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CHAPTER 6

LAPAROSCOPIC RENAL ONCOLOGICAL SURGERY IN THE PRESENCE OF ABDOMINAL AORTIC AND VENA CAVAL PATHOLOGY: 8-YEAR EXPERIENCE

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ABSTRACT

Purpose
The outcomes of laparoscopic renal oncologic surgery in patients with major aortic and/or inferior vena caval pathology are unknown. Herein, we present our experience spanning an 8 years period.

Materials and Methods
From March 1998 to October 2006, 1826 laparoscopic renal procedures were performed for tumor. Of these, 66 patients (3.6%) had major abdominal aortic or caval pathology concomitantly. Demographics, specific entities of the vascular disease, and intraoperative and postoperative data were reviewed.

Results
Sixty-six patients had a history of abdominal aortic disease (n=54), vena cava disease (n=9), or both (n=3). Of the patients, 85%, 88% and 88% had ≥3 comorbidities, American Society of Anesthesiologist score ≥3, were on chronic anticoagulation therapy respectively. Twenty-seven patients (41%) had undergone prior surgical treatment for their vascular pathology. Laparoscopic renal surgery (transperitoneal 25, retroperitoneal 41) included radical nephrectomy (LRN; n=20), partial nephrectomy (LPN; n=17), and cryoablation (LCA; n=29). Open conversion was performed in 3 patients (5%). There were 3 (5%) intraoperative and 9 (14%) postoperative complications. One patient died due to pulmonary sepsis. There was no statistically significant difference in the perioperative outcomes between aortic and vena cava disease groups. The retroperitoneal approach was associated with less blood loss (p=0.0003) and shorter operative time (p=0.004).
Conclusions

Laparoscopic surgery for renal tumor in the presence of aortic or caval disease is safe and feasible. Considerable prior laparoscopic experience is necessary when managing these high-risk patients.

INTRODUCTION

The gold standard treatment of organ-confined renal cell carcinoma (RCC) is surgery. Over the past four decades, the surgical management of RCC has evolved, with increasing acceptance of minimally invasive techniques. Parallel to the increase in the aging population, the diagnosis of renal mass in patients older than 70 years with multiple comorbidities has also increased [1]. Laparoscopic options for organ-confined RCC include radical nephrectomy (LRN), partial nephrectomy (LPN), and energy-based probe ablative procedures, such as cryoablation (LCA). Selection of the particular laparoscopic approach depends on the individual patient and tumor circumstances.

Abdominal aortic and vena caval pathology correlates with aging and systemic diseases such as hypertension and atherosclerosis. The population of patients with aortic and/or vena cava disease increases parallel to increasing life expectancy [2]. As one would expect, renal tumor and concomitant aortic/caval disease are not infrequently encountered amongst the elderly. Intraabdominal malignancies are found in up to 4% of patients at the time of aortic reconstructive surgery [3]. Hafez et al reported synchronous management of renal neoplasm and abdominal aortic aneurysm, and concluded that management of renal tumor and abdominal aortic aneurismal pathology is challenging and should be undertaken with extreme care [4].

Patients with untreated severe aortic/caval disease may be at higher surgical risk. Additionally prior surgical intervention on the aorta and vena cava may increase the difficulty of subsequent surgery due to intra-abdominal scarring. Laparoscopic renal surgery has generally been associated with quicker recovery and less morbidity. However, to our knowledge, the impact of preexisting aortic/caval disease/surgery on subsequent laparoscopic renal procedures has not been addressed to date. We report our experience in patients with aortic and/or vena caval disease who underwent laparoscopic surgery for renal tumor.

MATERIALS AND METHODS

From March 1998 to October 2006, 1826 laparoscopic procedures (LRN, LPN and LCA) were performed for suspected renal tumor in our institution. Of these, 66 patients
(LRN, n=20; LPN, n=17; LCA, n=29) with aortic and/or vena caval disease were retrospectively identified from a prospectively-maintained Institutional Review Board approved computerized database. All patients underwent computerized spiral tomography prior to surgery. Cardiology clearance including noninvasive cardiac stress testing was administered to all patients preoperatively. No patient underwent simultaneous vascular and laparoscopic renal surgery.

