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CASE REPORT

Single-incision robotic-assisted living donor nephrectomy: case report and description of surgical technique

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Summary

The introduction of laparoscopic surgery, and more recently of robotics, has increased the number of living donor kidney transplants. This approach has already improved living donor acceptance rates. Even newer developments in the field have now been introduced with the purpose of further reducing post-operative pain and length of hospital stay, while offering better cosmetic results. In particular, single-incision surgery has gained popularity by improving the well-known benefits of minimally invasive surgery. In this case report, we present the first single-incision robotic-assisted living donor nephrectomy.

Introduction

Living donor kidney transplant is the best technique for renal replacement therapy [1]. It is well established that living donor kidney transplants provide better graft function and survival than deceased donor kidney transplants [2]. The introduction of minimally invasive techniques in 1995 [3] allowed for a significant increase in living donor acceptance rates, thereby expanding the donor pool.

Numerous technological advancements have led to innovations that have revolutionized the field of minimally invasive surgery. Specifically, more than a decade ago, robotic technology for living kidney donation was first adopted to overcome some of the natural impediments of laparoscopic surgery [4]. In addition, the implementation of robotics has already demonstrated a shortening of the learning curve for donor nephrectomies [5]. Yet recently, single-incision laparoscopic techniques have gained popularity by further decreasing the invasiveness of laparoscopic procedures [6]. Nevertheless, single-incision surgery (SIS) is technically challenging and its application in living kidney donors is yet to be established. To date, only a handful of reports are available [7].

Our goal is to report the feasibility and the technical aspects of our first single-incision robotic-assisted (living) donor nephrectomy (SIRA-DN).

Materials and methods

The patient was a 21-year-old white woman, with no significant medical history. The CT angiogram revealed a single renal artery and vein on each side. The left kidney was chosen for donation according to our routine protocol.

Surgical procedure

The patient was placed on top of a cushioned beanbag in the right lateral decubitus position. The operating room table was flexed for optimal exposure of the left kidney.

A 5-cm incision was made starting transumbilical and extending infraumbilical. We inserted the GelPOINT into the abdomen. Four trocars were inserted through the gel of the GelPOINT in a diamond configuration (Fig. 1): one 12-mm trocar for the robotic camera, one 12-mm trocar for the assistant at the bedside, and two 8-mm robotic trocars. The abdomen was insufflated to a pressure of 14 mmHg. The patient cart of the da Vinci S system was connected to the specific trocars (Fig. 2). A 12-mm 30° camera was used; the robotic arms were crossed inside the abdomen inferior to the camera trocar. The control of the robotic arms was switched at the console, i.e., the right master controls the right instruments, and the left master controls the left instruments.

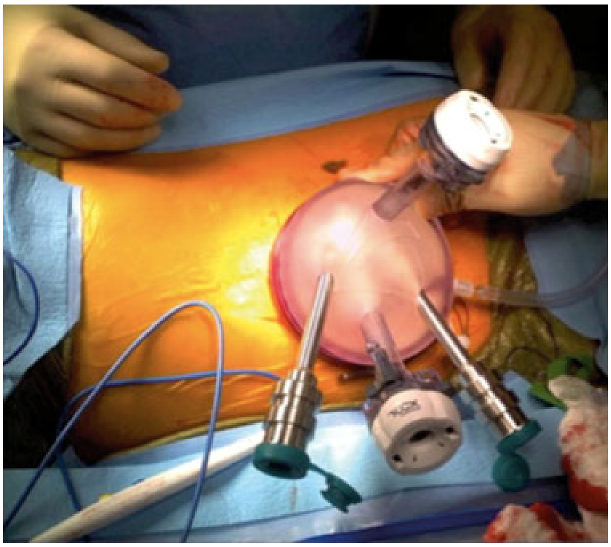

Figure 1 Four trocars were inserted through the gel of the GelPOINT in a diamond configuration.

