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Surgery in Motion

Robotic Laparoendoscopic Single-Site Radical Prostatectomy: Technique and Early Outcomes

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accompanying video.

Abstract

Background: Laparoendoscopic single-site (LESS) surgery is challenging. To help overcome current technical and ergonomic limitations, the da Vinci robotic platform can be applied to LESS.

Objectives: Our aim was to describe the surgical technique and to report the early outcomes of robotic LESS (R-LESS) radical prostatectomy (RP).

Design, setting, and participants: A retrospective review of prospectively captured R-LESS RP data was performed between May 2008 and May 2010. A total of 20 procedures were scheduled (12 with and 8 without pelvic lymph node dissection).
Surgical procedure: R-LESS prostatectomy was performed using the methods outlined in the paper and in the supplemental video material.

Interventions: All patients underwent R-LESS RP by one high-volume surgeon. Single-port access was achieved via a commercially available multichannel port. The da Vinci S and da Vinci Si surgical platform was used with pediatric and standard instruments.

Measurements: Preoperative, perioperative, pathologic, and functional outcomes data were analyzed.

Results and limitations: The mean age was 60.4 yr; body mass index was 25.4 kg/m². The mean operative time was 189.5 min; estimated blood loss was 142.0 ml. The average length of stay was 2.7 d, and the visual analog pain score at discharge was 1.4 of 10. Four focal positive margins were encountered, with two occurring during the first three cases. Pathology revealed a Gleason score of 3 + 3 in 3 patients, 3 + 4 in 11 patients, 4 + 3 in 4 patients, and 4 + 4 in 2 patients. There were a total of four complications according to the Clavien system including one grade 1, two grade 2, and one grade 4. The median follow-up has been 4 mo (range: 1–24 mo). Study limitations include the small sample size, the short follow-up, and the lack of comparative cohort.

Conclusions: The R-LESS RP is technically feasible and reduces some of the difficulties encountered with conventional LESS RP.

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1. Introduction

Laparoendoscopic single-site surgery (LESS) can be regarded as the latest progression in laparoscopic surgery and has garnered much enthusiasm with >400 cases reported [1–13]. LESS is evolving, and robotic assistance and other technical developments may well lead to its further advancement.

Early clinical experiences with LESS have pointed out several limitations related to technical constraints, including lack of triangulation, clashing of instruments, and limited operating space. To help overcome these limitations, the da Vinci surgical system has been applied to LESS and termed *robotic LESS* (R-LESS) [13–18].

Kaouk et al first reported an initial feasibility study of LESS radical prostatectomy (RP) in humans [19]. At that time, the authors acknowledged the limitation of embarking on this procedure due to challenges related to ergonomics and intracorporeal suturing, and they claimed a potential application of robotics.

We report in this paper on our initial experience of R-LESS RP. Our aim is to demonstrate the feasibility of the procedure by describing the technique and analyzing early outcomes.

2. Methods

2.1. Study design

Data were prospectively entered in an institutional review board approved LESS database and retrospectively reviewed. Demographic data were accrued including patient age, body mass index, preoperative prostate-specific antigen (PSA) level, Gleason score, biopsy characteristics, D'Amico risk classification, and Sexual Health Inventory for Men (SHIM) score. The preoperative evaluation included standard history and physical examination, basic laboratory blood work, metastatic staging when required, and further cardiac/pulmonary workup when indicated.

Apart from the exclusion criteria, any patient with prostate cancer fit for laparoscopic surgery was offered R-LESS RP. After comprehensive discussion, informed consent was obtained, and patients were counseled that additional incisions might be necessary as warranted during the surgical procedure. Exclusion criteria included previous radiotherapy to the prostate and conventional contraindications to laparoscopic procedures.

Perioperative data including the estimated blood loss, operative time, additional ports or conversion to standard robot-assisted laparoscopy, intraoperative complications, length of stay, and visual analog pain score were recorded.

All surgical complications were classified according to the Clavien classification [20].

Patients were followed at 1 wk after surgery for cystogram and catheter removal, at 6 wk, every 3 mo for 1 yr, and every 6 mo thereafter for continence assessment (pads daily), erectile function (SHIM score), and biochemical recurrence (PSA >0.1 ng/ml).

