



Open partial nephrectomy when a non-flank approach is required: indications and outcomes

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Abstract

Purpose To evaluate indications/outcomes for open partial nephrectomy (OPN) when non-flank approaches are required, with comparison to patients managed with the flank approach. Outcomes with a non-flank approach are presumed less favorable yet there have been no previous reports on this topic.

Methods 2747 OPNs were performed (1999–2015) and 76 (2.8%) required a non-flank approach. We also reviewed all traditional flank OPNs performed during odd years in this timeframe yielding 1467 patients for comparison.

Results Overall, median tumor size was 3.5 cm and 274 patients (18%) had a solitary kidney. Non-flank patients were younger, and tumor size and clinical/pathologic stage were significantly increased for this cohort, but the groups were otherwise comparable. Indications for non-flank OPN included large tumor size/locally advanced disease ($n=21$), need for simultaneous surgery ($n=25$), previous flank incision or failed thermoablation ($n=13$), or congenital/vascular abnormalities ($n=9$). The most common non-flank approach was anterior subcostal ($n=39$, 51%). Operative times, estimated blood loss, positive margins, and functional decline were all modestly increased for non-flank patients. Intraoperative and genitourinary complications were more common in non-flank patients ($p<0.05$), although all were manageable, typically with conservative measures. There were no mortalities among non-flank patients and none required long-term dialysis.

Conclusions Our series, the first to address this topic, suggests that outcomes with non-flank OPN are generally less advantageous likely reflecting increased tumor/operative complexity. However, complications in this challenging patient population are manageable and final dispositions are generally favorable. Our findings should be useful for counseling regarding potential outcomes when a non-flank incision is required.

Keywords Partial nephrectomy · Kidney cancer · Surgical approach · Complications

Abbreviations

CKD	Chronic kidney disease
CT	Computed tomography
GFR	Glomerular filtration rate

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IQR	Interquartile range
OPN	Open partial nephrectomy
PN	Partial nephrectomy
RCC	Renal cell carcinoma
R.E.N.A.L.	(R)adius (tumor size as maximal diameter), (E)xophytic/endophytic properties of tumor, (N)earness of tumor deepest portion to collecting system or sinus, (A)nterior(a)/posterior (p) descriptor, and (L)ocation relative to polar lines

Introduction

Most patients requiring PN can be managed with a minimally invasive approach in this era, but some patients with a solitary kidney, preexisting chronic kidney disease (CKD), or high complexity tumors may still be best managed with an open approach [1–7]. The open approach is versatile and allows the surgeon to deal with a number of potential contingencies, while also facilitating routine application of hypothermia, which reduces the risk of irreversible ischemic injury [2, 7, 8].

Open PN (OPN) has traditionally been performed through a flank incision which provides direct access to the kidney [1–7]. This can be particularly helpful for obese patients who tend to carry their weight intra-abdominally, or patients with adhesions from prior abdominal surgery. After mobilization of the kidney, all necessary steps can essentially be performed at skin level thus optimizing surgical exposure. The flank approach also allows for sequestration of complications because the intervention remains extraperitoneal and extrapleural. Downsides of the flank incision relative to minimally invasive surgery include increased narcotic requirements, longer hospital stay, and risk of a flank bulge [9–11]. A mini-flank incision can often be utilized to reduce the incidence and impact of these adverse events [2, 12, 13].

Nevertheless, a flank incision is not always possible for OPN due to large tumor size, vascular anomalies, or other complexities [14–16]. However, the indications for non-flank OPN, alternate surgical incisions required, and outcomes associated with this approach have not been adequately studied, and the potential complications of surgery in this setting remain poorly defined. In this study, we analyze a large cohort of patients managed with non-flank OPN with comparative analysis of outcomes relative to the traditional flank approach.

Patients/methods

With institutional review board approval, we performed retrospective review of 2747 patients treated with OPN by 11 experienced nephron-sparing surgeons (1999–2015), and 76 patients were managed with a non-flank approach. Patients

with conversion from minimally invasive PN to OPN were excluded. We also reviewed all traditional flank OPNs performed during odd years in this timeframe yielding 1467 patients for comparison.

