous tumor thrombus (VTT) with surgery and tumor thrombus extraction.¹⁰⁻¹³ Patients with VTT treated conservatively have an abysmal survival rate most patients succumb within 1 year.^{2, 3, 14} A recent study by Hatakeyama *et al*, described their 17-year experience with RCC IVC tumor extraction. Patients with VTT treated nonoperatively had a mean survival of 8.2 months and a 5-year survival of 0%. However, patients undergoing thrombus removal had a mean survival of 60 months and a 5-year survival of 54%.⁴ In a more recent study, Nooromid *et al* described a 15-year single center experience with RCC IVC tumor extraction. Patients with VTT who underwent thrombus removal had a 5-year survival of 71%.¹⁵ There is overlap between the patient populations in this study and the study by Nooromid *et al*.; however, this study is distinct in that it excluded any patient who did not undergo primary IVC repair, and included any patient with primary IVC repair after RCC with VTT for any iatrogenic (non-blunt or penetrating traumatic) indication.

Iatrogenic IVC Injury

Intraoperative iatrogenic injury to the IVC is rare and tends to occur during oncologic retroperitoneal surgery. Patients undergoing removal of large primary tumors, tumor debulking, or retroperitoneal lymph node dissection are all at risk for vascular injury. Mandolino *et al* conducted a retrospective study of 30 patients undergoing venous repair after sustaining an abdominal or pelvic iatrogenic injury.¹⁶ Of these, 33% ($n=10$) had an IVC injury, 6 of which were repaired primarily, with 4 requiring an interposition PTFE graft. They reported a mortality of 40% ($n=4$), 3 patients from multi-system organ failure and 1 intraoperatively from blood loss. A total of 12 patients were followed for a median of 2.3 years and only 2 developed complications relating to their repair (ileofemoral occlusions). Oktar *et al* published a series of 24 patients requiring abdominal and pelvic venous repair for iatrogenic injuries occurring during the course of cancer related surgery.¹⁷ This study only included 1 patient with an IVC injury, which was repaired primarily without complications. Oderich *et al* published a study describing the Mayo Clinic experience in regards to repair of iatrogenic abdominal and pelvic vein injury in 40 patients operated on between 1985 and 2002.¹⁸ Six patients required IVC repair, 4 of which occurred during surgery specifically related to cancer requiring retroperitoneal dissection. Of these patients, 4 were repaired primarily and 2 required a PTFE interposition graft. From the group undergoing IVC repair, 1 patient died and 4 had major complications related to their injury.

Options for Repair

The first prosthetic IVC replacement was performed and subsequently described by Sarti in 1970.²⁰ In rare cases where the IVC is resected before robust collaterals have been established, reconstruction with PTFE or autologous conduits are suitable options.^{7, 21, 22} One recent study, published by Benkirane *et al*, explored IVC resection and reconstruction with PTFE in 26 cancer patients.⁶ They had a median follow-up of 28 months, during which

time 19.2% of grafts thrombosed ($n=5$). Patency of the replaced IVC at 6 and 12 months was 88% and 79%, respectively. Today, total IVC replacement has assumed a niche role, applicable to only certain specific circumstances due to the magnitude of the operation and the associated risks.^{20, 23} In the setting of iatrogenic injury and acute blood loss, primary IVC repair is a faster more efficient alternative.

There is a role for short-segment PTFE interposition grafts in cases where primary closure is not possible.²⁴⁻²⁷ Some surgeons recommend creating an arterio-venous fistula to augment venous flow and anticoagulation postoperatively, which prolongs operative time and incurs the risks associated with long-term postoperative anticoagulation.²⁵ Bovine patch venotomy repair has also been used with acceptable patency rates.^{7, 28-30} As with PTFE interposition grafts, there is an increased risk of infection with bovine patch repair compared to autologous or primary repair. Outcomes of IVC direct primary repair have been described in several studies,^{8, 31-33} yet few studies have reported on long-term IVC patency associated with this technique. Most studies commenting on the mechanism of IVC repair are more focused on reporting long-term cancer-free survival and rates of local recurrence. The focus of these articles is not on IVC patency, but instead highlights outcomes of an oncologic nature. One study previously published by our group and another by Wang *et al* are amongst the few that specifically describe the outcomes of primary repair on subsequent rates of IVC stenosis and occlusion. Wang *et al* retrospectively reviewed 23 patients undergoing primary repair after RCC tumor thrombus extraction.⁸ Median follow-up in this study was only 15 months, with postoperative imaging acquired for 19 patients. IVC patency was 95%, with one case of occlusion undergoing successful thrombolytic therapy and stenting. Our group previously reported on a cohort of 22 patients undergoing primary IVC repair after tumor thrombus removal. Median follow-up was 36 months with no postoperative clinical or radiological findings consistent with IVC stenosis or occlusion.³²