2.2. Surgical technique

2.2.1. Port placement

An incision is created intraumbilically (3–4.5 cm), and the umbilicus is released from the rectus fascia. A 2-cm incision is created through the linea alba. The initial robotic port (8 mm) is placed at the most caudal portion of the incision on the right side and directed as far laterally as possible. This is repeated on the opposite side with a 5-mm pediatric or standard 8-mm robotic port. A SILS port (Covidien, Cupertino, CA, USA) is inserted through the fascial incision into the abdomen (Fig. 1).

The patient is positioned in steep Trendelenburg, and either the da Vinci S or Si system (Intuitive Surgical, Sunnyvale, CA, USA) (in a three-arm approach) is docked. The robotic 12-mm scope is introduced through the SILS port, and a 5-mm channel remains free in case the suction needs to be repositioned or sutures need to be passed (Fig. 2).

2.2.2. Bladder mobilization

Bladder mobilization is performed using the 8-mm EndoWrist (Intuitive Surgical) monopolar shears in the right hand and a 5-mm EndoWrist Schertel Grasper in the left. Instruments are not intentionally crossed throughout the procedure. Using a 30° lens looking upward or a 0° lens, the peritoneum is widely incised high on the undersurface of the anterior abdominal wall, and dissection of the bladder is performed.

2.2.3. Defatting of the prostate and incision of the endopelvic fascia

Using the 8-mm EndoWrist monopolar shears in the right hand and a 5-mm EndoWrist Schertel Grasper or 8-mm EndoWrist ProGrasp forcep in the left, fatty tissue is swept free from the pubic symphysis exposing the endopelvic fascia, which is then incised (Fig. 3). The prostate is mobilized off the levator fibers.

2.2.4. Ligation of the dorsal venous complex

An 8-mm and 5-mm EndoWrist robotic needle driver are used to ligate the dorsal venous complex with a 2.0 polyglactin suture (Vicryl). Furthermore, to enhance the continence outcomes, the dorsal vein stitch

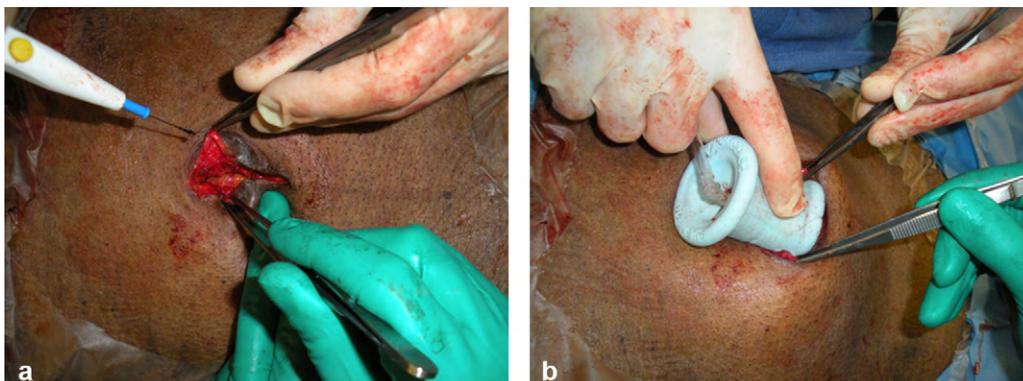


Fig. 1 – Depiction of intra-abdominal access: (a) Intraumbilical incision; (b) placement of SILS port.



Fig. 2 – SILS port with 5-mm adjacently placed robotic cannulas.

is also secured to the pubic symphysis [21]. A back-bleeding stitch is placed across the anterior surface of the prostate.

2.2.5. Bladder neck dissection

A suture can be placed through the abdominal wall and passed through the distal bladder neck or prostatic base and then exited out of the abdominal wall to serve as a retractor in a “marionette” fashion. The anterior bladder neck is transected. The urethral catheter is suspended from the abdominal wall with a 2-0 suture in the previously described marionette fashion. The posterior bladder neck is then gradually dissected away from the prostate.

2.2.6. Seminal vesicle dissection

The anterior layer of Denonvillier's fascia is incised, and the vas deferens and seminal vesicles are mobilized with the 5-mm harmonic scalpel in a non-nerve-sparing approach and athermally with Hem-o-lok clips (Teleflex Medical, Research Triangle Park, NC, USA) in a nerve-sparing approach. The vas deferens and seminal vesicles are retracted anteriorly with either the left or right robotic instrument or with marionette sutures if needed.

