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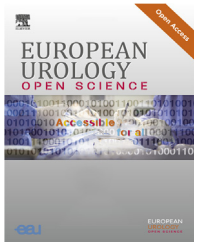

European Association of Urology

Case Report

Initial Experience with Hybrid Partial Nephrectomy with Ultrasound-guided Balloon Catheter Occlusion of the Renal Artery for Recurrent Renal Tumors

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Abstract

Repeat partial nephrectomy (PN) is an effective treatment in improving the prognosis for patients with recurrent renal cancer after initial PN. However, salvage PN (sPN) is inevitably associated with a higher rate of complications, largely because of intraperitoneal adhesions and fibrosis. Here we describe three initial cases for which recurrent renal tumors were treated with a novel minimally invasive approach, namely Ultrasound-guided Renal Artery Balloon catheter Occluded Hybrid Partial Nephrectomy (UBo-HPN).With laparoscopic ultrasound (LUS) guiding a Fogarty catheter to occlude the arterial blood supply, dissection of the renal hilum and most of the abdominal cavity can be avoided. UBo-HPN was successfully performed in three patients. One case of postoperative fever (Clavien-Dindo grade II) occurred, with no other complications. The mean operative time was 106 min, with a mean warm ischemia time of 21 min. UBo-HPN may be considered a safe and effective alternative for sPN, with a minimally invasive surgical footprint and better surgical outcomes.

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1. Case series

1.1. Introduction

Renal cancer is one of the most common urological cancers worldwide and its incidence rate is expected to increase in the coming years [1]. Partial nephrectomy (PN) is the standard treatment option for localized renal cancer [2]. Although uncommon, recurrence was observed in approximately 1.5% of cases after initial treatment [3]. Robot-assisted PN (RAPN) presented as an effective and minimally invasive treatment option for recurrent renal cancers. However, difficulties in dissecting the renal hilum and other surrounding structures because of extensive abdominal adhesions greatly increase the risk of complications and the positive surgical margin (PSM) rate in salvage PN (sPN), in comparison to the initial surgery [4–6]. Therefore, a conventional sPN approach significantly affects the achievement of trifecta outcomes, including complete removal of the tumor, maximum preservation of renal function, and surgical safety. To date, no ideal surgical methods for enhancing the safety and efficiency of sPN have been reported.

To address this gap, we developed a technique that achieved occlusion of the renal artery with a minimal intraabdominal footprint, namely Ultrasound-guided Renal Artery Balloon catheter Occluded Hybrid Partial Nephrectomy (UBo-HPN). The technique was successfully performed in three patients with locally recurrent renal cancer.

1.2. Study cohort

The study got registered from the Chinese Clinical Trial Registry (www.chictr.org.cn; ChiCTR2100050808) and was conducted according to the Declaration of Helsinki. From February to August 2023, three patients with suspected recurrent renal cancer in Tongji Hospital were prospectively enrolled in the study.

1.3. Clinical and pathological evaluation

Each patient's general condition was recorded at the time of admission (Table 1). Data for intraoperative characteristics including operative time, warm ischemia time (WIT), and estimated blood loss (EBL) were collected. Hemoglobin and serum creatinine were measured at admission and 48 h after surgery. Complications were graded according to the Clavien-Dindo scheme. Follow-up after UBo-HPN was every 3–6 mo.

1.4. UBo-HPN procedure

The patient was placed in a 70° oblique lateral position and general anesthesia was administered according to the local routine. All procedures were performed using a da Vinci Si or Xi robotic system. One trocar for optics, two trocars for robotic instruments, and two assistant trocars were placed as for conventional RAPN.

1.4.1. Release of abdominal adhesions and insertion of the femoral vascular sheath

Careful preoperative imaging of the tumor and abdominal blood vessels is important (Fig. 1A). The intra-abdominal adhesions were first dissected and the Gerota fascia was exposed (Fig. 1B). The tumor site and abdominal arteries were located under laparoscopic ultrasound (LUS; Fig. 1C, D).

