



# Past, present, and future of laparoscopic renal surgery

Kevin Cwach, Louis Kavoussi

The Smith Institute for Urology, New Hyde Park, NY, USA

Although laparoscopic renal surgery dates to almost 30 years ago, in which the first laparoscopic nephrectomy was performed in 1990, the history of laparoscopy extends back over 100 years, when laparoscopy was first performed on dogs. Over the last 30 years, laparoscopic renal surgery has seen many advancements in technology and technique. With the introduction of robotics and new instruments, renal surgery is becoming increasingly less invasive, and patients are having improved operative outcomes. As new technology develops, the envelope will continue to be pushed by urologists with the hope of improvement of patient outcomes and satisfaction.

**Keywords:** History; Laparoscopy; Natural orifice endoscopic surgery; Nephrectomy

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

## HISTORY OF LAPAROSCOPIC SURGERY

The history of laparoscopy dates back to 1901, when Georg Kelling of Dresden, Germany performed diagnostic laparoscopy on the peritoneal cavity of a dog. Using a cystoscope inserted through a trochar with creation of pneumoperitoneum with filtered air, he described his technique to the German Biological and Medical Society as *koelioskopie*, and was published in 1902 [1]. In Sweden around the same time, a surgeon, Dr. Jacobaeus, published reports on laparoscopy on humans in the peritoneal, thoracic, and pericardial cavities—a technique he referred to as *laparothorakoskopie*. The term laparoscopy stems from the Greek words *lapara*, meaning “the soft part of the body between ribs and hip, flank, loin” and *skopein*, meaning “to look at or survey.” [1]. In Russia during this same time, von Ott examined the peritoneal cavity of a pregnant woman

through a culdoscopic opening [2].

The initial application for laparoscopy was diagnostic only, however this tool rapidly became popular across the world for viewing and diagnosing of a wide range of intra-abdominal pathology [1]. The technique improved with the descriptions and inventions of the Trendelenburg position in 1912, the use of needle insertion to obtain pneumoperitoneum, and the creation of the dual-trochar technique, which opened the door to operative laparoscopy.

Gynecologists were among the first surgeons to pioneer operative laparoscopic techniques. Therapeutic procedures, including: tubal ligation, ovarian cystectomy, incision and drainage of tubo-ovarian abscesses, and lysis of pelvic adhesions were described starting around 1933 [1,2]. Laparoscopy was slow to advance between 1940 and 1960 in the United States. One of the most critical advances occurred, however, in 1952 with the invention of the Hopkins

**Received:** 10 October, 2016 • **Accepted:** 3 November, 2016

**Corresponding Author:** Kevin Cwach

The Smith Institute for Urology, 450 Lakeville Rd, New Hyde Park, NY 11042, USA  
TEL: +1-516-734-8500, FAX: +1-516-734-8535, E-mail: kevin.cwach@gmail.com

rods-lens system, which improved optics and thus gave confidence in performing more complicated laparoscopic surgery [1].

With gynecologists being the first to advance the techniques of the field, Kurt Semm [3], a gynecologist by training, was the first to perform a laparoscopic appendectomy in 1983. Following, the first laparoscopic cholecystectomy was performed in 1987 [2].

## HISTORY OF LAPAROSCOPIC RENAL SURGERY

With success of laparoscopy in other disciplines, Ralph Clayman and his team at Washington University began to explore the potential for laparoscopic nephrectomy. After multiple laboratory experiments on pigs and observation of general surgery laparoscopy, they successfully completed the first laparoscopic nephrectomy at Washington University in 1990 [4]. In a 1991 letter to the editor in *The New England Journal of Medicine*, they described their operation. The patient, an 85-year-old woman, had a 3-cm asymptomatic right middle lower pole renal mass discovered on computed tomography (CT) scan for a trauma work-up. Following Investigation Review Board approval, the patient underwent preoperative embolization with ethanol under intravenous sedation. She was taken to the operating room, a ureteral catheter was inserted to help identify the ureter, and five laparoscopic ports were used for dissection. The kidney was successfully dissected, and was removed by morcellation. In total, the operation lasted seven hours, and the patient was discharged on postoperative day 6 [5].