2.2.7. Prostatic dissection

In a non-nerve-sparing procedure, a 5-mm harmonic scalpel is used in the right hand to cauterize the lateral pedicles bilaterally. Additionally, the harmonic scalpel is used to detach the lateral border of the prostate and the neurovascular bundle from the perirectal fat. An interfascial

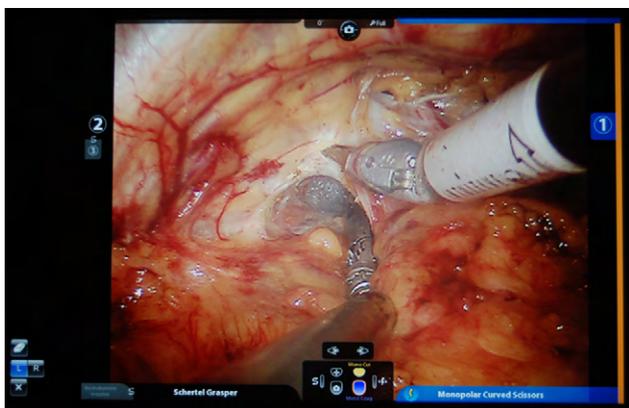


Fig. 3 – Intraoperative image of endopelvic fascia incision.

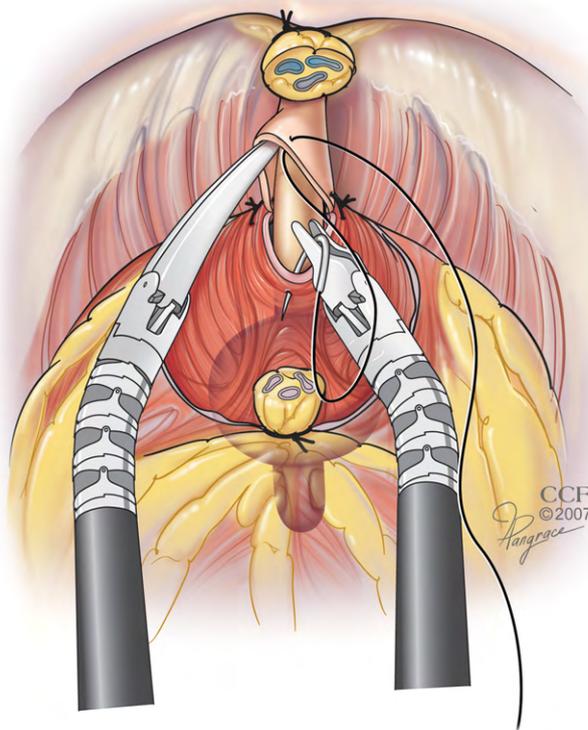


Fig. 4 – Illustration of urethral-vesical anastomosis with 5-mm robotic instruments. Reprinted with the permission of the Cleveland Clinic Center for Medical Art & Photography.

nerve-sparing approach [22] is accomplished with a combination of sharp dissection and robotically applied Hem-o-lok clips. Assistant retraction with the suction device and/or marionette sutures allows for placement of Hem-o-lok clips.

2.2.8. Urethral dissection and division

The 8-mm monopolar shears are used to incise the ligated dorsal vein complex, exposing the underlying urethra. The urethra is transected without cautery. The tip of the urethral catheter is withdrawn, and the posterior urethral wall is transected sharply. Complete dissection of the prostate apex is accomplished in a retrograde fashion; the prostate is released and placed in a 10-mm entrapment bag.

2.2.9. Pelvic lymph node dissection

A standard lymph node dissection is performed in the identical manner to our robot-assisted laparoscopic prostatectomy (RALP) technique. External iliac nodal tissues, as well as nodes from the obturator fossa, are included in the dissection. The specimen is removed with a laparoscopic grasper.

2.2.10. Urethrovesical anastomosis

Robotic needle drivers in the left and right hand are used to complete the vesicourethral anastomosis (Fig. 4). Two sutures of 2-0 polyglecaprone 25 (Monocryl) on an RB-1 needle are placed in a semicircular “running” fashion starting from the 6 o'clock position toward the 12 o'clock and then tied together. A 20F Foley catheter is inserted under vision into the bladder before completion of the anastomosis.