Femoral artery puncture was performed under ultrasound guidance and a 6F vascular sheath was inserted using the modified Seldinger method. Systemic heparinization was achieved via injection of 3000 U of heparin, followed by 1000 U of supplemental heparin every hour.

1.4.2. Placement and inflation of the balloon catheter in the renal artery

A 5F guiding catheter, an ultra-slip guidewire, and a compliant Fogarty balloon catheter were successively inserted via the iliac artery and abdominal aorta to the opening of the renal artery, which was the site for occlusion. The entire

Table 1 – Patient information

Case	Age (yr) Sex	BMI (kg/m^2)	Prior renal surgery	Hx at prior PN	Time from last surgery (mo)	Tumor side	Tumor location	TD (cm)	cT stage	RENAL score
1	69 Male	29.1	Open radical nephrectomy (right) + RAPN (left)+ kidney cyst decortication (left)	RCC	7	Left	Upper pole, posterior	3.7	T1a	5
2	63 Male	26.4	RAPN (right)	RCC	11	Right	Upper pole, anterior	2.0	T1a	6
3	56 Male	26.4	Laparoscopic PN (left)	RCC	11	Left	Middle pole, anterior	1.3	T1a	5

BMI = body mass index; RAPN = robot-assisted partial nephrectomy; Hx = histology; RCC = renal cell carcinoma; TD = tumor diameter on computed tomography.

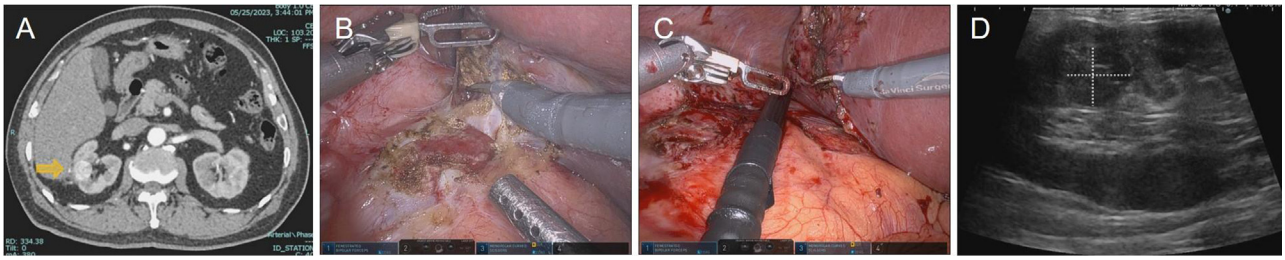

Fig. 1 – (A) Detailed preoperative imaging of the tumor and abdominal blood vessels is important. Preoperative enhanced computed tomography showed an enhanced nodule of 2.0 cm × 1.9 cm in the right kidney (arrow). (B) The intra-abdominal adhesions were dissected and the Gerota fascia was exposed. (C) The tumor site and abdominal artery were located under laparoscopic ultrasound (LUS). (D) LUS revealed that the tumor was located in the anterior upper pole of the right kidney.

