Laparoscopy in Paediatric Urology: Recent Advances

JD **SIHOE,** N **MAGSANOC,** B **SREEDHAR,** CK **YEUNG**

Abstract   Over the past decade, major advances in laparoscopy, aided by the development of more optically refined and diminutive instruments specially geared for use in infants and young children, have allowed the application of minimally invasive surgery (MIS) techniques in a wide spectrum of paediatric surgical and paediatric urological procedures. These modern and newer techniques are undergoing rapid evolution and additional innovative procedures are being continually introduced. The Division of Paediatric Surgery and Paediatric Urology, Chinese University of Hong Kong, has been pioneering many of these novel paediatric MIS procedures. This article aims to provide an updated synopsis of the advances in various laparoscopic procedures that can currently being performed safely and effectively in the context of paediatric urology.

Key words   Laparoscopy; Nephrectomy; Paediatric urology; Pyeloplasty; Ureteric reimplantation; Varicocelectomy

Introduction and Background

The concept of minimally invasive surgery (MIS) is not new. Back in 1805, Bozzini, an obstetrician from Frankfurt, already made the first attempts to examine the urethra of a patient using a candlelight through a cannula.[1] However, the real big leap forward wasn't until the advent of fibro-optics by Hopkins in 1953 that really opened the way for the development of laparoscopic surgery to what it is today.[2]

Gans and Berci[3] first reported the use of laparoscopy in children in 1971 but its use had been limited to diagnostic purposes for many years. During the early 1990's, widespread enthusiasm to perform minimally invasive surgery in adults finally led to increased interest among paediatric surgeons to develop its use in operative procedures in young children.[1] Innovative modifications

have been developed to account for the smaller body cavities and more restrictive working areas in the paediatric patients. In addition, a different spectrum of pathologies has led to the development of many paediatric-specific procedures. Since then success in many MIS operative procedures in children such as laparoscopic cholecystectomies,[4] laparoscopic fundoplications[5] and laparoscopic pullthrough have been reported.[6]

Similarly, in the field of paediatric urology, there has been a quantum leap over the past decade from purely diagnostic laparoscopy before to the development of therapeutic laparoscopic procedures for a comprehensive spectrum of urological conditions recently. Major advances have been made in the application of MIS techniques in various paediatric urology conditions. Discussions among paediatric surgeons and paediatric urologists now about the use of laparoscopy are no longer whether it is feasible in young children but how best one can apply it successfully in different conditions. The Division of Paediatric Surgery and Paediatric Urology, Chinese University of Hong Kong, has pioneered many novel paediatric MIS procedures over the past years. Paediatric urological operations that are now routinely performed using the MIS technique in our Division range from simpler procedures like orchidopexy for undescended testes, varicocelectomy, nephrectomy or hemi-nephroureterectomy for non-functioning kidneys or

Division of Paediatric Surgery and Paediatric Urology, Department of Surgery, The Chinese University of Hong Kong, Prince of Wales Hospital, Shatin, N.T., Hong Kong, China

JD SIHOE   *B Med Sci(Hons), BMBS(Nottm), MCSHK*
N MAGSANOC   *MD*
B SREEDHAR   *BSc(Biol), MSc(Appl. Biol)*
CK YEUNG (   ) *MD, FRCS, FACS*

Correspondence to: Prof CK YEUNG

dysplastic renal moieties, laparoscopy for diagnosis and gonadectomy for ambiguous genitalia or intersex, localisation and excision of "invisible" dysplastic kidneys with ectopic ureteric insertion causing urinary incontinence, to more sophisticated reconstructive procedures like pneumovesicoscopic ureteric reimplantation for vesicoureteric reflux, retroperitoneoscopic dismembered pyeloplasty for hydronephrotic kidneys with ureteropelvic obstruction, excision of complicated prostatic utricles, excision of ureteroceles and caecoureteroceles with simultaneous bladder base and bladder neck/posterior urethral reconstruction, endoscopic removal of urinary calculi, laparoscopic bladder neck sling or various reconstructions, augmentation cystoplasty, uretero-ureterostomy, Mitrofanoff appendicovesicostomy, Malone's antegrade continent enema (ACE) appendicocaecostomy, etc… In essence, most (>90%) operative procedures that have conventionally been performed with an open approach and requiring big open incisions can now be very safely and effectively performed using the MIS technique.