Data on demographics, renal tumor characteristics, aortic and/or caval disease, prior management of the vascular disease, and other associated comorbidities, and surgical treatment were obtained from our database and patient charts. Intraoperative and postoperative parameters analyzed included type of laparoscopic renal procedure, operating room time (ORT), estimated blood loss (EBL), perioperative complications, hospital stay, and postoperative renal function assessment.

Surgical management of renal tumor including type of procedure and method of approach was based on tumor size, location, overall renal function, technical feasibility of laparoscopic renal surgery, associated medical comorbidity, and surgeon preference and confidence. Our respective surgical indications for and techniques of LRN, LPN, and LCA have been described previously [5-7]. However, minor, individualized modifications were applied according to the major vascular pathology.

Postoperative follow-up consisted of serum creatinine at 1 month, and abdominal computerized tomography or magnetic resonance imaging at 6 months and yearly thereafter in patients with pathologically confirmed renal cancer. Follow-up was obtained by contacting the patient, family, and/or referring physician.

Descriptive statistics are presented with median and inter-quartile range (IR). Statistical analyses were based on the influence of the procedure type (LRN vs LPN vs LRC), the type of approach (transperitoneal vs. retroperitoneal), the type of vascular disease (aortic vs. vena cava) and whether specific disease type was previously treated or not (treated vs. non-treated). Each variable was analyzed in order to determine risk factors for EBL, ORT, intraoperative complications, conversion rate, postoperative complications and length of hospital stay. Multivariable linear regression models were used to model the data. To satisfy the distributional assumptions associated with a linear model, EBL, ORT and length of hospital stay were transformed using a log transformation. To test the statistical significance of each covariate incorporated into model, separate Type III F tests were performed and p-values were adjusted using a Bonferroni-Holm multiple comparison procedure. Statistical significance was assessed using a 0.05 significance level.
RESULTS

Demographic data are presented in Table 1. Median tumor size was 3.3 cm (2.5, 4.2). Renal tumors were treated with LRN (n=20), LPN (n=17), and LCA (n=29). Overall, the transperitoneal approach was employed in 25 patients and the retroperitoneal approach in 41. In addition to the aortic/caval pathology, all patients had ≥1 pre-existing comorbidities, with 56 patients (85%) having ≥3 comorbidities at the time of surgery. The significant comorbidities included hypertension in all patients (100%), diabetes mellitus in 44 (67%), cardio-vascular disease in 39 (59%), cerebrovascular disease in 7 (11%), chronic renal disease in 10 (15%), other cancer in 6 (9%), and other co-morbidities in 23 (35%). Fifty-eight patients (88%) were on anticoagulation therapy at the time of diagnosis of the renal mass and anticoagulants were temporarily stopped as least 7 days before surgery. Anticoagulants were resumed 5-7 days postoperatively if there was no complication occurred.

Vascular disease included aortic pathology in 54 patients, vena caval disease in 9, and both in 3. Aortic pathology included abdominal aortic aneurysm (AAA) (n=47), descending aortic dissection (DAA) (n=3), aortic transection (n=3) and aortic occlusion (n=1). Caval pathology included vena cava filter placement due to deep vein thrombosis/pulmonary embolism in 9 patients. In the 3 patients with combined aortic and caval disease, 2 had AAA and caval filter and 1 had descending aortic dissection and caval filter placement. Prior vascular intervention had been performed in 27 patients, including 15 patients in the aortic disease group, all 9 patients in the vena cava group, and all 3 patients in the combined group. These treatment modalities included open AAA repair in 10, open repair of aortic transection in 3, endovascular aortic stenting insertion in 2, caval filter placement in 10, and both open AAA repair and caval filter placement in 2 patients. Median interval between prior vascular surgery and the laparoscopic renal procedure was 5.5 years (range 3.5-9). Thirty three patients had AAAs<4cm, all managed with close observation. Of these 33 AAAs, 23 involved the renal hilum and 10 were infra-hilar.
Table 2. Summary Statistics According to the Type of Major Vessel Disease