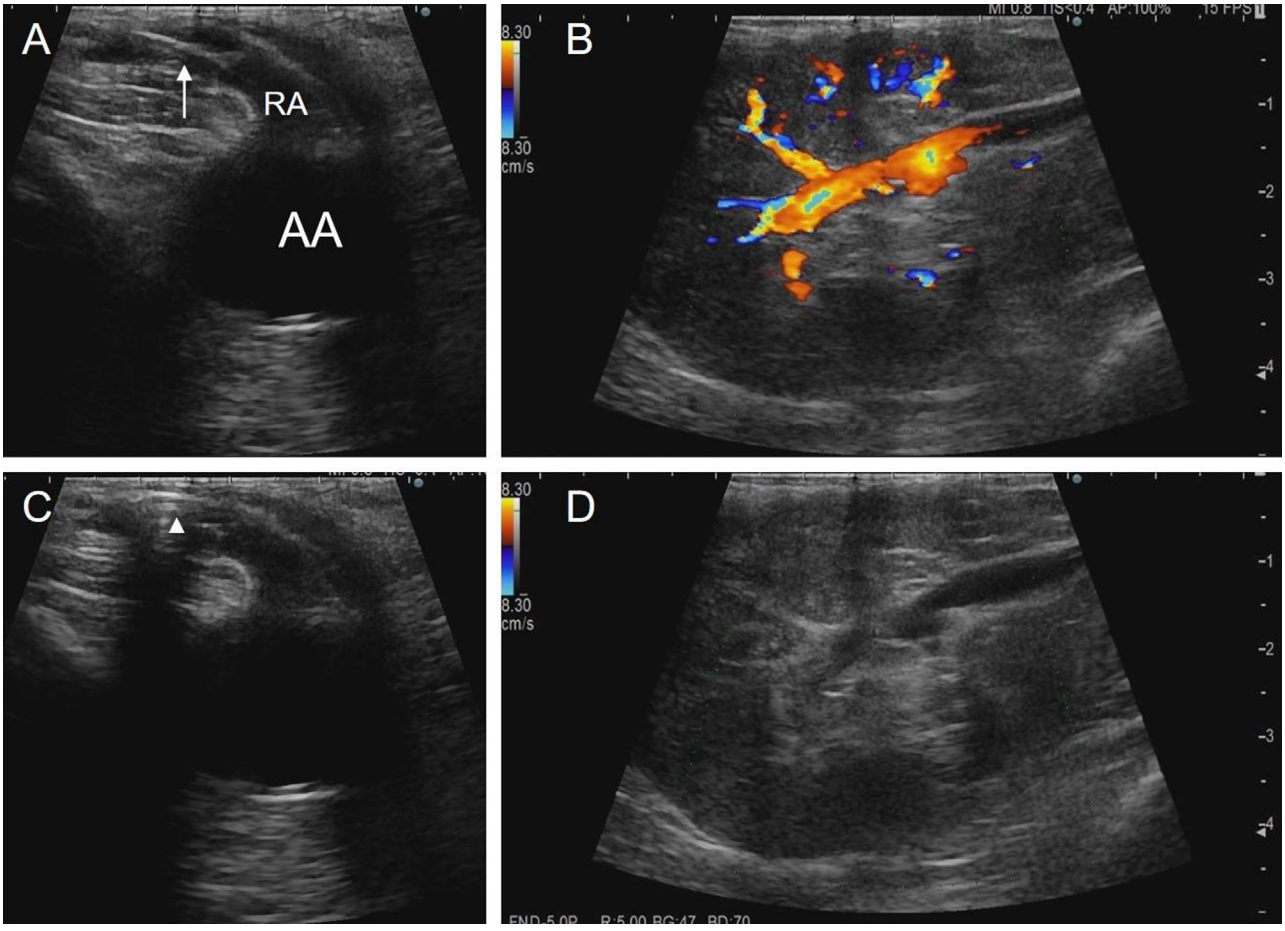

Fig. 2 – (A) An ultra-slip guidewire was inserted through the iliac artery and abdominal aorta (AA) until the opening of the renal artery (RA) to reach the occlusion site, which was monitored under full laparoscopic ultrasound (LUS) guidance during the entire process. LUS revealed the short-axis section of the AA and the long-axis section of the RA, as well as the guidewire in the RA (arrow). (B) Color Doppler flow imaging (CDFI) showed renal blood flow signal before the balloon was inflated and renal artery blood flow was occluded. (C) A compliant Fogarty catheter (△) was then inflated with a suitable amount of saline. (D) Loss of blood flow signal within the tumor area was confirmed on CDFI.