The operation began with mobilization of the descending colon. The left ureter was identified and circumferentially dissected along the gonadal vein. Following the left gonadal in the cephalad direction, the left renal vein was identified. Gerota's fascia was incised, and the kidney was separated from its attachments to the left adrenal gland and the spleen.

The renal vein was circumferentially dissected. The gonadal vein was divided close to the renal vein between clips. Four posterior lumbar veins and the adrenal vein were taken down with clips and divided with scissors. The left renal artery was circumferentially isolated to the level of its aortic takeoff. After dissection was completed, to decrease warm ischemia time, the da Vinci system was detached, and the procedure was then completed laparoscopically through the GelPOINT.

The ureter was clipped distally at the level of the iliac artery and transected. Intravenous (i.v.) heparin was administered (80 U/kg). The renal artery was transected with an Endo TA 30 Stapler (Covidien, Norwalk, CT, USA) at the takeoff. A clip (Hem-o-Lok; Weck Closure Systems, Research Triangle Park, NC, USA) was placed on top of the staple line. The artery was sharply divided just distal to the staple line. Protamine was given once the artery was divided. Proper exposure of the renal vein was achieved, and an ENDOPATH Linear Cutter (Ethicon Endo-Surgery, Cincinnati, OH, USA) was used for transection of the renal vein. The gel was detached; the surgeon inserted his right hand and removed the left kidney from the abdomen. The kidney was taken to the recipient's room.

Results

The procedure was completed without intraoperative complications. Operative time was 150 min, warm ischemia time was 200 s, and estimated blood loss was 75 ml.

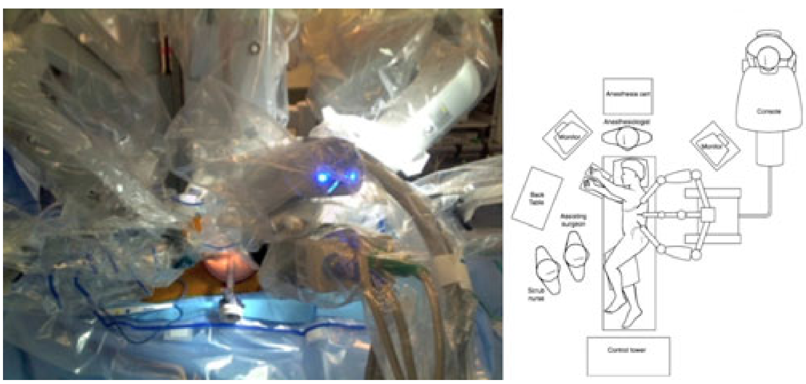

Figure 2 The robotic cart of the da Vinci S system 'docked' into the operating field.

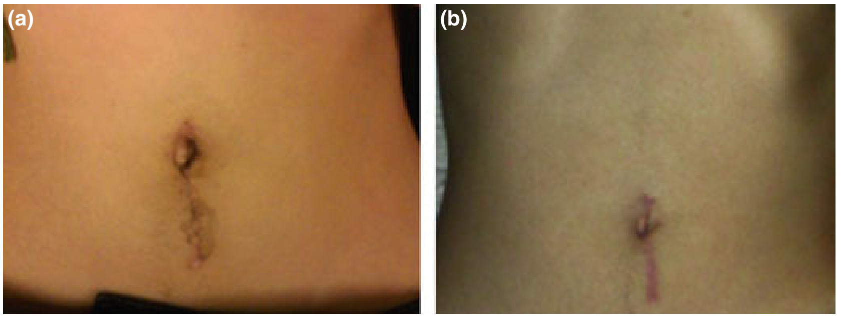

Figure 3 (a) Ten-day follow-up and (b) 3-month follow-up.

Postoperative pain was 6/10 on postoperative day 1 and decreased to 2/10 on postoperative day 3. The patient was discharged 72 h after surgery; no 30-day complications were observed (Fig. 3).

The kidney functioned immediately after transplantation, with no occurrence of post-transplantation delayed graft function. Recipient's creatinine levels at 1 week, 1 month, and 3 months were 1.2, 1.1, and 0.8 mg/dl, respectively.

