Original Article

Off-clamp robotic partial nephrectomy: Technique and outcome

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Abstract

Introduction: Robotic partial nephrectomy (RPN) is a technically challenging procedure. Advanced skills are needed to accomplish tumor resection, hemostasis, and renorrhaphy within short ischemia time in RPN. Off-clamp RPN with zero ischemia may decrease the risk of ischemic reperfusion injury to the kidney. However, the off-clamp technique has been associated with an increased risk of blood loss. The purpose of this study was to evaluate the outcome of our modified off-clamp technique utilized in certain RPN cases.

Patients and Methods: A total of 81 patients underwent RPN between September 2009 and July 2013 for renal masses. We studied a subgroup of patients who underwent off-clamp RPN with zero ischemia time. The off-clamp technique was utilized for exophytic, nonhilar tumors that have a base of 2 cm or less. We developed a novel technique to avoid ischemia reperfusion renal injury while minimizing blood loss in certain cases of RPN.

Results: Of the 81 cases of RPN, we reviewed and adopted the off-clamp technique in 34 patients (41.98%). Utilizing off-clamp RPN resulted in an average blood loss of 96.29 ml and 1.56 days (range: 1-3 days) of hospital stay and minimal change in serum creatinine.

Conclusions: Off-clamp RPN is safe and feasible approach to excise certain kidney tumors. It carries the benefits of RPN and prevents ischemia reperfusion renal injury.

Key Words: Warm ischemia, nephron sparing, partial nephrectomy, robotic surgery.

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INTRODUCTION

Minimally invasive nephron sparing surgery (MINSS) has been increasingly appreciated due to its excellent oncologic outcome accompanied with preservation of renal function.[1] The shorter hospital stay, lower incisional morbidity, and a better cosmetic outcome paved the way to the acceptance of MINSS.[2,3] Utilizing robotic technique in MINSS was increasingly adopted as it demonstrated easier handling of the complex renal tumor and reduced warm ischemia time (WIT). In fact, robotic partial nephrectomy (RPN) gained clear advantages over the traditional laparoscopic partial nephrectomy (LPN).[2,3] RPN provides the surgeon with a three-dimensional view through the binocular camera and 7 degrees of freedom through the Endo-Wrist® technology. Actually, using the robotic technology made it easier for the surgeon to accomplish the required surgical task, that is, tumor excision and renorrhaphy.[1,4,5]

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The feasibility and safety of RPN depend on the surgeon experience and the position and the size of the tumor.[4] RPN is a complex procedure that demands well-trained surgeon to achieve the job safely.[4] Many previous studies demonstrated the safety and feasibility of RPN.[6,7] In fact, RPN is the fastest growing form of MINSS in the US.[6] Rogers *et al.* concluded

that the required skills for robotic approaches are acquired faster compared to the skills needed in LPN.[1]

Although RPN has become an established treatment for small renal masses, multiple studies demonstrated a negative impact of WIT on the renal function.[8] Patel and Eggener's proved that warm ischemia minute has an additive effect into development of acute kidney injury and deterioration in kidney function.[8] The three main variables contributing to the final renal function after partial nephrectomy are: the baseline renal function preoperatively, the amount of remaining renal parenchyma left postoperatively, and the length of WIT.[9] As a result, establishing a technique for zero ischemia time, can eliminate any potential harmful effect of warm ischemia during partial nephrectomy.[10] Nevertheless, there is no consensus on the length of safe WIT that usually does not lead to deterioration of the renal function after partial nephrectomy. It was reported by multiple studies that up to 40 min of WIT is safe, sufficient for the resection of the tumor, and performing renorrhaphy.[11,12] There are multiple ways to assess the renal function, and each technique has some advantages and disadvantages. Serum creatinine measurement and radionuclide renal scans are the most commonly utilized tools to assess the renal function.[4,5,11] On the other hand, other studies used glomerular filtration rate (GFR) to measure the renal function.[2,3]

Spending more days at hospital postoperatively does not only increase the health care cost, but it also carry the risk of developing of other medical complications such deep venous thrombosis and pneumonia. Long stay is usually indicated when patients get big wounds that generate pain, hinder movement, and required additional care. Therefore, the earlier the patients are discharged home in a comfortable status, the better they will be.[3] Blood transfusion in the setting of losing large amount of blood during the surgeries carries certain hazard to the patient like cross reactions and infection with blood born organisms.[1,2]

We adopted a novel off-clamp technique, whenever that was possible, to minimize renal ischemic injury and prevent some of the incidents related to hilar dissection and clamping during RPN. In this paper, we present our experience with off-clamp RPN and demonstrate the selection criteria and the outcome of this technique.