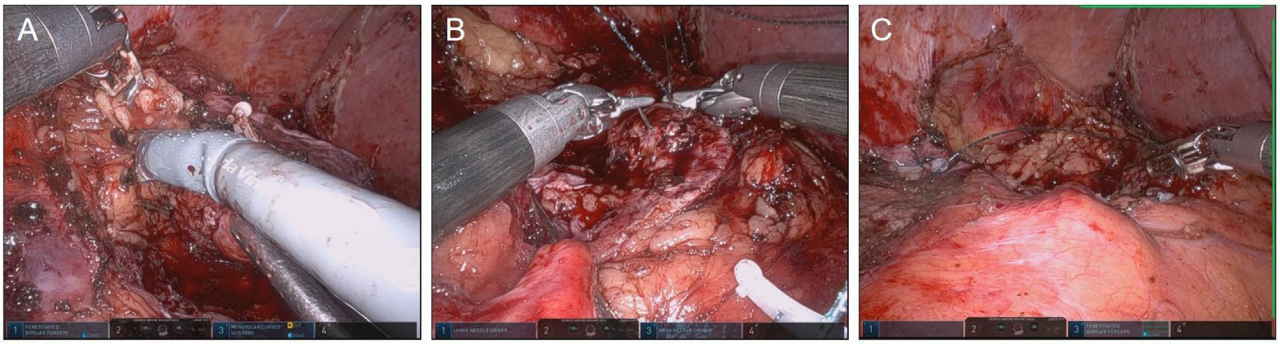

Fig. 3 – (A) The tumor was removed outside the surgical margin. (B) The renal medulla and parenchyma were sutured in a routine manner. (C) After suturing was completed and the balloon was deflated, the operative area was continiously observed to confirm that there was no active bleeding.

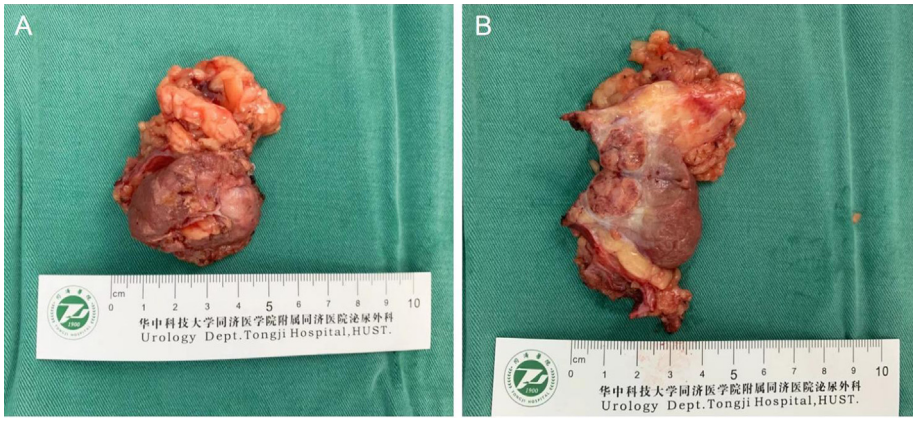

Fig. 4 – Specimen and dissection. To minimize blunt or sharp separation of any tissue, the perirenal fat and Gerota fascia were not routinely dissected (these structures were often indistinguishable were adherent in salvage partial nephrectomy cases). Instead, fibrous connective tissue, perirenal fat, and Gerota fascia fat along the cutting path are removed altogether along with the tumor using cold scissors.

process was monitored under full LUS guidance (Fig. 2A, B). The Fogarty catheter was then inflated with a suitable amount of saline, which occluded the arterial blood supply to the tumor (Fig. 2C). Loss of blood-flow signal within the tumor area was confirmed via color Doppler flow imaging (CDFI; Fig. 2D) and in some cases via contrast-enhanced LUS. This occlusion step with the Fogarty balloon catheter replaced the dissection and clamping process for the renal hilum in the conventional PN approach.

1.4.3. *Resection of the tumor and surrounding fibrous tissue*

The tumor was subsequently removed outside the surgical margin (Fig. 3A). To minimize blunt or sharp separation of any tissue, the perirenal fat and Gerota fascia were not routinely dissected (these structures were often indistinguishable and were adherent in sPN cases). Instead, fibrous connective tissue, perirenal fat, and Gerota fascia fat along the cutting path were removed altogether along with the tumor using cold scissors (Fig. 4). Then the renal medulla and parenchyma were sutured in a routine manner (Fig. 3B).