The anastomosis is tested by instilling 100 ml of saline into the bladder to ensure water tightness. A Jackson-Pratt drain is placed in the pelvis and exited through a separate fascial stab but via the same skin incision.

3. Results

3.1. Demographic data

From May 2008 to May 2010, a total of 20 R-LESS RPs were scheduled at our institution. All patients were nonsmokers except one, and none required narcotics or pain relievers for preexisting conditions. The patients had an average of two comorbidities, including atrial fibrillation, hypertension, diabetes mellitus, hypercholesterolemia, osteoarthritis, hypothyroid, multiple sclerosis, depression, gastroesophageal reflux, asthma, and emphysema. Table 1 lists the complete demographic data.

3.2. Operative data

The mean operative time was recorded from skin incision to skin closure. Table 2 details the operative and postoperative data.

3.3. Pathologic data

Four focal positive margins (3 in T2 and 1 in T3a disease) were encountered, with two occurring during the first three cases. Three of the four margins occurred at the apex; one occurred laterally. All of the positive margins were in non-nerve-sparing cases and in Gleason scores of 3 + 3, 3 + 4, 4 + 3, and 4 + 4. Lymph nodes were negative in all cases.

3.4. Complications and conversions

One case was converted to traditional RALP because of the presence of a large median lobe and the need for more robust retraction. Two cases required an additional 8-mm robotic port placed outside of the single-site incision due to excessive external instrument clashing and leakage of gas from the SILS port.

Table 1 – Demographic and preoperative data

No. of patients	20
Age, yr, mean (range)	60.4 (51–74)
BMI, kg/m ² , mean (range)	25.4 (20.1–32.3)
PSA, ng/ml, mean (range)	6.0 (2.4–19.1)
SHIM, No.	
≥21	3
<21	17
Clinical TNM stage, No.	
T1c	20/20
Gleason score, No. (%)	
3 + 3	9/20 (45)
3 + 4	5/20 (20)
4 + 3	3/20 (15)
4 + 4	3/20 (15)
D'Amico risk stratification, No. (%)	
Low	9/20 (45)
Intermediate	8/20 (40)
High	3/20 (15)
BMI = body mass index; PSA = prostate-specific antigen; SHIM = Sexual Health Inventory for Men.	

Table 2 – Perioperative and postoperative outcomes

No. of patients	20
Perioperative outcomes	
EBL, ml, mean (range) [†]	128.8 (50–350)
Operative time, min, mean (range) [†]	187.6 (120–300)
Intraoperative complications	0
Length of stay, d, mean (range) [†]	2.5 (1–6)
VAPS at discharge, 0–10/10, mean (range) [†]	1.6 (0–9)
Morphine equivalents, mg, mean (range)	22.3 (0–52.7)
Conversion to traditional RALP	1
Additional ports	2
Nerve-sparing procedures	3
Postoperative outcomes	
TNM staging, No. (%)	
T2a	3/20 (15)
T2b	3/20 (15)
T2c	10/20 (50)
T3a	4/20 (20)
Pathologic Gleason score, No. (%)	
3 + 3	3/20 (15)
3 + 4	11/20 (55)
4 + 3	4/20 (20)
4 + 4	2/20 (10)
Nodes removed, mean (range)	4 (1–12)
Positive nodes, No.	0
Margin status, No. (%) [†]	
Positive	4/17 (23.5)
Follow-up, mo, mean (range)	5.9 (1–24)
Time to catheter removal, d, mean (range) [†]	8.6 (5–14)
Biochemical recurrence, No.	0
Complications (Clavien-Dindo), No.	
1	1
2	2
3	0
4	1
EBL = estimated blood loss; RALP = robot-assisted laparoscopic prostatectomy; VAPS = visual analog pain score. [†] Includes patients who did not require additional ports.	

