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Percutaneous Renal Surgery: A Pioneering Perspective

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INTRODUCTION

THERE IS NO BETTER WAY to reminisce about the 1980s, when the seeds of minimally invasive therapy in urology were sown, than to quote from "The new surgery" in the *British Medical Journal*, 1987[1]:

> The history of surgery may now be divided into three phases. From ancient times until the mid-nineteenth century surgery was rough, rapid, brutal, ablative and had only limited applications. In the second phase, which lasted until about 1960, anaesthesia and improved resuscitation techniques allowed complicated procedures to be carried with only minimal thought being given to the effects on the patient: many deaths and much illness were caused by the activities of the surgeon rather than the disease. Since 1960 some surgeons have realised that operations could be performed more elegantly and less traumatically with advanced instruments, particularly endoscopes.

Wickham's vision may have been looked on by some with scepticism. Nonetheless, the dreams of a number of endourologists from that era have come true. Urologists have become masters of endoscopic surgery. Laparoscopy is the most rapidly advancing subspecialty within urology. Robotic systems are leading us toward a digital future. In these days of technologist leaps, it is worthwhile remembering the transition from open surgery to minimal/non-invasion: a concept heralded by the advent of extracorporeal shockwave lithotripsy (ESWL) to treat renal stones. The same period saw the introduction of percutaneous renal surgery, early attempts at retroperitoneoscopy, and the first steps in urologic robotics. This article provides an overview of these developments with particular reference to contributions from one of the authors (JEAW).

PERCUTANEOUS NEPHROLITHOTOMY

Elective percutaneous nephrolithotomy (PCNL) has become an important technique for renal calculi extraction, avoiding the complications of open surgery. With the development of percutaneous nephrostomy insertion by the radiologists, the path was paved to revolutionize the way renal calculi within calices or the renal pelvis could be extracted.

The technique we use today is a modification of the method that Wickham and his contemporaries designed and revised.[2] The procedure was initially performed over several days.[3] A percentaneous sheathed needle was introduced into the renal collecting system under local anesthetic and the needle removed and replaced with a guidewire. Small dilators were introduced over the guidewire, and finally, an 8F pigtail catheter was inserted. At this stage, the patient often went home and returned over the next few days to have the tract dilated serially to 22F to 26F. A further 2 or 3 days later, with the patient under a general anesthetic, the nephrostomy tube was removed and a standard rigid 21F 30° cystoscope used to access the caliceal system.

Wickham, in conjunction with a radiologist, Kellet, performed his first case at the Institute of Urology, London, in 1979. The tract was positioned by Kellet, following which, Wickham identified the patient's calculus with a cystoscope, introduced a stone basket down the operating channel, and removed a pea-sized stone. The early cases treated were mobile stones in the renal pelvis. In 1979, Wickham presented his initial results at the first meeting of the Endourological Society at the Institute of Directors, London. At the same meeting, Alken[4] described his pioneering experience using such a technique as a salvage procedure to remove stones remaining after open surgery, down an operatively established nephrostomy tract. The meeting was a big success in that whereas the organizers had budgeted for only 50 people, more than 200 enthusiastic urologists attended.

The method as a primary procedure as described above involved two stages, the first being the radiologic placement of the nephrostomy tube and the second the surgical extraction of the calculi with a nephroscope. Patients with caliceal and pelvic calculi were being treated successfully using this new percutaneous method, and any calculi that were too large for simple extraction were fragmented using an ultrasonic lithotripter. Then, with the increase in experience of both the radiologists

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and the surgeons; the development of purpose-built nephroscopes, electrohydraulic lithotripters, and triradiate graspers; and the evolution of sophisticated flexible instrumentation, the success rate of this now widely accepted procedure increased dramatically.[5,6]

As the technique became more successful, the next advancement was obvious: the one-stage procedure.[7] In 1984, Wickham described his first 100 patients undergoing one-stage PCNL. Puncture and dilation were exactly the same as for the two-stage approach, but when dilation was complete, an Amplatz sheath was inserted along with a floppy J wire. A nephroscope was then introduced through the sheath and the stone(s) extracted.

