Minimally Invasive Management of Renal Artery Pseudoaneurysm following Robotic Nephron-sparing Surgery: Report of Two Cases and Review of Literature

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Abstract

Partial nephrectomy (PN) either done open, laparoscopic, or robotic is associated with the complication of renal artery pseudoaneurysm (RAP), which is rare but can have grave prognosis. Minimally invasive intervention using endovascular techniques can safely treat this problem with minimal morbidity. We present here two cases of RAP following robotic PN. The first case was a 78-year male patient who underwent robotic PN 3 months prior for a 55 mm × 53 mm clear cell carcinoma of the left lower renal pole. On his 3-month follow-up computerized tomography (CT), he was incidentally diagnosed with a 48 mm × 40 mm × 36 mm well-defined pseudoaneurysm with supply from the lower polar accessory renal artery. The second case was a 42-year male patient who had undergone a robotic PN for a 3.5 cm renal mass. On day 24 postsurgery, he developed hematuria and evaluation with renal CT angiography showed two pseudoaneurysms of approximately 8–9 mm each; associated with a hematoma extending from the mid pole of the left kidney to the tail of the pancreas. We managed to successfully embolize the RAPs endovascularly in both the patients; case one with glue and case two with coils. Both patients were discharged on the next day with no side effects, complications, or morbidity. RAP post-PN; though rare, is a dreaded complication that one should be aware of and be able to treat it timely. Knowing how to managing these situations with minimally invasive techniques should be a part of the armamentarium of all endovascular specialists.

Keywords: Endovascular embolization, renal artery pseudoaneurysm, robotic partial nephrectomy, super-selective renal embolization

INTRODUCTION

Nephron-sparing surgery also known as partial nephrectomy (PN) over the years has advanced from open to laparoscopic to robotic. These surgeries have been historically associated with renal artery pseudoaneurysms (RAPs), which are rare but could be life-threatening. The incidence of RAPs following nephron-sparing surgeries done by laparoscopic technique has been reported to be higher than that seen with open surgeries. Based on some available literature RAP incidence following open PN is in the range of 0.43%–0.6%, while that following laparoscopic nephron sparing surgery is 1.7%–2.6%. Interestingly, the incidence of RAP reported by a recent study which performed CT scan on postoperative day four in all their patients undergoing PN is very high (open– 12.3% and laparoscopic–18.2%). With the advent of robotic surgery, the technical feasibility and safety of robotic-assisted PN (RAPN) have now been well established even for hilar tumors. Robotic nephron-sparing surgery is also associated with RAPs, but its true incidence is yet difficult to assess. The complication rate associated with RAPN for cases with tumors >4 cm has been reported differently, with one study showing no difference while the other showing higher likelihood of pseudoaneurysms causing Clavien grade III complications. These RAPs could be life-threatening, and hence, physicians encountering these problems should be aware of their incidence and management modalities.

We present here two cases of RAP following Robotic PN which were managed successfully with minimally invasive endovascular techniques; with the relevant review of literature.

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REPORT OF TWO CASES

Case 1

A 78-year male was incidentally diagnosed on a regular ultrasonography checkup with a left lower polar renal mass. Computerized Tomography (CT) was performed which showed a heterogeneously enhancing solid lobulated mass measuring 55 mm × 53 mm arising exophytically from the lower pole of the left kidney. It was involving the lower polar cortex and medulla. There was no regional lymphadenopathy with the normal renal vein. He underwent transperitoneal robotic PN which confirmed the 5.5 cm exophytic cystic tumor arising from the lower pole of the left kidney. The patient had two renal arteries and one renal vein. Renorraphy was done with polydioxanone suture (PDS) in two layers, and Floseal was used for adjuvant hemostasis. Warm ischemia time was 22 minutes. Histopathology had shown a clear cell carcinoma, pT1b, and Fuhrman G1 with negative margins. He underwent a follow-up CT scan at 3 months which showed a 48 mm × 40 mm × 36 mm well-defined pseudoaneurysm with supply from the lower polar accessory renal artery [Figure 1a and b]. There was no evidence of perinephric collection and no communication with the pelvicalyceal system (PCS), with no obvious enhancing soft-tissue mass. Both kidneys were normal functioning with excretion seen on CT urography.