Overall, there were four complications, including a Clavien grade 1 conservatively managed ileus (one patient), a Clavien grade 2 single transfusion in a patient on postoperative day 1 due to blood loss anemia (one patient), a Clavien grade 2 pulmonary embolus detected 2 wk postoperatively and managed with 6 mo of anticoagulation

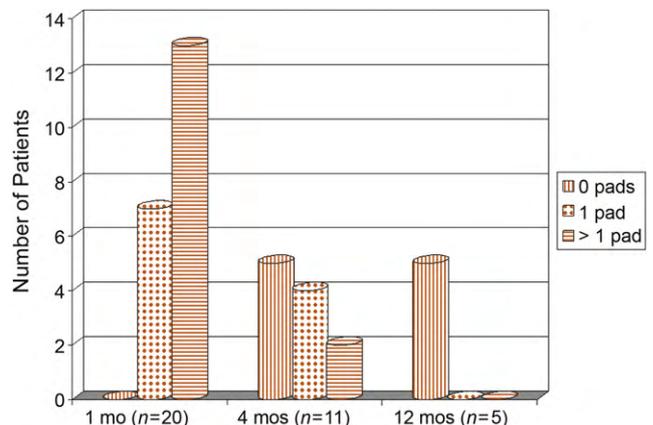


Fig. 5 – Functional outcomes: urinary continence.



Fig. 6 – Postoperative incision closure, 4 cm in length: (a) Immediately postoperative; (b) 1 mo postoperative (different patients).

(one patient), and a Clavien grade 4 urosepsis with intensive care admission that occurred 45 d postoperatively and resolved with intravenous antibiotics and supportive care.

3.5. Postoperative data

3.5.1. Oncologic outcomes

Postoperatively all PSA values were <0.03 ng/ml as compared with preoperative PSA values (mean: 6.01).

3.5.2. Continence outcomes

A trend toward improved urinary continence was observed over the follow-up period (Fig. 5).

3.5.3. Sexual function

Three patients underwent an athermal nerve-sparing technique, and at 3 mo postoperatively one had a SHIM ≥ 21 .

3.5.4. Catheter dwell time

Cystograms were performed on all patients, and catheters were not removed if there was evidence of anastomotic leakage. Seventy-one percent of patients had their catheters removed 1 wk postoperatively and 29% after 2 wk. The five patients who required an additional week of Foley catheter drainage were found to have an anastomotic leak on cystogram.

4. Discussion

Minimally invasive urologic surgery has been growing and evolving ever since Clayman et al performed the first laparoscopic nephrectomy in 1991 [23]. Recently, advancements in optics and instrumentation have led to an increase in LESS and therefore an additional option for patients desiring laparoscopic surgery. Although not enough randomized data are available in the literature, it appears as though this technique may have promise compared with its conventional laparoscopic counterpart, in terms of operative outcomes, postoperative pain, and patient-reported

convalescence after certain procedures including nephrectomy and pyeloplasty [24–27].

Although promising, it is important to remember the underpinnings of this technique and its inherent difficulties. First and foremost, considerable instrument clashing limits precise tissue handling and retraction. Instruments are placed in-line, and triangulation is not possible unless prebent or articulating instruments are used, both of which are nonergonomic and counterintuitive. Fine movements, such as those required for suturing, are difficult and require a considerable number of prior laparoscopic surgeries. Finally, LESS is physically demanding on the operative surgeon and assistant due to the body positions necessary to complete the procedure.

In an attempt to overcome the challenges encountered with LESS, our group introduced the da Vinci surgical system to several urologic procedures [14,16,17]. Specific to R-LESS, the robotic platform reduces or eliminates instrument crossing, has superior ergonomics, and instrument tip articulation significantly facilitates suturing.

Our results demonstrate a positive margin rate of 23.5%, which is consistent with prior published robotic series [28,29]. Positive margins occurred in two of the first three patients, and although this was more than anticipated, it was likely a result of the learning curve, and rates improved as our technique evolved. Cosmesis as evaluated by the surgical team was excellent; the skin incision measured 3–4.5 cm and was mostly concealed within the umbilicus (Fig. 6).

Perioperative complications occurred in four patients, with one consisting of a Clavien grade 4 (ie, intensive care admission due to urosepsis). He recovered uneventfully, and we believe a significant contributing factor was his prior diagnosis of multiple sclerosis and potential diminished bladder contractility because there was no evidence of bladder neck contraction. One patient suffered a pulmonary embolus postoperatively despite early ambulation and intermittent compressive stockings, and he was managed by anticoagulation therapy.