Data collected included patient/tumor characteristics, specific indications for a non-flank approach, and perioperative outcomes. Tumor complexity was defined by R.E.N.A.L. [17], and preoperative/postoperative glomerular filtration rates (GFR) were calculated using Modification Diet Renal Disease-2 [18]. Choices of flank versus non-flank and warm versus cold ischemia were based on individual patient, tumor, and anatomic characteristics, need for concomitant surgery, and surgeon preference. Choices of which non-flank incision to utilize were also based on surgeon preference. Intraoperative/postoperative complications were assessed using Clavien–Dindo [19]. Major complications (Clavien 3–5) were classified as genitourinary versus non-genitourinary. Urine leakage severity was classified by treatment: expectant management, stent required for resolution, or urinoma requiring drain placement.

Continuous variables were presented as medians (interquartile range) and compared using Mann–Whitney *U* test. Categorical variables were presented as numbers (percentages) and compared using chi square. All tests were two-tailed; $p < 0.05$ was considered significant. Data were analyzed using SPSS version 20.0.

Results

Our study focused on 76 patients who underwent OPN through a non-flank incision with comparison to 1467 patients managed with OPN via the standard flank approach (Table 1). Overall, the median age was 71 years and 66% of patients were male. There were no significant differences in comorbidities between the two cohorts. Median tumor size was 4.2 cm in the non-flank cohort versus 3.5 cm in the flank patients ($p = 0.002$), and clinical stage also tended to be more advanced in non-flank patients ($p < 0.001$). However, median R.E.N.A.L. scores were 7 in both cohorts. Overall, 274 patients (18%) had a solitary kidney, and median preoperative GFR was 74 ml/min/1.73 m². In general, there were more benign tumors in the non-flank cohort, but cancers in this group tended toward higher stage/grade (Supplementary Table).

Indications for non-flank incision for OPN mostly fell into four categories. In 21 patients, a non-flank approach was required due to large tumor size ($n = 16$) or locally advanced disease (clinical T3–T4 or infiltrative appearance, $n = 5$), with representative cases shown in Fig. 1a–d. Tumor size > 10 cm was generally considered for a non-flank approach, although individualized surgeon assessment of ability to adequately mobilize the kidney to allow for PN