Special Advantages of MIS in Paediatric Urology

There are several special advantages of using the MIS approach for various paediatric urological procedures. Firstly, the laparoscope eliminates the depth of the pelvic cavity and provides a well-illuminated and significantly magnified view of all anatomic structures deep in the pelvis, and even down to the pelvic floor, that is way superior compared with the surgical view one can previously obtain via an open approach. This makes it ideal for operations in the bladder base, bladder neck and posterior urethra even in the small pelvic cavity in a young infant, which is previously rather inaccessible by routine open surgery. For instance, a bladder neck reconstruction procedure or excision of a complicated prostatic utricle can now be very comfortably accomplished using the laparoscope, with a remarkably clear and magnified endoscopic vision that is hard to imagine just a few years ago. Secondly, the panoramic view of both the abdominal and the pelvic cavities provided by the laparoscope allows exploration and surgery to both the upper and the lower urinary tracts at the same setting, hence avoiding the need for multiple operations or making separate, long incisions. Surgical operations for pathologies affecting both the upper and lower urinary tracts, that have to be undertaken in multiple stages before, can now be easily completed using the laparoscope in one single stage. For instance, traditional

management of a duplex kidney with a non-functioning moiety that is associated with a dilated megaureter and a complicated prolapsing caecoureterocele necessitates multiple operations in different stages, usually commencing with a upper pole hemi-nephroureterectomy via a loin muscle-cutting incision, followed by excision of the caecoureterocele and then reconstruction of the bladder base via a suprapubic Pfannenstiel incision and then reimplantation of the lower moiety orthotopic ureter. These can now all be accomplished in one single setting using the MIS technique. Thirdly, infants and young children are particularly susceptible to post-operative pain and separation anxiety and any manoeuvre that can significantly reduce surgical trauma, minimise post-operative pain and shorten the hospital stay would be a major advantage. The advent of the MIS technique allows the paediatric urologists to dramatically change our traditional practice and convert major urological procedures that used to require prolonged hospitalisation to a short-stay or even day surgical procedure. For instance, a traditional open Cohen's ureteric reimplantation using a classical suprapubic open incision would normally require a hospital stay of over a week to ten days, the use of suprapubic and urethral urinary diversion, ureteric stenting and also extravesical wound drains. In sharp contrast, a young infant undergoing a similar Cohen's ureteric reimplantation that is performed with our pneumovesicoscopic technique can now be discharged home on the same evening, with almost no wound pain and without any drains or stents. The much superior wound cosmesis serve as additional bonus.

Laproscopic Varicocelectomy

A varicocele is an abnormal dilation of the pampiniform plexus that constitutes the primary drainage of the testis. It is found approximately in 15% of male adolescents with a left-sided predominance. Majority of which is due to retrograde flow of blood in the internal spermatic vein and differences in the configuration of the right and left internal spermatic veins and their embryologic origins.[7,8]

Laparoscopic varicocelectomy has been proposed as an alternative surgical procedure for the repair of varicocele with reported benefits of better convalescence, minimal invasiveness, less analgesic requirement postoperatively. It was reported as one of the most commonly performed laparoscopic procedures in urology. The indication for intervention in a paediatric varicocele remains controversial. However, there is consensus that laparoscopic

varicocelectomy can be performed in the paediatric age group if the varicocele is accompanied by symptoms or testicular growth retardation.

To date, several treatment options available include spermatic vein sclerotherapy or embolisation, and open surgical ligation of the varix, through a retroperitoneal, inguinal or a subinguinal approach. On the other hand, since Sanchez de Badajoz et al reported the first laparoscopic varicocelectomy in 1988, extensive experience has been gained with reasonable results in terms of testicular size and growth being reported.[9-11]

Laparoscopic varicocelectomy may either be transperitoneal or retroperitoneal. The major advantage of the laparoscopic approach is that it provides a direct and magnified view of the structures allowing precise identification and dissection. It likewise allows a bilateral laparoscopic ligation to be done through the same incisions, instead of the two incisions required in an open surgical approach. However the main disadvantages of laparoscopy are the high cost and the need for multiple port placements, which make it quite inappropriate in treating a unilateral varicocele.

Laparoscopic varicocele ligation is well reported in literature and appears to offer a lower recurrence rate than conventional open operation, although a meta-analysis of the literature by Matsuda did not show much difference in surgical outcome.[12] In a series of 82 patients and 115 laparoscopic varix ligations, Kwon and associates reported a recurrence or persistence rate of 1.8%, and the rates of major and minor complications were only 1.2% and 8.5%, respectively.[13] Similarly, Jarow and coworkers reported a persistent varicocele rate of 1% and a complication rate of 4%.[14]

Laparoscopy in Intersex Disorders

In recent years, laparoscopy has been used as a method for the evaluation and treatment of intersex patients.[15] At present, laparoscopy has gained acceptance as the ideal method of surgical treatment of the internal genital organs in patients with intersex disorders as a minimally invasive procedure whose efficiency is equivalent to that of open surgery, laparoscopy is associated with low morbidity, allowing a quicker postoperative recovery and an almost complete absence of cutaneous scars. This latter aspect is important for patients with sexual ambiguity who need reaffirmation of their body image and self-esteem.[16]