A few limitations to the present study should be mentioned. Most importantly, we did not include a RALP comparative cohort and therefore can only establish conclusions with regard to feasibility and reduction of limitations as applied to conventional LESS RP. Selection bias may have been introduced as a result of the retrospective nature of this analysis. Currently this is unavoidable because this is a new approach, and feasibility must first be established before embarking on a prospective comparative analysis. Additionally, we cannot draw conclusions regarding erectile function outcomes because most patients had significant dysfunction preoperatively with only three patients possessing a mean SHIM score ≥ 21 . We speculate that through refinement of the technique, improved retraction, along with robotically applied Hem-o-lok clips, it might be reasonable to attempt a nerve-sparing approach when indicated. Another important limitation is the short follow-up, which limits conclusions about oncologic and functional outcomes.

4.1. Tips and tricks

We were able to duplicate all steps of traditional RALP, but certain modifications were necessary on a case-by-case basis. We attempted to use a 0° lens in all scenarios, but use of a 30° lens looking upward helped when instrument clashing occurred, repositioning the scope out of the path of the instruments. Instrument crossing was nearly eliminated by slightly staggering the robotic cannulae, ensuring that they were not in parallel.

We prefer to use an 8-mm instrument in the right hand and a pediatric grasper in the left hand to maximize the benefits of each instrument. Pediatric instruments deflect instead of articulate and therefore improve overall range of motion while the standard instrument articulates and greatly facilitates fine movements such as those required for suturing. An additional benefit of using an 8-mm robotic instrument is the ability to use the robotic Hem-o-lok clip applier. This allows the operating surgeon to place clips and overcomes the clashing encountered by the assistant. More important, use of the robotic clip applier has allowed for the replication of our nerve-sparing technique that we perform during traditional RALP. In non-nerve-sparing cases a 5-mm harmonic scalpel can be used, but it must be recognized that this instrument does not articulate or deflect and can be challenging at times. Fortunately, the use of this device is purely optional, and the pedicles can be controlled with either Hem-o-lok clips or suture ligation.

Tissue retraction can be difficult due to lack of utilization of the fourth robotic arm. To combat this, we use internal retraction sutures in a marionette fashion. These can be placed through the abdominal wall with a straight needle and used to retract desired tissues and then fixed outside of the abdomen with a straight clamp. Additionally, the suction plays an important role in retraction. An essential modification necessary to allow this is bending of the laparoscopic suction so it deflects downward. This can be done manually, and 15–30° of deflection toward the distal third of the suction should be the desired adjustment.

Lastly, introduction and extraction of sutures can be challenging. We prefer to pass the dorsal vein suture directly through an unoccupied channel in the SILS port. The needle must be grasped on the concave side with a laparoscopic needle driver and passed with steady pressure. To extract this suture we perform the same steps, except the needle is grasped on the convex side.

At this point in time, R-LESS appears feasible and less challenging compared with conventional LESS. Our hope is that by continuing to challenge the limits of our technology we will force the adaptation and innovation of new devices and procedures. The ideal robotic system would be task specific, deployable through a single incision, possess articulating instruments, and have reduced external housings. If we can deploy a platform through a single-muscle splitting incision, we should be able theoretically to decrease postoperative pain, encountered during the placement of multiple cannula insertion points, and thereby shorten convalescence.

5. Conclusions

Our preliminary experience with R-LESS RP demonstrated feasibility of the procedure. The R-LESS RP reduces some of the difficulties encountered with conventional LESS RP. Comparative investigation to traditional robot-assisted RP is needed.

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: White, Kaouk.

Acquisition of data: White, Haber.

Analysis and interpretation of data: White, Autorino, Khanna, Haber.

Drafting of the manuscript: White, Autorino.

Critical revision of the manuscript for important intellectual content: White, Autorino, Kaouk.

Statistical analysis: None.

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Supervision: Kaouk.

Other (specify): None.

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Appendix A. Supplementary data

The Surgery in Motion video accompanying this article can be found in the online version at [doi:10.1016/j.eururo.2010.06.040](https://doi.org/10.1016/j.eururo.2010.06.040) and via www.europeanurology.com. Subscribers to the printed journal will find the Surgery in Motion DVD enclosed.

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