<table>
<thead>
<tr>
<th></th>
<th>Aortic (n=54)</th>
<th>Vena Cava (n=9)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT size (cm)</td>
<td>3.5 (2.5, 4.2)</td>
<td>3.1 (2.3, 3.6)</td>
<td>0.26</td>
</tr>
<tr>
<td>Type of procedure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cryoablation</td>
<td>23 (43%)</td>
<td>5 (56%)</td>
<td>-</td>
</tr>
<tr>
<td>LPN</td>
<td>15 (28%)</td>
<td>4 (44%)</td>
<td></td>
</tr>
<tr>
<td>LRN</td>
<td>16 (30%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>Type of approach</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retroperitoneal</td>
<td>34 (63%)</td>
<td>5 (56%)</td>
<td>0.85</td>
</tr>
<tr>
<td>Transperitoneal</td>
<td>20 (37%)</td>
<td>4 (44%)</td>
<td></td>
</tr>
<tr>
<td>Estimated blood loss (cc)</td>
<td>150 (100, 250)</td>
<td>100 (100, 200)</td>
<td>0.18</td>
</tr>
<tr>
<td>Surgery time (min)</td>
<td>180 (158, 235)</td>
<td>168 (148, 203)</td>
<td>0.05</td>
</tr>
<tr>
<td>Intraoperative complications (%)</td>
<td>2 (4%)</td>
<td>0 (0%)</td>
<td>-</td>
</tr>
<tr>
<td>Open conversion (%)</td>
<td>3 (6%)</td>
<td>0 (0%)</td>
<td>-</td>
</tr>
<tr>
<td>Postoperative complications (%)</td>
<td>7 (13%)</td>
<td>2 (22%)</td>
<td>-</td>
</tr>
<tr>
<td>Hospital stay (hours)</td>
<td>72.0 (37.0, 116.0)</td>
<td>84.0 (60.8, 96.0)</td>
<td>0.66</td>
</tr>
<tr>
<td>Difference between pre- and post-op serum creatinine (mg/dl)</td>
<td>0.1 (0.0, 0.4)</td>
<td>0.2 (0.1, 0.6)</td>
<td>0.11</td>
</tr>
</tbody>
</table>

LPN=laparoscopic partial nephrectomy; LRN=laparoscopic radical nephrectomy

Patient, tumor, and operative details for aortic and caval disease groups are presented in Table 2. Size of the tumor, warm ischemia time (for LPN cases), EBL, ORT, hospital stay, and difference of pre- and post-operative serum creatinine level were not statistically different between aortic and caval groups. Comparison between patients with and without prior surgical intervention for the aortic/caval vascular pathology is summarized in Table 3. No differences were noted as regards age, ORT, EBL and hospital stay between these 2 groups. However, patients without prior intervention for the vascular pathology had significantly larger tumors.

Table 3. Peri-Operative Outcomes of Groups with and without Prior Intervention for the Vascular Pathology

<table>
<thead>
<tr>
<th></th>
<th>With intervention (n=27)</th>
<th>Without intervention (n=39)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>70 (59, 74)</td>
<td>71 (66, 75)</td>
<td>0.06</td>
</tr>
<tr>
<td>Aortic/caval disease</td>
<td>15/12</td>
<td>39/0</td>
<td></td>
</tr>
<tr>
<td>Tumor size (cm)</td>
<td>3.1 (2.2, 3.6)</td>
<td>3.7 (2.5, 5.0)</td>
<td>0.006</td>
</tr>
<tr>
<td>OR time (min)</td>
<td>210 (150, 240)</td>
<td>180 (150, 220)</td>
<td>0.37</td>
</tr>
<tr>
<td>EBL (ml)</td>
<td>100 (100, 231.3)</td>
<td>150 (87.5, 250)</td>
<td>0.26</td>
</tr>
<tr>
<td>Hospital stay (hrs)</td>
<td>72 (40, 119.5)</td>
<td>72 (36, 116)</td>
<td>0.2</td>
</tr>
<tr>
<td>Intra-OP</td>
<td>1 (3.7%)</td>
<td>1 (2.5%)</td>
<td>-</td>
</tr>
<tr>
<td>Post-OP</td>
<td>5 (18.5%)</td>
<td>4 (10.3%)</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 4 demonstrates the outcomes of different laparoscopic approaches. Intra-operative complications occurred in 3 patients (4.5%), all managed by open conversion: splenic hemorrhage (1), mesenteric artery hemorrhage (1) and inability to progress due to retroperitoneal scarring (1). Postoperative complications occurred in 9 patients (14%), all managed conservatively: ileus (3), surgical site hematoma.
(2), scrotal hematoma (1), myocardial infarction (1), deep vein thrombosis (1), and pneumonia (1). Mortality occurred due to sepsis in the patient with pneumonia (1.5%). The difference in the pre- and post-operative serum creatinine level was 0.3, 0.3 and 0.05 for LRN, LPN and LCA respectively. On histopathology, RCC was confirmed in 48 patients (73%). In patients with pathologically-confirmed RCC, at a median follow-up 59.8 months (26-98.5), overall and cancer specific survival was 92.1% and 96.1% respectively. In patients with pathologically-confirmed benign tumors, overall survival is 100% at a median follow-up of 48.5 months (20-74).