1.4.4. *Deflation of the balloon catheter and check for bleeding*

After completion of resection and suturing, the balloon catheter was deflated and withdrawn along with the guidewire. On confirmation that there was no active bleeding (Fig. 3C) the specimen was removed and the femoral artery puncture was sealed using an arterial closure device. Low-molecular-weight heparin sodium (4100 U) was administered 3 hr after the operation.

1.5. *Case descriptions*

1.5.1. *Case 1*

Case 1 was a 69-yr-old male with body mass index (BMI) of 29.05 kg/m^2. Hypertension and hyperuricemia were previ-

Table 2 – Surgical data

Case	OT (min)	WIT (min)	EBL (ml)	Δ_{48} Hb (g/l)	sCr (μmol/l)		Complications	Pathological diagnosis	SM status	FU (mo)
					PRE	48 h_{PO}				
1	110	11	20	−37	133	344	–	Fibroadipose tissue	NA	8.6
2	119	30	120	−23	94	116	Fever (CD II)	Clear cell RCC (grade 1)[a]	Negative	5.2
3	90	22	50	−20	88	102	–	Clear cell RCC (grade 2)[a]	Negative	2.6

OT = operative time; WIT = warm ischemia time; EBL = estimated blood loss; Δ_{48} Hb = change in hemoglobin at 48 h after surgery; sCr = serum creatinine; PRE = preoperative; PO = postoperative; CD = Clavien-Dindo grade; RCC = renal cell carcinoma; SM = surgical margin; NA = not available; FU = follow-up.
[a] Grade according to the World Health Organization/International Society of Urological Pathology scheme.

ously diagnosed and treated with oral drugs. The patient had undergone open radical nephrectomy (right kidney) 17 yr previously. RAPN plus kidney cyst decortication (left kidney) was performed 7 mo before admission to our center, with a pathological diagnosis of renal cell carcinoma (RCC). With a solitary kidney, the patient's preoperative serum creatinine was 133 μmol/l.

Preoperative enhanced computed tomography (CT) revealed a low-density lesion with peripheral exudation in the upper pole of the left kidney. Magnetic resonance imaging showed a mass measuring 3.7 cm × 2.6 cm × 2.6 cm in the upper pole of the left kidney with a high signal on diffusion-weighted imaging, which was considered a neoplastic lesion.

UBo-HPN was performed on February 15, 2023. Intraoperative LUS detected a high-echo mass of 3.4 cm × 2.0 cm in the posterior upper pole of the left kidney, which grew inwards with clear boundaries and had an uneven internal echo. The specimen was a 3.5-cm-diameter mass with adipose tissue. Incision confirmed that the mass was a solid cyst. The pathological diagnosis was mainly fibrous adipose tissue with bleeding and necrosis.

Since the patient had a solitary kidney and the resected mass was of large volume, his serum creatinine increased to 344 μmol/l 48 h after surgery. At discharge, the patient was advised to avoid nephrotoxic drugs and holding of urine. His serum creatinine decreased to 213 μmol/l at 30 d after UBo-HPN (Table 2).

1.5.2. *Case 2*

Case 2 was a 63-yr-old male with BMI of 26.4 kg/m^2. Hypertension and cerebral infarction were previously diagnosed and treated with oral medication. The patient had undergone previous transurethral laser resection of the prostate (4 yr previously) and hernia surgery (1 yr previously). RAPN (right kidney) was performed 11 mo before presentation, with a pathological diagnosis of RCC. Preoperative enhanced CT revealed an enhanced nodule measuring 2.0 cm × 1.9 cm in the right kidney.

UBo-HPN was performed on March 29, 2023. Intraoperative LUS revealed tumor in the anterior upper pole of the right kidney. Specimen examination showed a nodular mass measuring 1.5 cm × 1.4 cm × 1.4 cm with adipose tissue. The pathological diagnosis was clear cell RCC (World Health Organization [WHO]/International Society of Urological Pathology [ISUP] grade 1) without a PSM.

The patient developed fever after surgery, which resolved after treatment with nonsteroidal anti-inflammatory medication (Clavien-Dindo grade II; Table 2).