PATIENTS AND METHODS

After Institutional Review Board approval, we reviewed the medical records of 81 patients, who underwent RPN at our institute, between September 2009 and July 2013. All the RPN were performed by the same surgeon. Thirty-four patients (41.98% of all RPN) who underwent off-clamp RPN with zero ischemia time were identified. Patients' demographics, main outcomes variables (preoperative and postoperative serum creatinine values, estimated blood loss [EBL], length of hospital stay), and tumors' histopathological results, size, site, side, and grade were collected. Serum creatinine, as a renal function indicator, was measured three times: Preoperative, immediately (within 48 h) postoperative, and long-term postoperative (3-6 months). The off-clamp technique was utilized among patients who had exophytic, solid or cystic masses that have a maximum base diameter of 2 cm or less and suspicious for malignancy Figure 1.

The surgical technique

After reflecting the colon, the tumor was located using intraoperative ultrasound. Gerota fascia was opened, and the tumor was exposed. The kidney was mobilized as necessary to expose the tumor. Second, ultrasonic exam was performed to measure the depth of the tumor and the dimension of the tumor bed. Multiple (1-4) # 1 Vicryl stitches, on a CT needles Ethicon, Cincinnati, Oh, were introduced into the tumor bed under US guidance before we began the resection. Tension on the sutures was created using two Hem-O-Loc clips placed parallel to the planned margin of resection; each clip was on one side of the tumor Figure 2. We made sure that the sutures are in the tumor bed and not penetrating the tumor using third US exam. This technique is modified from the novel one described by Abaza and Picard.[13] After the resection of the tumor with the robotic scissors, the margin of resection was sent to pathology for frozen section to insure complete excision of the tumor Figure 3. We added more stitches when the hemostatsis was not perfect. No hemostatic agents were used during the procedure.

Statistical analyses of the data were performed using SAS, version 10 (SAS Institute Inc., Cary, North Carolina, USA). After conducting the univariate analyses for the variable,

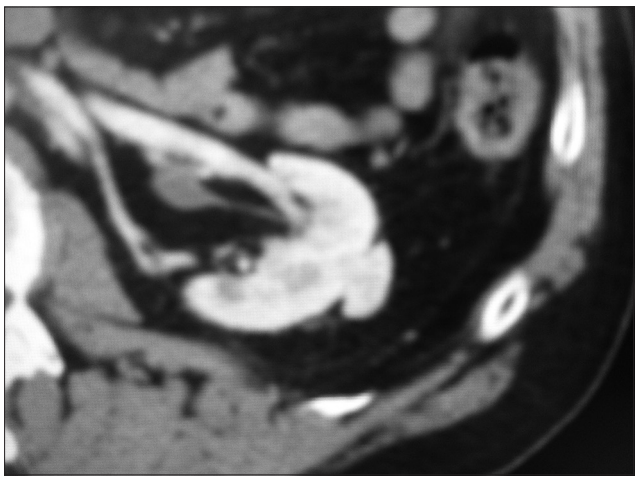

Figure 1: Computed tomography scan of the renal mass eligible for this technique. It shows an exophytic mass on the lateral aspect of the left kidney