Table 1 Demographics and tumor characteristics

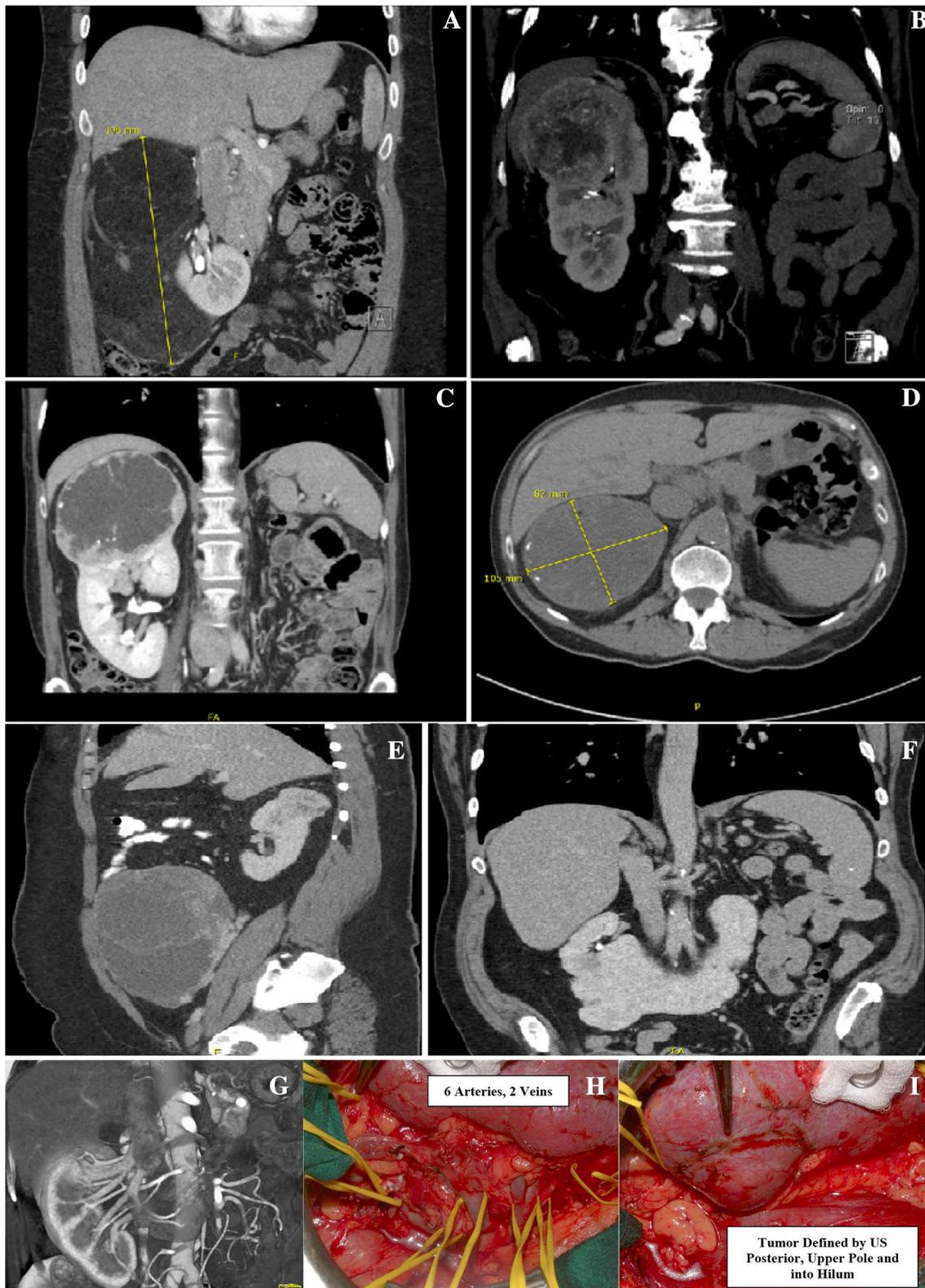
	Flank approach (<i>n</i> = 1467)	Non-flank approach (<i>n</i> = 76)	<i>p</i> value
Age (years), median (IQR)	72 (64–81)	60 (46–67)	<0.001
Gender, <i>n</i> (%)			0.14
Male	971 (66)	44 (58)	
Female	496 (34)	32 (42)	
Race, <i>n</i> (%)			0.22
Caucasian	1262 (86)	71 (93)	
African American	136 (9)	3 (4)	
Other	7 (1)	0	
Missing values	62 (4)	2 (3)	
Body mass index (kg/m ²), median (IQR)	30 (27–33)	30 (25–34)	0.31
Side, <i>n</i> (%)			0.16
Right	748 (51)	45 (59)	
Left	719 (49)	31 (41)	
Cerebrovascular disease, <i>n</i> (%)	59 (4)	2 (3)	0.54
Hypertension, <i>n</i> (%)	806 (59)	36 (47)	0.20
Diabetes mellitus, <i>n</i> (%)	283 (21)	11 (14)	0.30
Cardiovascular disease, <i>n</i> (%)	173 (12)	12 (16)	0.30
Tobacco use, active or prior, <i>n</i> (%)	531 (37)	25 (33)	0.56
Symptomatic, <i>n</i> (%)	298 (21)	17 (22)	0.67
Tumor size (cm), median (IQR)	3.5 (2.5–4.7)	4.2 (2.8–8.9)	0.002
R.E.N.A.L. score, median (IQR)	7 (6–9)	7 (6–8)	0.26
Tumor complexity, <i>n</i> (%)			0.56
Low (R.E.N.A.L. score 4–6)	305 (21)	24 (32)	
Intermediate (R.E.N.A.L. score 7–9)	568 (39)	36 (47)	
High (R.E.N.A.L. score 10–12)	120 (8)	6 (8)	
Missing values	474 (32)	10 (13)	
Clinical stage, <i>n</i> (%)			<0.001
Benign	12 (1)	1 (1)	
T1a	788 (54)	45 (46)	
T1b	402 (27)	21 (22)	
T2a	52 (3)	5 (5)	
T2b	10 (1)	14 (14)	
T3a	19 (1)	2 (2)	
T3b	0	1 (1)	
Missing values	184 (13)	8 (9)	
Solitary kidney, <i>n</i> (%)	255 (18)	19 (25)	0.09
Preoperative GFR (ml/min/1.73 m ²), median (IQR)	73.2 (55.0–89.5)	76.5 (54.6–102.8)	0.16