Limitations

This is a retrospective single center case series review of procedures performed by a single group of vascular surgeons and urologists. Since imaging studies were performed well outside of the perioperative period we assumed euvoemia in all patients; therefore, the volume status of patients was not accounted for when measuring the IVC. We did not measure IVC volume and felt that a reliable measure of the IVC diameter was simpler and more clinically relevant than measuring IVC volume after intervention. Since there were no clinically significant events such as IVC thrombosis or lower extremity edema, a measure of the diameter is sufficient as an intraoperative assessment and post-operative radiographic measure. Finally, these are observational data, and longer follow-up data is required to more accurately determine long-term IVC patency.

CONCLUSION

There are many techniques available for repairing an IVC venotomy that was iatrogenic or created during extraction of an RCC tumor thrombus. Primary repair, however, provides a quick, efficient means to repair the IVC while avoiding the use of prosthetic material. Long-term outcomes, while associated with radiologic stenosis, are excellent with clinically

insignificant IVC stenosis and long-term primary patency. Primary repair, therefore, should be the technique of choice when performing an IVC repair for either tumor thrombus extraction or repair of an iatrogenic injury.

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Figure 1.

Graphic depiction of (A) venous tumor thrombus extending from the right renal vein into the inferior vena cava(IVC); (B) control of the IVC and major vascular tributaries to allow for bloodless dissection of venous tumor thrombus; (C) technique of primary repair of IVC veinotomy.

Figure 2. Cross sectional imaging of the preoperative infra-renal inferior vena cava (IVC) (A), and postoperative infra-renal IVC (B) of a patient who underwent renal tumor thrombus removal with primary IVC repair. IVC outlined with green dots.

Table I

Patient demographics

Variable	All Patients n (%)	Tumor Thrombus n (%)	Iatrogenic Injury n (%)	P-Value
All Patients	n=47	n=26	n=21	
Sex				
Male	30 (64)	15 (58)	15 (71)	0.38
Female	17 (36)	11 (42)	6 (29)	
Age				
Years (range)	57 (31-83)	61 (39-83)	54 (31-82)	0.02
Co-morbidities				0.64
Hypertension	20 (43)	13 (50)	7 (33)	
Hyperlipidemia	8 (17)	5 (19)	3 (14)	
Chronic Renal Insufficiency	14 (30)	8 (31)	6 (29)	
Diabetes Mellitus	5 (11)	4 (15)	1 (5)	
Hypothyroidism	7 (15)	4 (15)	3 (14)	
Smoking	9 (19)	3 (12)	6 (29)	
Neves Level				
Level 1	-	1 (4)	-	
Level 2	-	15 (58)	-	
Level 3	-	6 (23)	-	
Level 4	-	3 (12)	-	
No preoperative imaging	-	1 (4)		
Clamp Position				
Infrahepatic	39 (83)	21 (81)	18 (86)	
Suprahepatic	4 (9)	4 (15)	0 (0)	
Sternotomy	1 (2)	1 (4)	0 (0)	
No Clamp	3 (6)	0 (0)	3 (14)	

Table II

IVC Diameters – All Patients

Location	Preoperative (mm)	Postoperative (mm)	Diameter Change(%)	P-value
Infra-Renal	18.9 (8.4-25.2)	16.5 (10.0-26.2)	-12.6	0.10
Renal	20.5 (8.9-30.0)	17.0 (10.5-24.7)	-17.1	0.03
Supra-Renal	21.1 (13.8-33.1)	19.0 (12.8-29.0)	-9.7	0.007

Table III

IVC Diameters - Tumor Thrombus Extraction

Location	Preoperative (mm)	Postoperative (mm)	Diameter Change (%)	P-value
Infra-Renal	19.3 (13.8-24.0)	16.5 (10.0-26.2)	-14.9	0.15
Renal	20.2 (11.4-29.0)	18.5 (11.5-22.3)	-8.6	0.14
Supra-Renal	21.2 (15.0-33.1)	19.1 (12.8-25.1)	-9.7	0.02

Table IV

IVC Diameters - Iatrogenic IVC Injury

Location	Preoperative (mm)	Postoperative (mm)	Diameter Change (%)	P-value
Infra-Renal	18.3 (8.4-25.3)	16.7 (13.8-23.9)	-9.2	0.32
Renal	20.8 (8.9-28.0)	16.1 (10.5-24.7)	-22.4	0.16
Supra-Renal	19.8 (13.8-29.1)	19.0 (15.3-29.0)	-4.4	0.35