Discussion

Single-incision surgery has been described in several urologic procedures, such as pyeloplasty and partial and radical nephrectomy [8–13]. Authors have demonstrated the benefits of SIS over conventional laparoscopic nephrectomies in nontransplant patients including less postoperative pain, lower analgesic dosage, and shorter hospital stay [14].

Nevertheless, its application in living kidney donors has yet to be established, because it poses an increased intraoperative technical challenge in a healthy patient. Earlier reports showed the feasibility of the procedure with no intraoperative complications and with adequate allograft function [7,15]. In their initial report, Gill *et al.* [7] described a technique using a 2-cm skin incision, a 2- to 3-cm fascial incision, and a 2-mm needlescopic instrument in the epigastric area for triangulation. Even though Gill *et al.* described an attractive alternative, placement of additional ports elsewhere in the abdomen requires additional incisions on the abdominal wall, which dilutes the basic principle of SIS. In their extended series, Gill *et al.* described a 4-cm skin incision and a 6- to 7-cm fascial incision for specimen extraction. They commented on the extended operative time, which was attributed to the learning curve, instrument clashing, and continuous repositioning between the operating surgeon and assistant in a constrained working space [15]. Gimenez *et al.* observed similar difficulties in their series of 38 consecutive patients [16].

Unquestionably, SIS is technically demanding, perhaps because of the natural impediments of the approach and the physical challenges for surgeons. The introduction of robotics has the potential to eradicate some of those impediments; however, only a handful of reports have described the use of robotic technology for SIS [9,13,17,18]. Specifically, White *et al.* have demonstrated comparable results between robotic versus laparoscopic single-incision radical nephrectomies [18]. However, we know of no previous report in the literature on SIRA-DN. By merging robotics with SIS, our goal was to facilitate an already challenging surgical procedure, although several limitations of single-incision robotics have been described [19]. To overcome some of these impediments, technical modifications were adopted. First, we made the decision to create a 5-cm incision at the beginning of the operation, to simplify extraction of the kidney, and to prevent longer warm ischemia time as described by Canes *et al.* [15]. Another advantage of this larger incision was the increased range of motion of the robotic instruments reducing instrument collision. To prevent leak of the pneumoperitoneum, we used the GelPOINT that allowed for placement of four trocars through the gel, including a 12-mm trocar for the bedside assistant. Secondly, the distribution of the trocars on the GelPOINT was also important. The placement of the R-camera at the 12 o'clock position and the assistant trocar at the 6 o'clock position further diminished clashing of the instruments. This, along with the placement of the operating surgeon seated at the console during the operation, freed up space at the patient's bedside for the assistant to move liberally. The presence of the bedside assistant allows for suction and traction–countertraction to facilitate dissection during critical steps of the procedure potentially decreasing operative time.

Undoubtedly, single-incision robotic-assisted surgery restores triangulation and ergonomics by enhancing the degree of freedom of surgical movements and the surgeon's ability to perform complex surgical maneuvers with no instrument clashing, while seated remotely. These advantages are mainly because of the crossing of robotic instruments at the robotic console, with switched robotic arm control.

In summary, retrieving the kidney through a single umbilical incision could potentially reduce postoperative pain, hasten convalescence, and improve the cosmetic outcome, thereby increasing the acceptance rate of living donors and expanding the donor pool. Unfortunately, current robotic systems were not meant for SIS and their broad implementation in clinical practice may carry substantial challenges such as prolonged set-up time, difficult instrument exchange, and a new learning curve.

Conclusion

Although this is the first case of SIRA-DN, our initial experience is encouraging. The procedure is feasible and this case was completed safely.

Single-incision robotic surgery provides considerable potential benefits over SIS; however, there is a need for the development of novel robotic systems specifically designed for surgeons to perform complex procedures through single incision.

Authorship

CAG, UG, RWG: designed research/study. CAG, UG, CSD, RWG: performed research/study. AK, AE, TJ, RD: collected/analyzed data. CAG, UG, ML: participated in the writing of the article.

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