GFR glomerular filtration rate, *IQR* interquartile range, *R.E.N.A.L.* (R)adius (tumor size as maximal diameter), (E)xophytic/endophytic properties of tumor, (N)earness of tumor deepest portion to collecting system or sinus, (A)nterior (a)/posterior (p)descriptor and (L)ocation relative to polar lines

was the main factor. Twenty-five patients required simultaneous surgery that could not be performed through the flank (Fig. 1e). Eleven patients had previous flank incisions and two had prior thermoablation raising concern about challenging adhesions and fibrosis, and alternate incisions were thus selected. Complex congenital or vascular abnormalities were identified in nine patients, with representative cases shown in Fig. 1f–i. Seven patients also underwent non-flank

OPN for other reasons: multiple tumors (*n* = 3), severe scoliosis (*n* = 2), kidney cancer in a transplant allograft (*n* = 1), and retroperitoneal fibrosis (*n* = 1).

The most common non-flank approach was anterior subcostal (51%), but midline and thoracoabdominal incisions were also used in 22 and 21% of cases, respectively (Table 2). Overall, median warm/cold ischemia times were 22/37 min, respectively. There were no significant



differences between the cohorts with respect to type of ischemia ($p=0.59$). Estimated blood loss, incidence of blood transfusion, and operative times were significantly increased

in the non-flank cohort ($p \leq 0.002$). Positive margins were also more common in non-flank patients ($p=0.03$), and this cohort associated with reduced global GFR preserved (83

Fig. 1 Open PN performed through a non-flank incision. **a** 52-year-old woman with a large posterior right angiomyolipoma displacing the kidney anteromedially, shown on coronal images of CT scan; **b** 71-year-old man with a 9.3 cm upper pole RCC in a solitary kidney, shown on coronal images of CT scan. Tumor was invading the collecting system and proximal aspect of a branch of the renal vein; **c**, **d** 48-year-old woman with a 10.5 cm right upper pole RCC shown on coronal and transverse images of CT scan; **e** 32-year-old woman with synchronous presentation with upper pole RCC and serous cystadenocarcinoma of the ovary shown on sagittal view of CT scan; **f** 58-year-old man with preexisting CKD and proteinuria who presented with RCC in a horseshoe kidney shown on coronal images of CT scan; **g–i** 61-year-old man with partly exophytic right-sided RCC that also extended into the collecting system. Vascular anatomy was complex with six renal arteries and two renal veins as illustrated on CT (coronal image). Intraoperative photos demonstrate the planned dissection in preparation for clamped PN with hypothermia. The first 3 cases were managed with subcostal incisions to facilitate adequate mobilization of the kidney prior to PN, and the final 3 were managed with midline incisions

versus 93%, $p=0.01$). None of non-flank explorations were converted from PN to radical nephrectomy.

Perioperative and postoperative outcomes are detailed in Tables 2 and 3. Intraoperative complications occurred in 7% of patients managed with non-flank incisions versus 3% of patients undergoing traditional flank incisions ($p=0.03$). Genitourinary complications were also more frequent in non-flank patients (22 versus 10%, $p=0.001$). Postoperative complications were more common in non-flank patients (36 versus 26%), but statistical significance was not observed. Major complications (Clavien 3–5) were also more common in non-flank patients (7 versus 3.3%), although again statistical significance was not observed.

Of 76 non-flank patients, nine required transfusion, but none required embolization. One patient required a temporary drain for urinoma, and the other urine leak was managed expectantly. Six patients experienced acute kidney injury with one needing temporary dialysis, but no patients required permanent dialysis. In addition, no non-flank patients required repeat surgery and there were no mortalities (Table 3).

Discussion

The open approach to PN offers potential advantages for patients with a solitary kidney, preexisting CKD, or high complexity tumors, and has traditionally been performed through the flank [1–7]. The flank incision provides great access, effortless application of hypothermia, and sequestration of complications [2, 7, 8]. However, a flank approach is not always possible due to variety of anatomic and oncologic considerations, or other complexities that may be difficult to manage within the confines of the retroperitoneal space [14–16, 20–22]. In this study, which is the first to address

this challenging patient population, we evaluate a relatively large cohort ($n=76$) managed with non-flank OPN, with focus on the indications that mandated this approach, alternate incisions required for such procedures, and comparative outcomes for flank versus non-flank approaches, including relative rates of perioperative complications.