This patient was then referred to our vascular surgery department for further management. We planned to treat this asymptomatic RAP preemptively with minimally invasive endovascular technique. The patient was taken up in our hybrid endovascular operating room for angioembolization under local anesthesia. The right common femoral artery access was taken under ultrasound guidance, and 6F sheath was placed. Selective cannulation of the left renal artery was performed. A selective angiogram confirmed the pseudoaneurysm arising from the lower polar accessory renal artery [Figure 1c]. A coaxial system with a 6F renal double curve (RDC) guiding catheter and 2.7F Progreat microcatheter (Terumo Interventional Systems) was used for embolization. Embolization of the accessory renal artery leading into the RAP was performed using a combination of N-butyl 2-cyanoacrylate (NBCA) glue and Lipiodol (1:3). Postembolization angiogram showed complete obliteration of the RAP [Figure 1d]. The patient had a speedy recovery and was discharged the next day with no side effects, complications, or morbidity. Six-month follow-up showed completely thrombosed RAP with normal residual kidney on ultrasonography (USG) Doppler, with a normal urine routine microscopy and a blood creatinine level of 1.2 mg%.

Case two

A 42-year male known case of hypertension and a tobacco addict underwent abdominal USG for abdominal discomfort which showed a left renal mass. CT scan confirmed a heterogeneously enhancing exo-endophytic left renal tumor of 3.5 cm with a single artery and vein, and no vascular or lymph node involvement. He underwent robot-assisted partial nephrectomy with frozen section from the tumor base being negative for malignancy. The PCS closure and renorraphy performed with PDS suture, and Floseal was used as an adjuvant hemostatic agent. Warm ischemia time was 20 minutes. The final histopathology of the tumor showed a clear cell carcinoma (grade 2, T1b). On postoperative day 24, he presented with painless hematuria with drop in hematocrit, and on evaluation with a CT angiography was diagnosed with two arterially enhancing pseudoaneurysms (approximately 8–9 mm each) seen within the hematoma at the postoperative site in the left kidney [Figure 2a]. The hemorrhagic collection was extending from the mid pole of the left kidney to the tail of the pancreas.

The patient was then referred to our vascular surgery service at which time he was taken up for an emergency angioembolization. Right common femoral artery access was taken under USG guidance, and a 6F sheath was placed. Selective angiogram of left renal artery confirmed the two RAPs [Figure 2b]. Using a coaxial system with a 5F RDC catheter and 2.7F Progreat microcatheter (Terumo Interventional Systems) superselective embolization was performed with coils (MicroNester Embolization Coil from Cook medical). The segmental and interlobar arteries with RAPs were superselectively embolized with 2 mm × 7 mm and 2 mm × 2 mm coils (0.018”), respectively [Figure 2c]. Postembolization angiogram showed complete obliteration of the RAPs [Figure 2d]. Hematuria resolved, and the patient was discharged on the next day. Three-month follow-up CT scan showed no residual RAP with the coils in situ [Figure 3].


**DISCUSSION AND REVIEW OF LITERATURE**

RAPs are a known complication of PN which can present as asymptomatic to mild hematuria to life-threatening hemorrhage. Laparoscopic partial nephrectomy (LPN) which is reported to be more technically challenging than robotic-assisted PN (RAPN) is associated with a higher incidence of RAPs when compared with open PN.\(^5,6\) The incidence of RAP with RAPN seems to be low, but there is not enough literature to know its exact occurrence. Zeccolini *et al.* in their experience of 60 cases of RAPN showed no occurrence of RAP.\(^10\) Bahler *et al.* in their study to assess the feasibility of RAPN with and without renorrhaphy showed an occurrence of one RAP in the renorrhaphy group of 30 patients, that is, an incidence of 3%; as opposed to no RAP in the nonrenorrhaphy group of 15 patients.\(^11\) Both of our patients had undergone renorrhaphy during their RAPN. Kara *et al.* in their retrospective review of robotic partial nephrectomies for angiomylipomas reported no pseudoaneurysm that required second intervention.\(^12\)

The true incidence of RAPs following nephron-sparing surgeries seems to be underestimated; we are probably looking at only the tip of the iceberg. Takagi *et al.* performed CT scan on the fourth postoperative day in all patients who underwent PN and found RAP in 17 patients out of 117, that is, an incidence of 15% (open– 12.3% and laparoscopic– 18.2%). However, only one patient out of these 17 was symptomatic, that is, had postoperative bleeding; while rest were asymptomatic. Five patients with RAP of 2–4 mm were managed conservatively and the RAP’s resolved. In the remaining eleven patients, ten patients had >4 mm RAP, and one had rapidly expanding RAP, and these eleven underwent preemptive embolization.\(^5\)

Among our two cases, the first case was asymptomatic diagnosed with RAP on his 3-month follow-up CT scan, and he underwent preemptive embolization as his RAP was approximately 4 cm. Our second case presented with hematuria on postoperative day 24 with two RAPs approximately 8–9 mm each, which were embolized as the patient was symptomatic.