As laparoscopic nephrectomy became more widespread, urologists began to advance their techniques. In 1995 a paper published by Winfield et al. [6] described their success of laparoscopic partial nephrectomy in 4 patients. Around the same time, the first laparoscopic live donor nephrectomy was performed by Dr. Kavoussi and colleagues at Johns Hopkins University in 1995 [7]. As techniques were refined, average operative time and length of stay both improved, and exploration of other laparoscopic urologic surgeries such as laparoscopic nephroureterectomy and retroperitoneal lymph node dissection began to emerge [4]. Initially the laparoscopic nephrectomy was slow to be adopted widely, secondary to increased operative time and the significant learning curve [4]. By 1998, a multi-institutional review found that 5-year survival was equivalent among open and laparoscopic nephrectomy groups [4]. The benefit of laparoscopic surgery, however, included significantly reduced postoperative analgesia requirements (9 fold) and intraoperative blood

loss [4]. Eventually with more widespread adoption and the increased benefits, laparoscopic radical nephrectomy became the gold standard for renal tumors not amenable to partial nephrectomy [4].

With advancing robotic technology and the development of the DaVinci system, urologists began to explore the realm of robotic-assisted urologic surgery. In 2004, Gettman et al. [8] published a paper describing their experience with robotic-assisted laparoscopic partial nephrectomy. Robotic surgery offered the benefit of increased dexterity and range of motion, 3-dimensional viewing, and a shortened learning curve compared to purely laparoscopic dissection and suturing [4]. Multiple studies of robotic versus laparoscopic partial nephrectomy have demonstrated equivalent perioperative outcomes in regards to average operative time, hospital length of stay, complications, and positive margins [9]. One of the biggest differences between the 2 techniques appears to be the associated cost. A 2012 study by Yu et al. [10] found robotic partial nephrectomy to cost an average of \$1,600 more per person or an additional 6% per case compared to laparoscopic partial nephrectomy.

With increasing advances in technology, the interest in advancing minimally invasive procedures was high, and the concepts of NOTES and laparoendoscopic single-site surgery (LESS) developed. NOTES, short for natural orifice transluminal endoscopic surgery, is a selective type of minimally invasive surgery that functions to decrease the number of incisions as well as to eliminate postoperative scar appearance. The first application of NOTES in renal surgery occurred in 2002, Gettman et al. [11] described a transvaginal laparoscopic nephrectomy in a pig. Following this publication, several papers began to appear in the literature on this subject. In addition, laparoendoscopic single site surgery, or LESS, began to evolve in renal surgery. In 2008, Desai et al. [12] published the first paper describing a laparoscopic nephrectomy through a single abdominal incision.

## CURRENT TRENDS

The use of laparoscopic renal surgery in improving patient outcomes when compared to open renal surgery has been supported by the literature. A large retrospective study of over 14,000 patients undergoing open versus laparoscopic total or partial nephrectomies found that patients undergoing laparoscopic surgery had decreased rates of surgical site infection, sepsis, pneumonia, return to the operating room, need for blood transfusion, and length of stay [13].

With recognition of the benefits of nephron-sparing surgery in terms of equivalent oncologic and superior renal function outcomes, there is an increased drive to perform laparoscopic partial nephrectomies [14]. While once reserved for cases of bilateral renal masses or solitary kidney with a mass, partial nephrectomy has now become the preferred standard when feasible [14].