Overall, 2.8% of our patients underwent a non-flank approach to OPN for a variety of reasons. One indication was large tumor size or locally advanced disease, which can preclude adequate mobilization of the kidney and thus restrict access to the hilum. In patients with a prior flank incision or failed thermal ablation, the kidney is often adherent to the body wall and embedded within substantial fibrosis, making a repeat flank incision potentially challenging. A horseshoe kidney or other renal units with anomalous vasculature often cannot be managed via the flank approach, and midline incisions are typically best. For patients requiring concomitant surgery, including most general surgery and gynecologic considerations, a trans-abdominal approach is often required. The incidence of non-flank OPN in our series may have been increased due to referral patterns related to tertiary care practice.

The most common non-flank incision in this series was anterior subcostal, which provides great access to the upper aspects of the peritoneal cavity and retroperitoneal organs [14]. Bilateral procedures can also be addressed with this approach, but this often requires further extension of the incision, and in this setting a midline approach may be more appropriate [22]. For example, both cases of bilateral renal cancer surgery in this series were performed through a midline incision. The main advantage of the thoracoabdominal incision relates to pathology at the extreme cephalad aspects of the retroperitoneum, such as large or locally advanced upper pole renal tumors [16, 17]. However, such tumors are uncommon, and this approach was only utilized 16 times in our series. The thoracoabdominal incision is associated with substantial perioperative discomfort so it should be used selectively [16, 17]. Decisions about which incision to make for challenging cases of OPN can be complex, not only with respect to flank versus non-flank, but also which non-flank incision may be optimal. Surgeon experience is an important factor as well as body habitus, and the particular challenges that are inherent to each individual case must also be taken into account.

Our analysis allows us to highlight potential differences in functional and oncologic outcomes for patients managed with a traditional flank incision versus those who required a non-flank approach, as well as issues related to perioperative morbidity. Operative times, estimated blood loss, and transfusion rates were all significantly increased for non-flank patients, and positive margins were also more common in this group. Modest functional differences were also observed, as the percent global GFR saved was also reduced

Table 2 Procedural considerations and intraoperative outcomes

	Flank approach (<i>n</i> = 1467)	Non-flank approach (<i>n</i> = 76)	<i>p</i> value
Procedural considerations			
Approach, <i>n</i> (%)			
Flank	1467 (100)	0	
Anterior subcostal	0	39 (51)	
Midline	0	17 (22)	
Thoracoabdominal	0	16 (21)	
Other	0	4 (5)	
Ischemia type, <i>n</i> (%)			0.59
Warm ischemia	926 (63)	46 (61)	
Cold ischemia	367 (25)	18 (24)	
Zero ischemia	174 (12)	12 (16)	
Ischemia time, median (IQR)			
Warm ischemia time (min)	22 (17–28)	22 (15–29)	0.64
Cold ischemia time (min)	37 (25–50)	41 (23–56)	0.75
Intraoperative outcomes			
Estimated blood loss (ml), median (IQR)	250 (150–400)	600 (350–1250)	<0.001
Blood transfusion, patients, <i>n</i> (%)	54 (4)	14 (18)	<0.001
Operative time (min), median (IQR)	226 (185–271)	248 (201–332)	0.002
Positive margins, <i>n</i> (%)	85 (6)	9 (12)	0.03
Subjective estimate parenchyma preserved (%), median (IQR)	75 (60–85)	67 (60–90)	0.37
Intraoperative complications, <i>n</i> (%)			
Loss of kidney	0	0	0.03
Vascular injury	2 (0.1)	1 (1)	
Pleural injury	23 (2)	0	
Ureteral injury	7 (0.5)	1 (1)	
Other	4 (0.3)	3 (4)	

IQR interquartile range

in the non-flank patients (83 versus 93%) [8]. Variance in the cohorts related to tumor size and complexity likely contributed to these findings, as the non-flank cohort generally consisted of more challenging tumors and concomitant procedures were often required. Differences in surgical exposure for performing OPN via the various incisions may have also been a factor, as this consideration is particularly favorable for the flank incision which leaves the kidney essentially at skin level after mobilization.