Fardoun *et al.* retrospectively reviewed 199 patients who underwent PN between 2008 and 2012 to identify the predictive factors for hemorrhagic complications (hematoma requiring transfusion, an arteriovenous fistula, a false aneurysm, or a postoperative decrease of hemoglobin >3 g/dl). The method of surgery was open in 106 patients, laparoscopic in 54, and robotic in 39 cases. In their multivariate analysis, only operative blood loss of >250 ml was found to be a predictive factor for hemorrhagic complications.\(^13\) In both of our patients, the intraoperative blood loss was <250 ml. Although in both our patients a hemostatic agent (Floseal) was used, Peyronnet *et al.* have shown in their study that hemostatic agents have no impact on the hemorrhagic complications in RAPN.\(^14\) Thus, underlying the fact that hemostatic agents (like Floseal/Surgicel) may stop the surface ooze and may show a dry field, but the deep-seated open arteries may form the pseudoaneurysms later. Coverage of the cut surface with these hemostatic agents will only mask the surface ooze, but when the arterial spasm reduces, the cut arterial surfaces may open up, causing a much higher incidence of pseudoaneurysms. Therefore, it is of utmost importance for meticulous hemostasis even during these minimally invasive techniques of PN.

Omae *et al.* in their study which included 101 patients undergoing LPN and RAPN concluded that RAP occurrence is higher with renal sinus exposure.\(^15\) Kondo *et al.* in their study have concluded that early unclamping and reducing the renal ischemia time could reduce the risk of RAPs following RAPN.\(^16\) The warm ischemia time in our patients was 22 and 20 min; larger studies are required to assess the correlation between the renal ischemia time and RAP.

Interestingly, recurrent or residual renal masses following RAPN also could mimic as pseudoaneurysms, as reported by

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**Figure 1:** Case 2 – (a): Preembolization computerized tomography angiography (MIP image), (b): Digital subtraction angiography before embolization, (c): Coil deployment during embolization, (d): Postcoil embolization digital subtraction angiography

**Figure 2:**

**Figure 3:** Case 2 – Three-month follow-up computerized tomography
Among the cases of RAPs following open PN more than a decade ago,[1] the safety and efficacy of selective renal angiography and therapeutic coil embolizations for RAPs following open and laparoscopic PN were shown by Cohenpou et al. in a decade ago in their case series of five patients. All these five patients presented in the first 21 days with hematuria.[20] Subsequently, the studies continued to show the feasibility and safety of selective embolization for RAPs following nephron-sparing surgeries performed by open and laparoscopic techniques. The time of presentation of these symptomatic RAPs is very similar in most of the studies; in the study of Shapiro et al. the mean time of presentation was 12.6 days and Ghoneim et al. reported that the diagnosis of the RAPs was made at a median of 14 days.[3,4] Irvine et al. reported one of their two cases of RAP following open PN to have presented with hematuria 23 days postsurgery, which was successfully managed with transcatheter embolization with multiple coils.[18] Even our second case which was symptomatic with hematuria on the postoperative day 24 was successfully managed with an urgent CT angiography followed by superselective embolization of the two pseudoaneurysms with coils. It seems that at the first 2–4 weeks post nephron sparing surgery the incidence of symptomatic RAP is higher, whereas the small asymptomatic ones tend to resolve spontaneously and the large asymptomatic ones are diagnosed on the follow-up CT scan. Larger and well-structured studies are needed to design a protocol to pick up these RAPs post RAPN and categorize them as to which asymptomatic ones would benefit the most by a preemptive embolization.