As the average life expectancy increases, and the number of small, incidental renal masses found on CT scan increases—particularly in the elderly—the role of observation versus intervention becomes increasingly uncertain. Previously, thermal or cryoablation techniques were limited to small renal masses in poor surgical candidates. In further outcome studies, however, the local recurrence rates of cryotherapy (4.6%) or radiofrequency ablation (11.7%) were found to be similar to partial nephrectomy, thus questioning the role of partial nephrectomy in this population [4]. Most recently, studies have examined the combination use of laparoscopic radio frequency ablation versus laparoscopic partial nephrectomy alone, and have found a decrease in operative blood loss, operative time, and hospital length of stay [15]. Most likely, as targeting improves accuracy, percutaneous ablative therapies will supplant the laparoscopic approach.

## FUTURE LAPAROSCOPIC RENAL SURGERY

Laparoscopic renal surgery is far from being perfected. As the incidence of renal cell carcinoma increases with the aging and increasingly morbid population, the incidence of renal incidentaloma will only rise. Goals for the future of laparoscopic renal surgery include improving outcomes, decreasing morbidity and mortality, and decreasing length of recovery while trying to be cost effective and as least invasive as possible.

As technology expands, so will the capabilities of LESS and NOTES as new instruments are designed. As robotic technology improves, new and future robots hope to include haptic and force feedback to assist in completing increasingly difficult operations [16]. Additionally, future developments aim to decrease intervariability of performance with decreased learning curve in an effort to improve and standardize patient outcomes [16].

The primary limitation of LESS currently involves the ability to dissect in a triangulation approach as well as the close proximity of instruments. With robotic advancements, newer robots will have better flexibility and ability to perform from a single port site [4,16]. Potential natural

orifices that have been explored in animal studies include transgastric, transvaginal, transcolonic, and transvesical approaches [16].

An emerging trend is computer-assisted surgery (CAS), which is the integration of computer technology for presurgical planning and guiding, and includes the fields of surgical robots as well as image-guided system and augmented reality (AR) [16]. Future robotic applications include image-guided robots that through use of CT, magnetic resonance imaging, or ultrasound, aid in safely introducing instruments or needles into the kidney [16]. Such systems would help in reducing inadvertent organ injury such as obtaining percutaneous access for nephrolithotomy. AR is the overlay of a 3-dimensional reconstructed image (from preoperative imaging) onto a live video. With increasing push to perform LESS and NOTES, AR technology can help in identifying organs as well as orientating structures and position from novel approaches [16]. Such technology would also allow for improved identification of renal masses with the aim of increasing complete tumor resection rate while minimizing removal on healthy renal parenchyma.

Lastly, the future of advancements in laparoscopic renal surgery consists of improving and standardizing training in an effort to reduce adverse surgical events and improve outcomes. The GOALS score, short for Global Operative Assessment of Laparoscopic Skills, is a validated global rating scale for laparoscopy and consists of 5 categories: depth perception, bimanual dexterity, efficiency, tissue handling, and autonomy, that are evaluated by a blind observer [17]. Multiple studies have attempted to investigate the best method for introducing new trainees to laparoscopy, and how to best shorten the learning curve and minimize adverse events. In a recent blinded, three-arm study of general surgery resident, 30 residents were assigned to one of 3 groups. The control group had a traditional intraoperative laparoscopic learning model in which the surgeon taught the trainee intraoperatively. The second group received intensive simulated training prior to real life exposure, and the third group was a blend between the first 2 groups. In their investigation, they found the second group to have the shortest learning curve on GOALS assessment, and they were able to perform their procedures more quickly and accurately with decreased adverse events than the other 2 groups [17]. From this study, the author argues that simulation modules are important curriculum component prior to “hands on” operative experience, although larger studies are needed.

## CONCLUSIONS

The history of laparoscopy dates back over 100 years, and laparoscopic renal surgery to almost 30 years. Over the last 30 years, laparoscopic renal surgery has seen many advancements in technology and technique. With the introduction of robotics and new instruments, renal surgery is becoming increasingly less invasive, and patients are having improved operative outcomes. As new technology develops, the envelope will continue to be pushed by urologists with the hope of improvement of patient outcomes and satisfaction.

## CONFLICTS OF INTEREST

The authors have nothing to disclose.