Univariate analysis showed no statistically significant difference between aortic disease and vena cava disease regarding to EBL, ORT, intraoperative complications, conversion rate, postoperative complications and length of hospital stay. When patients with prior vascular surgery versus those without prior vascular surgery were compared, no statistically significant difference was noted in any outcome measures.

Figure 1 gives the EBL values adjusted for the disease, procedure and approach type. Multivariable linear regression model demonstrated statistically significant interaction between procedure type and approach type on the log of EBL ($p=0.001$). Pairwise comparisons showed statistically significant difference on the log of EBL using the transperitoneal approach between LCA and LPN ($p=0.0091$), between LRC and LRN ($p$-value < 0.0001), between LPN and LRC ($p$-value = 0.0114), and between retroperitoneal and transperitoneal approaches using LRN ($p$-value = 0.0003). There was no statistically significant difference among disease types ($p$-value = 0.8440).
between the 2 different approaches on the EBL was noted on LRN (p=0.0003). There was no statistically significant difference among disease types on the log of EBL.

Figure 2 gives the ORT adjusted for type of disease, procedure and approach. Based on the fitted linear model, there was no statistically significant interaction between procedure type and approach type on the log of ORT. Also, there was no statistically significant difference among disease types on the log of ORT. However, there was a statistically significant difference between approaches on the log of OR time (p-value = 0.0042).

Figure 2 gives the ORT adjusted for type of disease, procedure and approach. Based on the fitted linear model, there was no statistically significant interaction between procedure type and approach type on the log of ORT. Also, there was no statistically significant difference among disease types on the log of ORT. However, there was a statistically significant difference between approaches on the log of OR time (p-value = 0.0042).

Figure 2

No statistically significant difference can be shown between procedure types and among disease types on the log of surgical time (p-value = 0.1168 and 0.360, respectively). However, there was a statistically significant difference between approaches on the log of surgical time (p-value = 0.0042).

Figure 2

No statistically significant difference can be shown between procedure types and among disease types on the log of surgical time (p-value = 0.1168 and 0.360, respectively). However, there was a statistically significant difference between approaches on the log of surgical time (p-value = 0.0042).

DISCUSSION

Since the aorta and vena cava are located in immediate proximity to the kidneys, major pathologic conditions of these 2 great vessels can potentially, sometimes dramatically, alter the surgical anatomy of the retroperitoneum, increasing the technical difficulty of oncologic renal surgeries. Moreover, untreated patients with major vessel disease are particularly at greater risk for any type of surgery. In this series, overall complication rate was 15.2% and all laparoscopic operations were completed with reasonable blood loss, operative time and complication rates, despite the elderly patient
population (median age: 70 years) with co-morbidities. In addition, there was no increase in significant postoperative complications.

Incidental renal tumors and concomitant aortic disease such as AAA and DAA are increasing with widespread application of non-invasive imaging modalities [3]. Certain aortic diseases require surgical intervention; however, in many cases, close surveillance and medical prevention of the complications are the management of choice [8]. Vena cava filters are implanted in patients with high risk of venous thrombo-embolism to prevent pulmonary embolism (PE). Filter placement just below the renal veins is important for effective PE prophylaxis [9]. The impact of vena cava filter on renal procedures requiring manipulation of the renal pedicle has not been evaluated to date.