This development was exactly what was required to prove the advantage of PCNL over open surgery. At the 2nd World Congress on Percutaneous Renal Surgery in Mainz, more than 3000 cases of PCNL were presented with a success rate exceeding 90%. The PCNL was deemed a preferable alternative to open surgery.

Combined with ureteroscopy and SWL, contemporary German endourologists had demonstrated in five centers that there was virtually no need for open stone surgery. In a study of 1052 patients comparing open surgery, SWL, and PCNL, Wickham's group found the latter two techniques to be significantly less morbid and cheaper than open surgery.[8]

PERCUTANEOUS PYELOLYSIS

By the early 1980s, percutaneous surgery had become an established technique in the treatment of a large percentage of renal stones. The focus then turned to the management of pelviuruteral junction obstruction (PUJO). Up until that time, PUJO had been treated reliably by open surgery alone. It was important to prove to any remaining sceptics that percutaneous surgery was about to undergo rapid advancements in its application and to define its role in PUJO.

Like PCNL, percutaneous pyelolysis was initially performed as a two-stage procedure. Firstly, a transparenchymal percutaneous tract was established, followed 72 hours later by the incision of the PUJ posterolaterally for 1.5 to 2 cm through this tract. A ureteral splint was then railroaded across the PUJ. This technique, based on modification of the Davis intubated ureterostomy, was first described in 1983 and was successful in two of three patients.[9] In 1984, 18 of 28 patients were treated successfully by this method.[10] Pyelolysis failed when the caliber of the splint was too small and in the presence of infection.

It was accepted that urologists embarking on percutaneous surgery for renal disease would encounter a learning curve, which would affect their success rate. Initially, in some patients with a rather thick PUJ, the cuts were short and timid, but with experience, these incisions became longer and of full thickness. With perseverance, the procedure became an acceptable alternative to open surgery, and before too long, percutaneous pyelolysis had also become a one-stage procedure. Over the years, the technique and its name underwent change: in the USA, it was renamed endopyelotomy. Its overall success rate has been somewhat lower than that of open pyeloplasty largely because of unfavorable case selection and the presence of crossing vessels. At present, laparoscopic pyeloplasty is emerging as the true gold standard for treating PUJO. Despite this, with the recent advent of percutaneous endopyeloplasty,[11] it seems that the principles behind percutaneous pyelolysis have been rejuvenated.

LAPAROSCOPIC/RETROPERITONEOSCOPIC URETEROLITHOTOMY

Ron Miller, Wickham's lecturer at the Institute of Urology, investigated the potential of retroperitoneal laparoscopy of the kidney in the late 1970s. He found that it was very difficult to