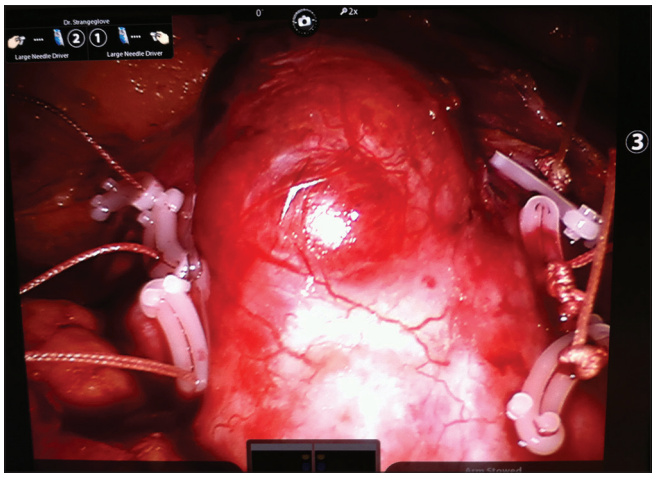

Figure 2: The tumor and the suture place into the base of the tumor before the resection. Each stitch is held between two Hem-O-Loc clips and cinched tight

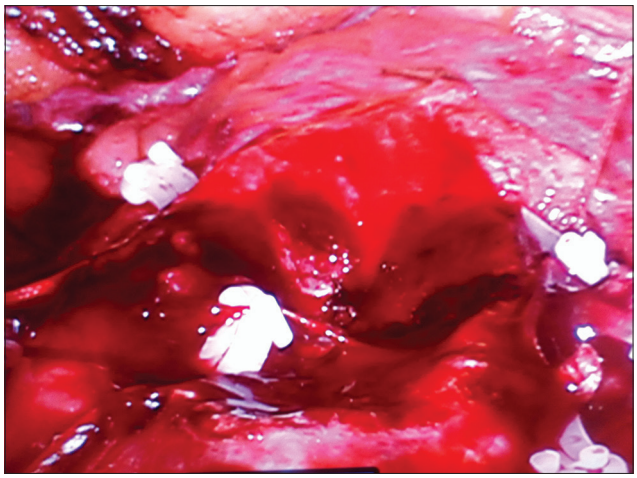

Figure 3: Tumor bed after the resection of the tumor, no bleeding is observed after the resection

the relationship between the main studied variables, serum creatinine values, EBL, length of hospital stay, and patients' age and gender, and type, size, and grade of tumors. Categorical data were analyzed using Chi-square. Pearson correlation coefficients were calculated between continuous variables. *P* values of 0.05 or less than were considered statistically significant and data were reported as mean.

RESULTS

Patient demographic

A total of 34 patients participated in the study, the mean patient age was 56.4 years (range: 33-83). More than half of patients were male 18 (52%).

Lesions characteristics

Histopathology clear-cell renal cell carcinoma (n = 12, 35.3%), benign complex cyst (n = 4, 11.8%), unclassified renal cell carcinoma (n = 4, 11.8%), chromophobe renal cell carcinoma (n = 6, 18.6%), papillary renal cell carcinoma (n = 1, 2.9%), oncocytoma (n = 2, 5.8%), adenoma (n = 2, 5.8%), angiomyolipoma (n = 1, 2.9%), and cystic renal carcinoma (n = 2, 2.9%).

Tumor location

About 15 tumors were in the right kidney (44.1%); the remaining 19 (55.9%) were in the left kidney. The average tumor size was 1.9 cm (range: 0.8–3.8 cm). The tumor was located on the lower pole in 13 patients (38%), on the upper pole in 7 patients (21%), on the anterior, middle aspect in 6 patients (18%), and on posterior middle aspect in 8 patients (23%).

Surgical outcome

All patients had negative surgical margins, and no recurrence was observed during the average follow-up of 18.7 months (range 5-40 months). Mean preoperative serum creatinine was 0.93 mg/dl (range 0.54–2.4 mg/dl), mean early postoperative serum creatinine was 1.13 mg/dl (range 0.52–2.5 mg/dl). The short-term postoperative creatinine was 1.07 mg/dl (range 0.5–2.8 mg/dl). The average blood loss was 96.29 ml (range 50–400 ml), and no transfusion was needed. The average hospital-stay was 1.56 days (range 1–4 day). We found that all studied variables, age, gender, and tumor characteristics such as type, size, and grade of the tumor have no significant association on the estimated intraoperative blood loss and the length of hospital-stay. There were no delayed complications such as urine leak or delayed bleeding. There was no need to convert any of the cases to clamped technique or to the open technique. Furthermore, no recurrence was encountered during the follow-up period ranging from 9 to 40 months (average 22 months).