First done in 1986, diagnostic laparoscopy offers direct visualisation of the internal genital structures in cases in which the anatomy may not be clear based on imaging studies. It also offers the ability to perform a diagnostic biopsy to establish a histologic diagnosis and the ability to remove aberrant gonadal or ductal structures if necessary.[17]

Diagnostic laparoscopy has limited role intersexual disorders as compared to therapeutic laparoscopy. Often in intersex disorders, the correct diagnosis has already been established with the aid of physical examination, laboratory work-ups, and imaging studies. The role of diagnostic laparoscopy is to confirm the diagnosis and evaluate the internal genitalia, which leads to appropriate surgical planning. On the other hand, therapeutic laparoscopy has a role in several intersex conditions. The intersex conditions for which therapeutic laparoscopy is employed are female and male pseudohermaphroditism, true hermaphroditism, and Turner's syndrome. The indications for therapeutic laparoscopy on these patients are the removal of normal gonads and ductal structures that are contrary to the assigned gender and the removal of dysgenetic gonads that are nonfunctional and that present potential for malignancy. A thorough investigation and evaluation by paediatric gynaecologists, endocrinologists, urologists and geneticists pre-operatively is essential.[18]

Laparoscopic Nephrectomy

Conventional open surgery for diseases of the kidneys in children is very safe. It is usually well tolerated but is associated with postoperative pain and discomfort. Laparoscopic nephrectomy has been suggested to be an effective alternative surgical technique in the management of benign renal diseases. It is associated with significant less post-operative pain, blood loss, lower analgesic requirements and better cosmesis compared to open surgery.[19]

Clayman et al in (1991) introduced laparoscopic nephrectomy in adults.[20] Kavoussi et al reported the first laparoscopic paediatric nephrectomy in 1992.[21] At present, indications for the procedure include benign diseases including multicystic dysplastic kidney, severe pelviureteric junction obstruction, chronic pyelonephritis, hypertension, and renal failure wherein a nephrectomy is warranted.

The advantages of laparoscopic nephrectomy include decreased postoperative pain, improved cosmesis, a short hospital stay with the possibility of performing such procedures on an outpatient basis in select cases. And similar to any other laparoscopic procedure, the operative duration, blood loss and complications for laparoscopic

nephrectomies decrease with increasing experience of the surgeon.

It may be performed in conjunction with other reconstructive procedures. Similar to any other laparoscopic procedure, the operative duration, blood loss and complications for laparoscopic nephrectomies decrease with increasing experience of the surgeon.

There are two approaches to laparoscopic nephrectomy. It may either be a transperitoneal approach or retroperitoneal approach. Initial studies from different centers have reported similar results in terms of operative time and complication. However, there has been a shift towards the retroperitoneal approach.[22] Advantages of retroperitoneal approach include ease of direct kidney access by developing the existing retroperitoneal space; avoidance of the transperitoneal approach with a decreased risk of injury to the intraabdominal organs and the risk of intrabdominal adhesion formation is avoided. Likewise, previous abdominal surgery is not contraindicated. The retroperitoneal approach is also associated with shorter hospital stay and less postoperative analgesic requirement.[23]

Laparoscopic Management of Undescended Testis

Eighty percent (80%) of undescended testes are palpable while the remaining 20% are non-palpable. The non-palpable testis may either be undescended (intraabdominal or intracanalicular), ectopic or absent (vanishing testis, testicular agenesis).[24] With this in mind, the primary goal of diagnostic laparoscopy in undescended testis was initially to verify if a testis was indeed present. And if the testis was present, identify its exact location. The management of undescended testis has changed significantly in the past 10 years. Several modalities have been introduced in an attempt to confirm the presence of the testis like ultrasonography, CT scan or MRI. However, none of these imaging modalities were able to accurately identify the location and presence of an un-descended testis with certainty as compared to laparoscopy.[25] Cortesi and co-workers first described the use of diagnostic laparoscopy in visualising the non-palpable testis in 1976.[26] Upon introduction, diagnostic laparoscopy quickly became the diagnostic approach of choice for paediatric urologists since it provides the information on the existence and location of the testis. Open exploration has been compared with laparoscopy as a diagnostic and localisation modality. In fact, two analysts have suggested that laparoscopy may, in fact, be superior to open exploration.[27]

Several findings can be made on diagnostic laparoscopy, which in turn will be the basis of the surgical approach. First, the normal spermatic vessels and vas may be seen leading to an open or closed internal ring that suggests the presence of a peeping testicle or gonadal structures in the groin. As a result, the inguinal area must be explored either through an open method or by laparoscopy. Another finding on laparoscopy is the presence of an abdominal testis or gonadal structure. Based on the appearance and size of the abdominal testicle and gonadal structure, a decision between orchidectomy or orchidopexy, can be made for the correction of this condition.