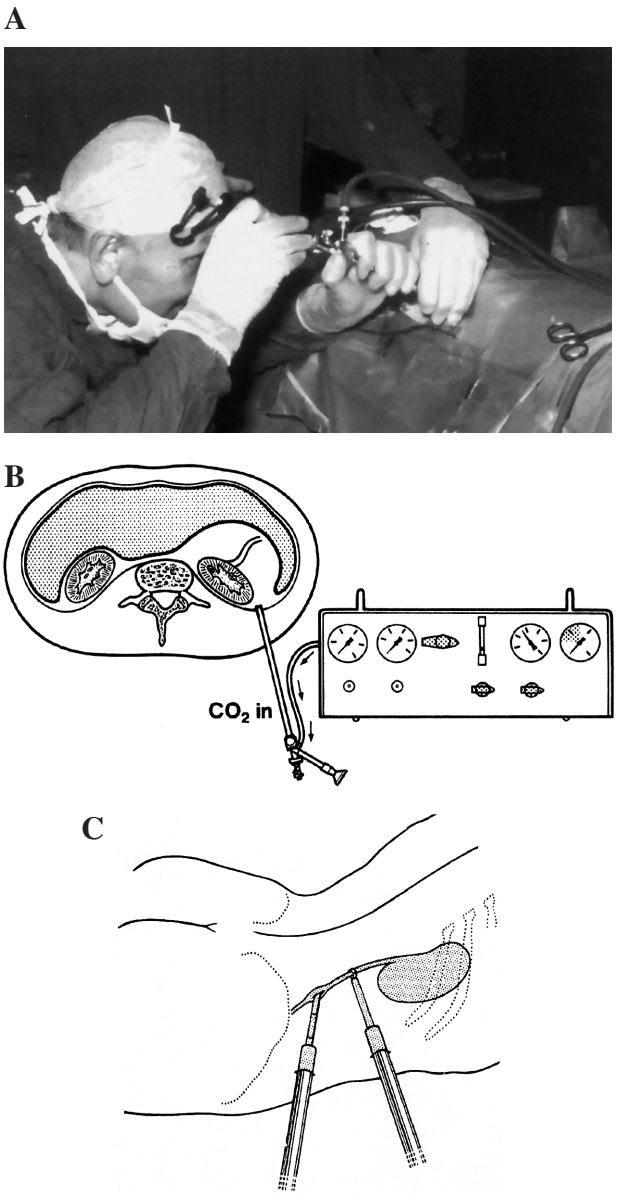

FIG. 1. John Wickham performing laparoscopic ureterolithotomy in 1979 (**A**) with schematic diagrams of technique (**B, C**). Note that Wickham is peering down endoscope rather than looking at a screen.

create an adequate retroperitoneal space to work in, and this opinion was later to be confirmed in humans. The early retroperitoneal endoscopic procedures were simply direct-vision, gasless techniques, and it was Wickham who first reported retroperitoneal urologic laparoscopy using pneumoinsufflation and a laparoscope.[12] He performed a laparoscopic ureterolithotomy by the retroperitoneal route in 1979 (Fig. 1), 12 years before Clayman's first laparoscopic nephrectomy. His subsequent attempts at retroperitoneal laparoscopy were largely unsuccessful because of the inability to create a satisfactory working space. It was not until 1992, when Gaur reported his innovative balloon technique of retroperitoneal dissection, that this approach was revolutionized.[13]

ROBOTIC PERCUTANEOUS NEPHROLITHOTOMY

Robot-enhanced surgery is emerging as a solution to some of the drawbacks of the traditional minimal-access surgery. Master–slave telemanipulator systems such as the DaVinci have been used extensively in surgical interventions and more recently have shown promising results in urology. Robotic endourology has had evidence of its effectiveness for some time. In the late 1980s, Wickham joined forces with the mechanical engineering group at the Imperial College, London, leading to the development of two uro-robotic systems: the TURP robotic frame and the percutaneous access to the kidney (PAKY) robot. The TURP robot underwent clinical trials at Guy's Hospital. The PCNL robot was a passive five-degrees-of-freedom manipulator with an access needle that was mounted on the operating table and guided by a C-arm. Positional sensors were used to record the position of the device, which was matched to the C-arm's coordinates. A personal computer displayed the access needle's trajectory on each fluoroscopic image, and the surgeon could manipulate its position. Initial experiments showed a targeting accuracy of within 1.5 mm.

Following this demonstration, Kavoussi and his colleagues first showed the possibility of using the RCM-PAKY, an active robot for needle puncture, in PCNL.[14] This has been superseded by the production of the Tracker in 2002, which is mounted on the operating table, allows six degrees of freedom, and can be used with fluoroscopy or CT guidance to improve the accuracy of needle placement. Robotic PCNL has been shown to be comparable to standard manual PCNL in a clinical trial and has subsequently been demonstrated to be more accurate than the human hand in a randomized controlled trial.

In 2003, the first randomized controlled trial of trans-Atlantic telerobotics between Guy's and Johns Hopkins hospitals was conducted with robotic needle punctures during PCNL into a kidney model controlled remotely.[15] Although somewhat slower than the human hand, the robotic arm was more accurate, which is vital in a procedure such as PCNL. Time delay did not compromise accuracy because of the use of high-speed telephone links. This raises the exciting future possibility of having patients operated by the best surgeons wherever on earth they may be.

CONCLUSIONS

Urology is the speciality that has seen the most far-reaching advances in minimally invasive surgery. A number of these were conceived in the Wickham era during which the seeds of percutaneous surgery, laparoscopic urology, and robotics were sown.

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