DISCUSSION

Minimally invasive nephron sparing surgery has become a favorable option by many surgeons and many patients as its showing outstanding oncologic outcome and at the same time, maintaining good renal function.[1,13] RPN using the daVinci® Robotic System (Intuitive Surgical®, Sunnyvale, California, USA) is the fastest growing form of MINSS in the US.[6] Rogers *et al.* concluded that the required skills for robotic approach may be gained faster than these for the classical laparoscopic skills and that handiness is necessary to perform RPN with the desired outcomes.[1]

This study concluded that off-clamp RPN is a safe and feasible approach for certain solid small renal masses up to 3.8 cm in size. Furthermore, RPN under zero ischemia is a practical approach for selected patients with a wide variety of both benign and malignant renal tumors.

Our results are supported by other studies which have shown that renal warm ischemia can be avoided in many

cases of both RPN and LPN and should be implemented when possible.[6,14,15] Furthermore, Thompson *et al*. have shown that off-clamp partial nephrectomy can reduce the hazard of both acute and chronic kidney disease.[12]

Warm ischemia time of 28-40 min was reported by different studies to be safe and sufficient for the resection of the tumor and performing renorrhaphy.[11,12] However, in the previous studies, renal function after RPN has not been adequately monitored for a long period of time.[11,12] Other studies have shown that LPN under warm ischemia has less blood loss than the off-clamp one,[14-16] no difference in hospital-stay,[14] and better renal function[14-16] than the classical technique utilizing ischemia. Thompson *et al*. concluded that 2% of their off-clamp cohort group developed excessive blood loss in comparison to 5% in hilar clamping group.[14] Moreover, they found that urine leakage, which we did not encounter, is higher among the hilar clamping patients (5%) in comparison to off-clamp patients (1%).[16] In addition, the low blood loss can be attributed to cinching the renal tissue between the two Hem-O-Loc clips before starting the resection. The minimal change in the creatinine is due to avoiding ischemia and the minimal proportion of resected renal parenchyma along with the tumor.

Our results demonstrated a trend to utilize the technique in the lower pole as this easier to access and mobilize. Our technique was less likely to be used close to the renal hilum and upper pole. It is easier to adopt the technique for smaller tumors (average 1.9 cm), as they are often easier to resect. Smaller tumors also tend to have less parenchymal attachment and less blood supply contributing to the minimal blood loss we experienced. In comparison to our synchronous clamped series, the group that had off-clamp RPN with zero ischemia time showed significant less blood loss, shorter hospital stay, and less postoperative serum creatinine rising ($P < 0.05$).

Our 3 years of experience with off-clamp RPN support the technique to be feasible and has excellent oncologic outcome for certain tumors size with a certain location. It combines the advantages of the minimally invasive nature of the technique with the objectives of partial nephrectomy, such as cancer control and nephron sparing. The MINSS merits of our technique were clearly demonstrated through the insignificant change in the renal function, the minimal blood loss, and a short hospital-stay. The implemented technique for off-clamp RPN was used for cases of exophytic tumors with ≤2 cm at the base. This approach depends on the length of the used needle which is passed under the tumor base as preexcision hemostatic measure. After the tumor is excised the sutures can be tightening quickly to prevent any potential bleeding. Noteworthy issue is that some tumors maximum diameter is wider than their basis that is why we reported larger tumors within our cohort.

This study was a retrospective nature and utilized creatinine numbers instead of GFR. In fact, GFR was not been accurately measured in our patient due to the complexity of the measurement. Serum creatinine levels can be affected by different factors such as hydration status, medications, protein intake, and renal tubular secretion and absorption. However, serum creatinine has been used to assess the renal function by many studies, and deemed to be sufficient.[1,2,12]

It would be ideal in the future to have a prospective randomized multicenter trial to compare the effects of off-clamp technique in comparison to the warm ischemia technique on the RPN patients on terms of short- and long-term renal function, intraoperative blood loss, procedure duration, and length of hospital-stay, after controlling age, gender, tumors' size and grade.

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