Robotic Partial Nephrectomy With Intracorporeal Renal Hypothermia Using Ice Slush

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OBJECTIVE To outline our technique for intracorporeal cooling with ice slush during robotic partial nephrectomy (RPN), with real-time parenchymal temperature monitoring.

MATERIALS AND METHODS Eleven consecutive patients with enhancing solid renal masses suitable for treatment with RPN between September 2013 and January 2014 were included in the analysis. Institutional review board approval and informed consent were obtained. Preoperative patient characteristics, intraoperative surgical parameters including patient body temperature and ipsilateral kidney temperature with real-time monitoring, and short-term functional outcomes were analyzed.

RESULTS Median age was 55 years (range, 39-75 years) and American Society of Anesthesiologists score was 3 (range, 2-4). Median tumor size was 4 cm (range, 2.3-7.1) and RENAL nephrometry score was 9 (range, 5-11). One patient had a solitary kidney. During cooling, the lowest median renal parenchymal temperature was 17.05°C (range, 11°C-26°C) and cold ischemia time was 27.17 minutes (range, 18-49 minutes). Median time to latest postoperative estimated glomerular filtration rate was 12 days (range, 2-30 days). Median glomerular filtration rate preservation was 81% (range, 47.9%-126%). There was one positive margin. There were no postoperative complications, and no patients experienced a prolonged ileus. The limitations of this study include a small number of patients and short-term follow-up.

CONCLUSION RPN with renal hypothermia using intracorporeal ice slush is technically feasible. Our simplified method of introducing the ice slush was free of complications and highly reproducible. The use of a needle temperature probe allowed us to monitor in real time cooling of the renal parenchyma. UROLOGY 84: 712–718, 2014. © 2014 Elsevier Inc.

The application of robotic technology to renal surgery, and specifically to partial nephrectomy, has allowed surgeons to recreate the principles of open surgery in a minimally invasive fashion.[1] With increasing experience, larger deeply infiltrative tumors, or tumors involving the renal hilum[2,3] can be treated with robotic partial nephrectomy (RPN). This requires a highly controlled excision of the tumor in a bloodless field, to ensure negative margins, proper hemostatic control of the renal parenchyma, and accurate closure of the collecting system. Clamping of the renal hilum is necessary to achieve these goals, as in open surgery. It has been well established that a warm ischemia time >30-40 minutes may be detrimental to long-term renal function.[4,5]

Renal hypothermia has been used in open partial nephrectomy (OPN) to protect against renal ischemic injury and to allow for longer clamp times.[4] It is thought that hypothermia slows renal metabolism, which is necessary for cellular protection and limiting post-ischemic renal injury.[6] Prior studies have shown that when renal parenchymal temperatures of 5°C-20°C are achieved, renal metabolism is almost completely suspended and the kidney can tolerate up to 3 hours of clamp time without permanent loss of function.[7,8]

With the widespread adoption of laparoscopic partial nephrectomy, various techniques were devised to induce renal hypothermia in a minimally invasive fashion,[9] including cold saline surface irrigation,[10] endoscopic retrograde cold saline infusion,[11] and transarterial renal hypothermia.[12] Our center's experience with intracorporeal ice slush during laparoscopic partial nephrectomy has been previously described.[13] This involved complete mobilization of the kidney and dissection of the

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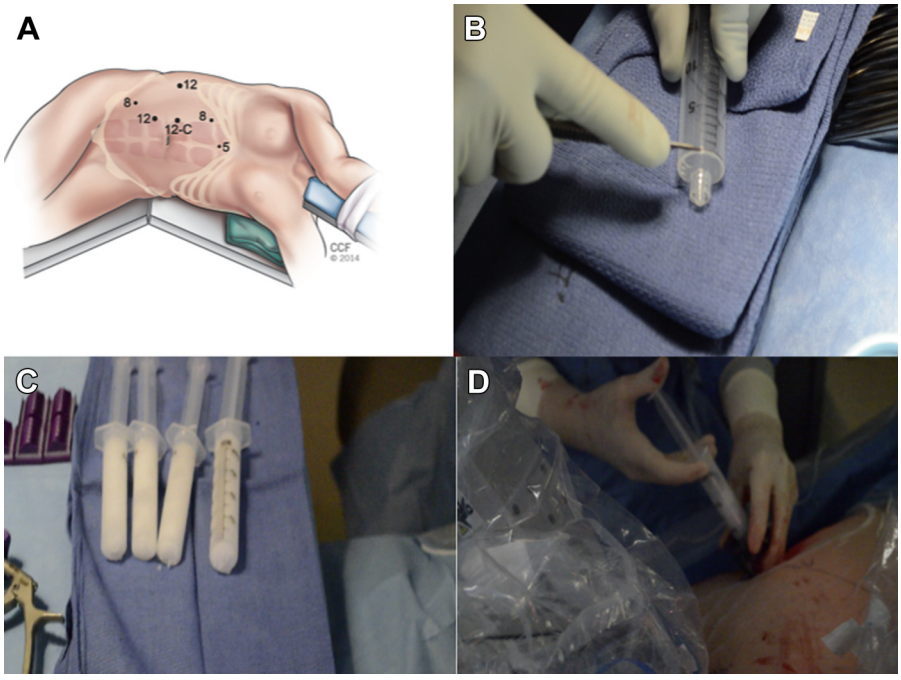

