Kidney Cancer

Single Port Access Renal Cryoablation (SPARC): A New Approach

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Abstract

Background: Cryoablation has been performed laparoscopically for small renal masses using 3–4 ports with promising oncologic results.

Objectives: To report the initial experience of Single Port Access Renal Cryoablation (SPARC).

Design, Setting, and Participants: Beginning in September 2007, outcomes of patients undergoing SPARC have been recorded into an IRB approved database. Patients with localized small renal mass (<3 cm) ineligible for partial or radical nephrectomy were included. Patients with multiple abdominal surgeries or solitary kidneys were excluded.

Intervention: The novel multichannel single port was positioned in the umbilicus during the transperitoneal approach and at the tip of the 12th rib during the retroperitoneal approach. Intraoperative ultrasound was used to localize and observe the renal mass during cryoablation.

Measurement: Operative time, blood loss, hospital stay, and complications were noted. Tumor characteristics and follow-up CT scans were evaluated.

Results and Limitations: All six cases, four retroperitoneal and two transperitoneal, underwent SPARC without conversion to laparoscopy or open surgery. Patient age and body mass index was 73 ± 9 yr and 33 ± 10 kg/m², respectively. Mean tumor size was 2.6 ± 0.4 cm. Total freeze time was 15 ± 1.8 min. There were no intraoperative complications and mean hospital stay was 2.3 d. One patient had a prolonged hospital stay due to preexisting respiratory condition. CT with contrast was performed in three patients and documented no residual tumor enhancement. Although flexible laparoscopic instruments allow parallel insertion through a single port, surgical range of motion is limited and clashing of instruments is frequent.

Conclusion: Single Port Access Renal Cryoablation (SPARC) for small renal masses is feasible and safe. Transperitoneal approach provides a virtually scarless surgery since the surgical incision is hidden in the umbilicus. Further studies are needed to define the role of and evaluate the potential advantages of single port surgery.

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1. Introduction

The management of renal cell carcinoma has been revolutionized by minimally invasive technologies. Through cryotechnology, small renal masses have been successfully treated via percutaneous or laparoscopic cryoablation, demonstrating acceptable oncologic outcomes with follow-up of up to 5 yr [1,2]. Cryoablation of renal masses offers an alternative to open or laparoscopic nephron sparing surgery for patients who have renal insufficiency and pose a high surgical risk for partial nephrectomy. Standard three-port laparoscopic technique is utilized for either transperitoneal or retroperitoneal renal cryoablation [3–5]. Although the morbidity associated with either approach is minimal, a new era has arrived with single port laparoscopic surgery. The Uni-X™ Single Port Access (Pnavel Systems, NJ) was conceptualized in 1999 when Piskun et al [6] performed a series of laparoscopic cholecystectomies through the umbilicus. Herein, we report on our initial six patients who have undergone single port access renal cryoablation (SPARC) with detailed description of the technique.

2. Material and methods

Beginning on September 25, 2007, a prospective data analysis of the initial six patients who underwent SPARC was entered into our IRB-approved data registry. Patients with localized, enhancing small renal mass (<3.5 cm) with renal insufficiency or increased surgical risk for partial nephrectomy were included in this study. Patients with previous abdominal and/or kidney surgery or with a solitary kidney were excluded. The decision to perform transperitoneal or retroperitoneal approach was based on tumor location. The transperitoneal approach was used for anteriorly located tumors, with a single incision made within the umbilicus. The retroperitoneal approach was used for posteriorly located renal masses via a single incision placed at the tip of the 12th rib. An open Hasson technique was employed for both transperitoneal and retroperitoneal access. In all cases, only one port with multiple working channels (Uni-X™ Single Port Access, Pnavel Systems, Inc) was used to perform the entire operation. The port is shown in Fig. 1.

2.1. Transperitoneal transumbilical approach

The patient is placed in the 45-degree modified flank position and the operating table is minimally flexed for the transperitoneal approach. Care is taken to pad all bony pressure points and the extremities are supported in neutral position on a double arm board. The patient is secured to the table with an adhesive tap. The surgeon and the assistant stand facing the abdomen of the patient.

Using an open Hasson technique, a 1.5-cm semicircular incision is made at the inner edge of the umbilicus and dissected deep to the rectus fascia. The anterior rectus fascia is sharply incised and four corner fascial stay sutures are placed and used to fix the multichannel port in place and prevent subcutaneous emphysema. The port has an insufflation channel that allows CO₂ insufflation, and a pneumoperitoneum pressure of 15 mm/Hg is achieved.

A 5-mm, zero-degree lens laparoscope with a flexible, steerable tip is used (Olympus Surgical, Orangeburg, NY). This scope has a light source incorporated within the camera and thus does not compete for the very limited space at the port site. Moreover, the tip of the scope can be steered internally without moving the rigid external straight segment outside the port, further maximizing surgical movement. Patient, incision, and scope placement are shown in Fig. 2.