Disease of aorta and vena cava are major vascular diseases and are usually diagnosed in elderly population with other co-morbidities. These diseases are potentially life-threatening and patients are at higher surgical risk. Laparoscopic renal procedures have the advantages of less pain, quicker recovery and less morbidity. Furthermore, laparoscopic renal surgeries are safe in the elderly population [10]. Even for selected patients with more than 3 co-morbidities, laparoscopic surgery maintains the advantages of minimally invasive surgery [11]. However, pneumoperitoneum itself can cause cardiovascular changes by increasing systemic and pulmonary vascular resistance which in turn increase cardiac afterload [12]. Therefore, intensive monitoring of these patients is essential during
laparoscopic surgery. Our intraoperative outcomes confirmed the feasibility of such procedures.

Certain personal technical nuances are emphasized. Due to the potential presence of peri-aneurysmal inflammatory changes and prominent collateral vessels in the retroperitoneum, dissection should be performed meticulously, maintaining complete hemostasis. When balloon dissecting the retroperitoneal space during retroperitoneoscopy, balloon dilation should not be excessive in order to minimize pneumatic compression of the AAA. During LPN, the renal artery and vein are secured individually, akin to standard techniques. No patient underwent hand-assist procedures in our series. During LPN, hilar clamping is performed at some distance lateral to the Aorta/IVC, with enough hilar fat maintained undisturbed. This allows soft cushioning of the potentially atherosclerotic renal artery, hopefully decreasing chances of plaque disruption. Satinsky clamp may provide more reliable occlusion of an atherosclerotic renal artery compared to laparoscopic bull-dog clamps, which may have insufficient coapting force. Also in patients undergoing LPN, the preoperative 3D CT scans were carefully scrutinized to confirm absence of calcified plaques in the ipsilateral renal artery.

In this series, intra-operative parameters such as blood loss, operative time, conversion rate, and complication rate were comparable to other reported series. When comparing aortic and vena cava groups, mean blood loss and hospital stay were marginally higher in the aortic group, but this did not reach statistical significance. Our results indicate that laparoscopic renal procedures are safe in patients with aortic and/or caval diseases and the type of major vessel disease did not have an impact on laparoscopic procedures. Moreover, difficulty of laparoscopic procedures or peri-caval inflammation response was not increased in patients with vena cava filters. Regarding the type of laparoscopic approach, patients undergoing retroperitoneoscopy had significantly less blood loss and operative time. Even though the number of LPNs was lesser in the retroperitoneal group compared to the transperitoneal group (4 versus 12), the number of LCA and LRN were similar (20 versus 16). From a technical standpoint, the retroperitoneal space could be easily created with a balloon dilator without any complication. In one patient, the retroperitoneal space could not be adequately created, resulting in conversion to open surgery.

Staged management of the aortic disease and renal tumor has been employed previously [3]. Staging avoids the possibility of graft contamination during manipulation. However, other reports demonstrate the safety of simultaneous approach in selected patients [4]. In the current series, we did not perform any simultaneous laparoscopic
operations for the simultaneous management of renal tumor and aortic/caval disease, since the laparoscopic vascular surgical techniques are not yet matured.

Swanson et al [14] also reported laparotomy to be a precipitating factor for early aneurysm rupture through a possible imbalance of collagen lysis mechanism after a major operation. Reduced inflammatory response was demonstrated in an animal study but still controversial in the clinical setting. Akhtar et al [15] reported both open and laparoscopic operations produced similar stress responses. However, open surgery resulted in a higher acute phase response and induced a greater endotoxin tolerance. Landman et al [16] reported that the immunological and stress response after LRN and open nephrectomy for renal cell carcinoma was similar. In this series, there was no intra-operative or post-operative rupture of the aortic aneurysm.

This report holds its limitations, as our analysis was retrospective. Also, the number of patients in each great vessel disease sub-group was unequal. However, we believe this report is of interest to the literature for the following reasons. This is the initial report confirming the safety and feasibility of laparoscopic treatment of renal tumor in the presence of great vessel disease. Also, our series included both previously treated and untreated group of patients widening the scope of the study.

**CONCLUSION**

Laparoscopic oncologic renal surgery is technically challenging but feasible in patients with major disease involving the aorta and/or vena cava. There was no difference as regards perioperative parameters between the aortic and vena cava groups. In addition, previous treatment of the great vessels did not preclude subsequent laparoscopic intervention. Patients undergoing retroperitoneal approach seem to have less blood loss and shorter operative time compared to transperitoneal laparoscopy.

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