Our analysis also demonstrates that intraoperative and genitourinary complications were more common in non-flank patients, although favorable outcomes were generally achieved. Increased tumor size and complexity in the non-flank cohort may have been a contributing factor, but many of these cases were also challenging in other important respects, even beyond the frequent need for concomitant procedures. Mobilization was occasionally difficult due to fibrosis from previous interventions, and complex vascular dissections were also occasionally required [23]. Most important, complications in non-flank patients were

uniformly manageable, typically with conservative measures. Repeat surgery or angioembolization was not required. There were no mortalities among non-flank patients and long-term dialysis was not required. Our data should be useful for counseling patients about outcomes when a non-flank incision is required.

Sequestration of complications is a potential advantage of the flank approach, as it could theoretically isolate any urine leaks, abscesses, or postoperative bleeds, within the confined space of the retroperitoneum [24–29]. As such, this could reduce the risk of intra-abdominal urinary ascites or sepsis and might lead to early tamponade of bleeding events. However, our series suggests that such events were uncommon with trans-abdominal OPN, even for a complex patient profile. Therefore, sequestration of complications may not be as important as previously believed [9, 10].

Our study has limitations including retrospective design and subjective selection of patients for the non-flank approach, which was done on an individualized basis taking into account patient/tumor characteristics and

Table 3 Postoperative outcomes

	Flank approach (<i>n</i> = 1467)	Non-flank (<i>n</i> = 76)	<i>p</i> value
Postoperative outcomes			
Hospital stay (days), median (IQR)	5 (4–6)	6 (5–7)	<0.001
Clavien–Dindo classification, <i>n</i> (%)			
Overall complications (Clavien 1–5)	388 (26)	27 (36)	0.08
Major complications (Clavien 3–4)	45 (3)	5 (7)	0.09
Postoperative mortality (Clavien 5)	5 (0.3)	0	0.61
Genitourinary complications			
Acute kidney injury requiring dialysis	9 (1)	1 (1.4)	0.48
Permanent	3 (0.2)	0	
Temporary	6 (0.4)	1 (1.4)	
Acute kidney injury not requiring dialysis	49 (3)	5 (6.5)	0.18
Urine leakage			
Conservative management	11 (1)	1 (1.3)	0.23
Stent required for resolution	11 (1)	0	
Urinoma requiring drain placement	3 (0.2)	1 (1.3)	
Nephrocutaneous fistula	0	0	
Bleeding requiring transfusion	71 (5)	9 (12)	0.02
Embolization required	4 (0.3)	0	
Perinephric abscess requiring drainage	2 (0.1)	0	0.75
Non-genitourinary complications			
Myocardial infarction	5 (0.3)	1 (1.3)	0.74
Pulmonary embolism	1 (0)	0	
Deep venous thrombosis	8 (1)	0	
Cerebrovascular event	0	0	
GI bleed requiring transfusion	2 (0.1)	0	
Pneumothorax requiring chest tube placement	10 (1)	1 (1.3)	
Functional follow-up			
Follow-up (months), median IQR	12 (1–60)	23 (6–79)	
Latest GFR (ml/min/1.73 m ²), median (IQR)	60 (46–84)	56 (36–87)	0.47
% global GFR preserved, median (IQR)	93 (73–100)	83 (56–100)	0.01
Severe CKD with delayed need for dialysis	4 (0.3)	0	
Total with long-term need for dialysis	7 (0.5)	0	

CKD chronic kidney disease, GFR glomerular filtration rate, IQR interquartile range

surgeon experience. Our study population was derived from tertiary care centers with experienced nephron-sparing surgeons, which could affect generalizability. While margin status was almost uniformly available, long-term oncologic outcomes will require further study. Strengths of our study include relatively robust numbers of subjects even for the non-flank cohort, and availability of a relevant comparator group from the same centers and timeframe. To our knowledge, our study is the first that addresses this challenging patient population, which represented about three percent of patients needing OPN at our centers.

Conclusions

A non-flank approach to OPN should be considered when necessary, dependent on tumor characteristics, anatomic or vascular considerations, or need for concomitant procedures. Such cases are generally more challenging and perioperative morbidity in this setting is increased. However, most such complications are manageable with conservative measures despite lack of sequestration with the intra-abdominal approaches. Our findings should be useful

for patient counseling regarding potential outcomes when a non-flank incision is required.

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Compliance with ethical standards

Disclosures None of the authors have disclosures or conflicts of interest to report.

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