After initial access is complete, the operating table is tilted towards the surgeon to help retract bowel away from the kidney. The colon is gently dissected off Gerota’s fascia and retracted medially. Gerota’s fascia is then incised at the expected location of the renal mass (as revealed by the preoperative CT scan) and the tumor is exposed. Intraoperative biopsy is performed and a 3.8-mm cryoprobe (Endocare, Inc, Irvine, CA) is inserted under ultrasound guidance. The cryoprobe is inserted through one of the multichannel...
working ports (see Fig. 3). If additional probes are needed, especially for masses larger than 2 cm, a 2.4-mm cryoprobe is inserted percutaneously without insertion of additional ports. A 10-mm flexible, steerable ultrasound probe is inserted alongside the single port through the same skin and fascial incision and kept in position for the entire operation. Two freeze-thaw cryoablation cycles are performed, with the ice ball monitored using ultrasound as described previously [5]. Following removal of the cryoprobe, hemostasis is achieved in a fashion identical to our standard laparoscopic approach. Following removal of the cryoprobe, biologic hemostatic agent (Floseal, Baxter, Deerfield, IL) is introduced into the entry site of the cryoprobe into the kidney and covered with a surgicel and pressure is applied continuously for 10 min. The surgicel is then removed and the entire ablated area is coagulated with Argon beam coagulator. Biologic hemostatic agents are reapplied and covered with surgicel. Insulation pressure is lowered to zero and hemostasis is checked in 10 min. This allows any venous bleeding to be noticed and gives enough time for complete thawing of the ice that may delay potential bleeding. Argon beam coagulation can be reapplied as needed until complete hemostasis is achieved.

2.2. Retroperitoneal approach

For retroperitoneal approach, the patient is positioned in the standard 90-degree full flank position. The kidney rest is elevated and the table is flexed. Care is taken to pad all pressure points, as described for the transperitoneal approach. During retroperitoneoscopy, the surgeon and the assistant stand facing the patient’s back [7].

The initial retroperitoneal access is achieved using the open (Hasson) technique. A 1.5-cm transverse skin incision is created just below the tip of the 12th rib; flank muscles are then bluntly split. The thoracolumbar fascia is exposed and sharply incised to enter the retroperitoneum. Using blunt finger dissection, a retroperitoneal space is developed immediately anterior to the psoas muscle and posterior to Gerota’s fascia. A balloon dilator (United Surgical, Norwalk, CT) is inserted in the created retroperitoneal space then inflated with 800 cc of air. The balloon is deflated and four corner fascial stay sutures are placed to fix the multichannel port in place and prevent subcutaneous emphysema. CO₂ pneumoperitoneum of 15 mm/Hg is developed.

Similar to the transperitoneal approach, a 5-mm laparoscope with a flexible tip (Olympus Surgical, Orangeburg, NY) is used. The anatomical landmarks are carefully examined, including the psoas muscle and the anteriorly displaced kidney with its surrounding Gerota’s fascia. A 5 mm bent laparoscopic grasper (Uni-X™ Single Port Access, Pnavel Systems, Inc) is used to retract the kidney medially, exposing the posterior aspect of Gerota’s fascia. Using 5 mm flexible scissors with monopolar cautery (Cambridge Endo, Framingham, MA), Gerota’s fascia is incised and the renal mass is exposed. Cryoablation is then conducted under ultrasound vision as described for the transperitoneal approach.

3. Results

SPARC was successful in all four retroperitoneal and two transperitoneal consecutive patients without addition of extra ports or open conversion. Mean patient age was 73 ± 9 yr and body mass index was 33 ± 10 kg/m² (range, 26–52 kg/m²). Mean tumor size was 2.6 ± 0.4 cm. Fig. 4a and 4b illustrate a pre-operative and postoperative CT scan of a patient selected for retroperitoneal SPARC. Detailed surgical data and tumor characteristics are presented in Table 1. Two freeze-thaw cycles were employed for all patients, resulting in a mean freeze time of 15 ± 1.8 min. Three patients required two cryo-probes to create an adequate freeze zone that extends 1 cm beyond the tumor margin to ensure a negative margin. Mean operative time was 170 min and there was estimated blood loss of 83 ± 26 cc. Biopsies performed prior to cryoablation confirmed renal cell carcinoma in four of the six patients. There were no intraoperative complications; however one patient with pre-existing pulmonary disease and anemia required prolonged in-hospital oxygenation for 1 wk. The same patient required transfusion of 3 units of blood. All patients had a CT scan of the abdomen prior to hospital discharge, revealing 1 patient with a small perinephric hematoma. Post-ablation CT kidney with contrast was performed at 3 mo follow-up in three patients, and documented no residual tumor enhancement. Mean hospital stay was 2.3 d (range 1—8 d).