1.5.3. *Case 3*

Case 3 was a 56-yr-old male with BMI of 26.4 kg/m^2. The patient had undergone laparoscopic PN (left kidney) 11 mo previously, with a pathological diagnosis of RCC. Preoperative enhanced CT showed a 1.3-cm area with abnormal enhancement in the left kidney, possibly neoplastic, with left perirenal exudation.

UBo-HPN was performed on August 16, 2023. Intraoperative LUS revealed tumor in the anterior upper and middle poles of the left kidney. Specimen examination demonstrated a 1.0-cm mass with adipose tissue. The pathological diagnosis was clear cell RCC (WHO/ISUP grade 2) without a PSM (Table 2).

Over median follow-up of 5 mo, none of the three patients experienced death, tumor recurrence, or further deterioration of renal function.

2. Discussion

More than 90% of renal cancers are RCC, for which the 5-yr cancer-specific survival rate is 80–90%. However, once local recurrence occurs, even without metastasis, the prognosis is poor [7]. Surgical resection of isolated localized recurrences

of renal cancer, including salvage radical nephrectomy (sRN) and sPN, are effective in improving cancer-specific survival and overall survival. In comparison to sRN, sPN has comparable clinical oncological outcomes and results in better preservation of kidney function.

However, PN is much more difficult in the salvage setting in comparison to primary PN. The overall complication rate for repeat robotic or laparoscopic PN increased from 17.6% to 42% [4,6], with the incidence of major complications (defined as Clavien-Dindo grade ≥III) as high as 10% [8]. One of the most common sPN complications was bleeding, with incidence ranging from 5.6% to 23% [4] and a blood transfusion rate of 5.9% [4,9,10]. In addition, the difficulty in dissecting the renal hilum increased the rate of conversion to an off-clamp technique, which can lead to excessive bleeding during tumor resection [4,9]. Moreover, patients with recurrent renal cancer often already have impaired renal function [6]. Furthermore, the surgical margin may not be clear, which was more likely to lead to either greater resection of normal kidney tissue or inadequate resection of tumor, resulting in PSMs in 2.9–11.5% of cases [2,11].

The lower surgical safety for repeat PN was largely because of the presence of peritumoral fibrosis and adhesive scarring to the previously resected bed and neighboring anatomical structures [9]. Here we reported three cases in which recurrent renal tumors were treated with UBo-HPN. In comparison to the conventional approach, UBo-HPN had an excellent safety profile for the treatment of recurrent renal tumors. One complication (fever, Clavien-Dindo grade II) occurred in our case series and there were no abdominal organ or vascular injuries. This was because UBo-HPN did not require good exposure of the renal arteries, in contrast to conventional sPN [9]. In our series, EBL was 20, 120, and 50 ml in the three cases, and no patient required a blood transfusion. Minimization of the surgical footprint was another advantage of UBo-HPN [8]. The characteristics of UBo-HPN meant that anatomical isolation of the renal hilar structure, the Toldt fascia, and mass abdominal structures iwas largely avoided. UBo-HPN may also contribute to protecting the renal function of the affected kidney. In our practice, a patient with a solitary kidney was able to avoid dialysis after UBo-HPN.

Limitations of our study includes the small number of surgical cases and the fact that all UBo-HPN procedures were performed by a single surgeon.

In conclusion, results from this initial series of patients treated for localized recurrence of renal tumor indicate that UBo-HPN is a safe and effective option. A larger patient cohort and longer follow-up are expected in the future.

Conflicts of interest: The authors have nothing to disclose.

Ethics considerations: This study was approved by the institutional review board (reference 2020S138). The clinical trial was registered on www.chictr.org.cn (ChiCTR2100050808). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

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CME question

What are the surgical steps that are usually omitted in UBo-HPN (Ultrasound-guided Renal Artery Balloon catheter Occluded Hybrid Partial Nephrectomy) in comparison to conventional partial nephrectomy?

a. Dissection of the renal hilum
b. Renal hilar clamping
c. Dissection of the Toldt fascia
d. Mobilization of the liver and spleen
e. Opening the inferior vena cava sheath

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