Loffroy et al. in their review on transcatheter arterial embolization in patients with kidney diseases have described the techniques, precautions, complications, and side effects of this modality that has been described since the 1970s. RAPs following blunt trauma was reported to have been successfully managed with transcatheter embolization by Miller et al. in 2002. Ginat et al. have described the various methods and modalities for transcatheter embolization of the renal artery and its branches. Embolization of renal artery and/or its branches is performed not only for hemorrhagic complications such as pseudoaneurysms but also has been utilized for multiple other indications such as ablation of renal tumors, management of angiomyolipomas, renal malignancy palliation, vascular malformations, and arteriovenous fistulas. Different embolic agents that have been described are metal coils, sclerosing agents such as absolute alcohol, liquid embolic agents such as Onyx, and NBCA glue with lipiodol; and particulate embolic agents (polyvinyl alcohol particles and embospheres). In more complicated cases, the aid of stent grafts and balloon or stent-assisted coiling has also been described.[21] Our first patient was managed with NBCA glue with lipiodol combination; and the second patient with metallic coils.

Sam et al. studied the safety and efficacy of renal artery embolization in 50 patients with severe hemorrhage after iatrogenic arterial kidney injuries. They found a high technical success rate of 98% and a high clinical success rate of 83%, 94% and 98% at 24, 48 and 96 h, respectively. Three patients had minor complications, and there was one death within 30 days. In their study, renal arterial embolization was not associated with significant worsening of renal function nor did it cause significant increase in blood pressure.[24] Wang et al. assessed the effectiveness of superselective renal artery embolization in the treatment of renal hemorrhages in 46 patients in the age range of 26–73 years. Six of these patients had hemorrhage post-PN. Successful embolization was achieved in 80.8% of patients at the first attempt, and after the second attempt, it reached 97.8%. There were no serious complications related to the procedure in their study. They concluded that superselective renal artery embolization is an effective minimally invasive method for control of renal hemorrhage.[25] In both the RAPs post-RAPN managed by us, there was successful complete resolution; with relief of hematuria in the second patient. At 6-month follow-up, both patients had no residual hematoma or recurrence, with complete preservation of renal function.

Netsch et al. retrospectively reviewed the occurrence of RAPs following open and laparoscopic PN’s and found an incidence of 1.82% symptomatic RAPs with hematuria. The median time of symptom presentation postsurgery was 12.5 days (6–36 days). All their patients were managed with microcoils in a superselective manner, with no episodes of hemorrhage or flank pain during the follow-up.[26] A retrospective review of 998 patients undergoing minimally invasive PN was performed by Hyams et al. to study the outcomes after treatment of iatrogenic vascular lesions. There were 20, that is, 2% of patients who presented with iatrogenic vascular lesions as hematuria at a mean postoperative day of 14.5. They concluded that there is a subset of patients who will resolve with observation only but most require angioembolization which has an excellent clinical and renal function outcome.[27] Although in most of the studies with RAP’s in non-RAPN, the average timing of their occurrence is at 2 weeks; as per recent report by Verge et al. of two cases of RAP post-RAPN their occurrence was delayed with presentation after postoperative day 24 with gross hematuria. Even they managed to successfully control the RAPs with coil embolization.[1,20,26,28] Among the case...
reports of RAP and post-RAPN, the one by Rajih et al. also occurred at postoperative day 22; except the one by Irvine et al. which occurred on postoperative day 2.\cite{18,19} The dilemma of when to screen for asymptomatic cases, which cases to embolize, when to embolize, and which case can be managed conservatively needs to be resolved with larger structured studies because there have been case reports of conservative management with resolution of symptoms and the pseudoaneurysm as large as 1.2 cm in 72 h.\cite{29}

### Conclusion

RAPs postnephron sparing surgeries may not be as rare as they are thought to be because they could be asymptomatic and many could be regressing with time. Nevertheless, their occurrence with the newly emerged technology of RAPN has been seldom reported. Our literature search has shown that only a handful of them have been reported till now,\cite{11,18,19,28} [Table 1]. They may present early or delayed and may not be always symptomatic but could be large, asymptomatic, and ready to rupture. What is more important is one should be aware that they occur and could lead to life-threatening hemorrhage and hence should be diagnosed as early as possible.

Although many of the undiagnosed ones are self-limiting, it is of paramount importance that there should be a protocol in place to identify the ones that could be problematic and they should be promptly treated. There is a need for more stringent follow-up in cases of robotic PN to diagnose these pseudoaneurysms early and treat them appropriately. Minimally invasive endovascular techniques to manage these pseudoaneurysms are a boon to these patients with much less morbidity and mortality as compared to other surgical options. Vascular and endovascular specialists should be well versed with these techniques and be available with all the necessary gadgets to manage them on an emergency basis.

### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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### Conflicts of interest

There are no conflicts of interest.

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