There were no incision-related complications and the transperitoneal approach provided a virtually scarless result since the surgical incision was hidden in the umbilicus, as shown in Fig. 5.
4. Discussion

During laparoscopic surgery, spacing of ports is important to avoid clashing of instruments and to optimize range of motion. Although single access laparoscopic surgery was reported in the literature more than a decade ago for cholecystectomy [6] and appendectomy [8], the applicability of single port access surgery did not gain widespread use due to the in-line surgical placement of instruments. However, advances in surgical equipment, articulating instruments, and flexible endoscopes have brought single port access surgery to the

![Fig. 4](image1.png) (a) CT scan demonstrating a 3.2-cm right posteromedial, upper pole enhancing endophytic renal tumor in a patient with a BMI of 56 cm/kg². (b) Postoperative day one following right retroperitoneal single port renal cryoablation using two cryoprobes. Note the ablation zone extending well beyond the tumor margin.

![Fig. 5](image2.png) Intraoperative image of the umbilical Incision measuring 1.8 cm used to insert the multichannel port.

<table>
<thead>
<tr>
<th>N</th>
<th>Age</th>
<th>BMI</th>
<th>Medical history</th>
<th>Side</th>
<th>Tumor size (cm)</th>
<th>Location</th>
<th>O.R. time (min)</th>
<th>EBL (cc)</th>
<th>Cryo cycles (min)</th>
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<td>69</td>
<td>52.6</td>
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<td>Interpolar lateral</td>
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forefront once again. Intra-abdominal and intrathoracic single port surgeries have now been reported [8,9] in both pediatric and adult populations. Potential advantages of this technique are related to limiting the port incisions to one site and the known advantages of minimally invasive surgery. For the transperitoneal approach, the umbilical incision avoids penetrating any muscle. The risk of epigastric vessel injury is eliminated by avoiding lateral placement of ports. The surgical scar can be hidden within the umbilicus, rendering the surgery virtually scarless. For the retroperitoneal approach, single port access is limited to a surgical incision at the tip of the 12th rib that is needed to obtain access to the retroperitoneum. Avoiding anterior port placement minimizes the risk of inadvertent peritoneotomy and bowel injury.

However, there are several potential disadvantages to single port access surgery. With parallel insertion of laparoscopic instruments, the range of motion is limited and instruments frequently clash. This is minimized by using articulating instruments and flexible tip scopes. Second generation laparoscopic instruments are needed to address specifically the single port approach with better ergonomics and instruments that have lower profile handles and better maneuverability, and can deliver more force to the tip of the flexible instruments. Potential umbilical incision complications, such as hernia or infection, are another disadvantage of single port access surgery. However, we have encountered no umbilical complications to date using the single port.

In our series, one patient required transfusion after surgery (3 units packed cells). This patient had a baseline hemoglobin of 11 g/dl prior to surgery and received intraoperative intravenous hydration to maintain adequate urine output during cryoablation. Intraoperatively, none of the patients had excessive bleeding or difficulty achieving hemostasis. Estimated blood loss was 83 ± 26 cc. Prior to transfusion postoperative day 1, patient hemoglobin was 9.5 g/dl and CT scan of the abdomen, revealed a small perinephric hematoma (3 cm x 1 cm) without evidence of significant bleeding.

This approach has its unique learning curve, principally in navigating the instruments within a limited range of motion. Given the complexity of most laparoscopic urologic cases, we find cryoablation to be an attractive procedure to gain experience in single port surgery. In properly selected patients, laparoscopic cryoablation needs minimal tissue dissection and requires no suturing.

For anteriorly located renal masses, transumbilical SPARC is a step further towards less invasive surgery. For the posteriorly located masses that can be accessed percutaneously, it is unclear if SPARC is superior to percutaneous approach. The percutaneous approach is definitely less invasive. But there is a concern that it may be less accurate in ablating renal masses compared to the laparoscopic approach [10]. Evaluation of oncologic adequacy after cryoablation is beyond the scope of this study, especially with the limited number of cases and short follow-up.

To our knowledge, this is the first report describing single port access cryoablation (SPARC). Overall intraoperative and postoperative results obtained in this initial series, albeit with small number of patients, are comparable to previously reported laparoscopic cryoablation series [5].

5. Conclusion

Single Port Access Renal Cryoablation (SPARC) for small renal masses is feasible and safe. Refinement of flexible laparoscopic instrumentation may expand the application of single port laparoscopy. Further studies are needed to define the role of and to evaluate the potential advantages of single port laparoscopy.

Author contributions: Jihad H. Kaouk had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Kaouk.
Acquisition of data: Goel.
Analysis and interpretation of data: Kaouk.
Drafting of the manuscript: Goel, Kaouk.
Critical revision of the manuscript for important intellectual content: Kaouk.
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Other (specify): None.

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