## REFERENCES

1. Lau WY, Leow CK, Li AK. History of endoscopic and laparoscopic surgery. *World J Surg* 1997;21:444-53.
2. Himel HS. Minimally invasive (laparoscopic) surgery. *Surg Endosc* 2002;16:1647-52.
3. Semm K. Endoscopic appendectomy. *Endoscopy* 1983;15:59-64.
4. Kerbl DC, McDougall EM, Clayman RV, Mucksavage P. A history and evolution of laparoscopic nephrectomy: perspectives from the past and future directions in the surgical management of renal tumors. *J Urol* 2011;185:1150-4.
5. Clayman RV, Kavoussi LR, Soper NJ, Dierks SM, Merety KS, Darcy MD, et al. Laparoscopic nephrectomy. *N Engl J Med* 1991;324:1370-1.
6. Winfield HN, Donovan JF, Lund GO, Kreder KJ, Stanley KE, Brown BP, et al. Laparoscopic partial nephrectomy: initial experience and comparison to the open surgical approach. *J Urol* 1995;153:1409-14.
7. Su LM, Ratner LE, Montgomery RA, Jarrett TW, Trock BJ, Sinkov V, et al. Laparoscopic live donor nephrectomy: trends in donor and recipient morbidity following 381 consecutive cases. *Ann Surg* 2004;240:358-63.
8. Gettman MT, Blute ML, Chow GK, Neururer R, Bartsch G, Peschel R. Robotic-assisted laparoscopic partial nephrectomy: technique and initial clinical experience with DaVinci robotic system. *Urology* 2004;64:914-8.
9. Aboumarzouk OM, Stein RJ, Eyraud R, Haber GP, Chlosta PL, Somani BK, et al. Robotic versus laparoscopic partial nephrectomy: a systematic review and meta-analysis. *Eur Urol* 2012;62:1023-33.
10. Yu HY, Hevelone ND, Lipsitz SR, Kowalczyk KJ, Hu JC. Use, costs and comparative effectiveness of robotic assisted, laparoscopic and open urological surgery. *J Urol* 2012;187:1392-8.
11. Gettman MT, Lotan Y, Napper CA, Cadeddu JA. Transvaginal laparoscopic nephrectomy: development and feasibility in the porcine model. *Urology* 2002;59:446-50.
12. Desai MM, Rao PP, Aron M, Pascal-Haber G, Desai MR, Mishra S, et al. Scarless single port transumbilical nephrectomy and pyeloplasty: first clinical report. *BJU Int* 2008;101:83-8.
13. Semerjian A, Zettervall SL, Amdur R, Jarrett TW, Vaziri K. 30-Day morbidity and mortality outcomes of prolonged minimally invasive kidney procedures compared with shorter open procedures: national surgical quality improvement program analysis. *J Endourol* 2015;29:830-7.
14. Zhao PT, Richstone L, Kavoussi LR. Laparoscopic partial nephrectomy. *Int J Surg* 2016 Apr 21 [Epub]. <http://doi.org/10.1016/j.ijssu.2016.04.028>.
15. Huang J, Zhang J, Wang Y, Kong W, Xue W, Liu D, et al. Comparing zero ischemia laparoscopic radio frequency ablation assisted tumor enucleation and laparoscopic partial nephrectomy for clinical t1a renal tumor: a randomized clinical trial. *J Urol* 2016;195:1677-83.
16. Micali S, Pini G, Teber D, Sighinolfi MC, De Stefani S, Bianchi G, et al. New trends in minimally invasive urological surgery: what is beyond the robot? *World J Urol* 2013;31:505-13.
17. De Win G, Van Bruwaene S, Kulkarni J, Van Calster B, Aggarwal R, Allen C, et al. An evidence-based laparoscopic simulation curriculum shortens the clinical learning curve and reduces surgical adverse events. *Adv Med Educ Pract* 2016;7:357-70.

## Past, present, and future of laparoscopic renal surgery