Figure 1. **(A)** Patient positioning and ports placemat: patients are placed in the modified flank position at approximately 60°, with the table partially flexed. A 12-mm camera port is placed at lateral border of the rectus at the level of the 12th rib. An 8-mm robotic port is placed at the lateral border of the ipsilateral rectus muscle, about 3 cm below the costal margin. A second 8-mm robotic port is placed approximately 5-7 cm cephalad to the anterior superior iliac spine. An assistant 12-mm port is placed along the lateral border of the rectus muscle between the camera port and caudal robotic port. A 5-mm accessory port is placed in the subxiphoid area for liver retraction. An additional 12-mm laparoscopic port is placed along the midaxillary line and the costal margin for introduction of the temperature probe and ice slush. **(B)** A 20 or 30 mL syringe is modified by cutting off the nozzle end of the barrel with scalpel. **(C)** The modified syringes are then prefilled with ice slush in preparation for instillation. **(D)** The ice is instilled through the accessory 12-mm port. (Color version available online.)

renal hilum, followed by placing it in an Endocatch II bag (United States Surgical Corp, Norwalk, CT). The bottom of the bag was cinched around the renal hilum and then the top was opened and ice slush was injected into the bag. Nadir renal temperatures of 5°C-19°C were achieved with good functional outcomes.

In the field of RPN, Rogers et al recently described their "intracorporeal cooling and extraction" technique, using ice slush introduced through a Gelpoint access port via syringes and applied over the kidney surface.[14]

Based on the same principle of "ice slushing", we recently conceived and developed an easily reproducible technique to obtain renal hypothermia during RPN. The aim of this study is to detail this novel technique and to report our early clinical experience with its implementation.

MATERIALS AND METHODS

Study Population

Consecutive patients undergoing transperitoneal RPN for an enhancing renal mass from late September 2013 to early January 2014 were prospectively identified for the study. Exclusion criteria included cases that were estimated to have a warm ischemia time <20 minutes. One surgeon experienced in RPN performed all surgeries. Data were collected prospectively in our institutional review board approved database.

Surgical Technique

Our standardized technique of RPN has been previously described[15] and has been modified to incorporate renal hypothermia using intracorporeal ice slush.

Patient Position, Port Placement, and Docking of the Robot. Patients are placed in the modified flank position at approximately 60°, with the table partially flexed. The abdomen is insufflated to 15 mm Hg with a Veress needle at the lateral border of the rectus at the level of the 12th rib and serves as the site of the 12-mm camera port (Fig. 1A). An 8-mm robotic port is placed at the lateral border of the ipsilateral rectus muscle, about 3 cm below the costal margin. A second 8-mm robotic port is placed approximately 5-7 cm cephalad to the anterior superior iliac spine. An assistant 12-mm port is placed along the lateral border of the rectus muscle in the ipsilateral lower abdominal quadrant between the camera port and caudal robotic port. For right-sided cases, a 5-mm accessory port is placed in the subxiphoid area for liver retraction. An additional 12-mm laparoscopic port is placed along the midaxillary line and the costal margin. This port is used for introduction of the temperature probe and ice slush during cooling phase of the procedure. The robot is then positioned over the patient's shoulder with the camera oriented approximately in line with the renal vessels. A 30° downscope is used along with the ProGrasp robotic grasper (Intuitive Surgical, Inc., Sunnyvale, CA) for retraction with either the monopolar scissors or hook in the primary hand.

Dissection. The colon is reflected medially and the ureter is elevated anteriorly. Dissection is carried cranially to the renal