Laparoscopic orchidopexy has become a standard procedure in the management of impalpable testes. In a multi-center trial done by Baker et al (2001), the results revealed that a single-stage Fowler Stephen laparoscopic orchidopexy resulted in a significantly higher atrophy rate than the two-stage repair. However, when considering both approaches, the laparoscopic approach gave greater success than previously reported for the same open approaches.[28] The results of laparoscopic orchidopexy are gradually surpassing open surgical exploration as the primary treatment in boys with impalpable testis. It is associated with better surgical outcome with less morbidity. It has also been reported that the success rate for inguinal testis in conventional open orchidopexy is 82% and 74% for the intraabdominal testis as compared to the overall success rate of 96% in laparoscopic orchidopexy.

If blind ending spermatic vessels and vas are identified on laparoscopy with no intervening gonadal structures, no further exploration is required. In rare cases where no obvious gonad or gonadal structure is appreciated, further exploration is warranted to rule out an ectopic testis which maybe anywhere in the abdominal cavity or pelvis.

Laparoscopic Excision of Complicated Prostatic Utricles

The prostatic utricle is an enlarged diverticulum in the posterior urethra. Although most prostatic utricles seldom cause any problems, they usually become symptomatic when they are large or infected. Surgical access to the prostatic utricles has been very difficult because it lies deep within the pelvis. There are several surgical approaches published, which includes abdominal, transvesical, suprapubic, perineal and anterior or posterior transrectal sagittal approach. However, these methods are associated

with prolonged hospital stay, technical difficulty and an increased risk of damage to vital structures such as the pelvic nerves and the external anal sphincter.

The first successful laparoscopic excision of the prostatic utricle was reported on 4 patients in 2001. It offers the advantage of a clear view of the deep pelvic structures, concomitant examination of the rest of the abdomen and urogenital system and good cosmetic results. Likewise it allows complete excision of the prostatic utricle without requiring an incision through the bladder or rectum, thereby reducing complication rate and hospital stay.[29]

Laparoscopy for Urological Neoplasms in Children

There is an abundance of literature on laparoscopy in adult urologic malignancy. However, the role of laparoscopy in managing paediatric urological malignancy has remained highly controversial. This is mainly due to the fears of inadequate access for complete resection, the possibility of malignant seeding, and the concern regarding the histological integrity of the specimens taken.[30]

Most neoplasms reported involve the adrenal gland.[31] This included adrenalectomy for an adrenocortical virilising tumour, adrenocortical, hyperplasia and ganglioneuroma. Laparoscopy was likewise employed in patients with neuroblastoma. Literature reports that in early stage neuroblastoma, laparoscopy was used for excision of the tumour. However in advanced neuroblastoma cases, laparoscopic biopsy was simply done with one report of hemorrhage after the procedure. Early result revealed no significant difference between open and laparoscopic groups in the length of the operation and intraoperative blood loss.

Two studies employed laparoscopic excision of adrenal masses in 7 patients, which turned out to be pheochromocytoma. There was no report of intraoperative complication in both studies.[32,33] Another study reported the use of laparoscopy in conjunction with brachytherapy in a case of Wilms tumour.[34]

Laparoscopic Dismembered Pyeloplasty for Pelvi-ureteric Junction Obstruction

Open Anderson-Hynes pyeloplasty has been widely accepted as the surgical treatment of choice for pelvi-ureteric junction (PUJ) obstruction in children, with a

success rate of >90% in most reports.[35-37] With the advent of laparoscopic techniques, laparoscopic dismembered pyeloplasty through a transperitoneal route has been described in both adults and children with comparable results.[38-41] Schuessler et al[42] described the first successful laparoscopic dismembered pyeloplasty in adults in 1993, whereas Peters et al[39] described the first successful case in a child in 1995. However, the procedure differs from the standard extraperitoneal route for open pyeloplasty and necessitates transgression of the peritoneal cavity with mobilisation of the colon, increasing the risks of visceral injury and subsequent adhesive intestinal obstruction. It does, however, have the advantage of an adequate working space. With further refinements in technique, most pyeloplasties can now be performed laparoscopically via a retroperitoneal approach. Expanding a glove balloon through a 1 cm incision, which is also used as the camera port site, develops the retroperitoneal space. The whole procedure can be performed with another two to three 5 mm working ports in a similar manner to the open technique. A double-J ureteral stent left in-situ at the end of the procedure, which can be removed via cystoscopy 3 to 4 weeks after surgery. Initial and long-term follow-up of these patients showed promising results and is technically feasible.[43] However, for young infants less than 6 months of age with pelvic diameter >50 mm, a transperitoneal approach is still preferable due to the limitation in retroperitoneal space.[44]

Endoscopic Ureteric Reimplantation

Vesicoureteral reflux is a significant clinical problem in children and has been reported to be accountable for 20-50% of children evaluated for urinary tract infections.[45] Reflux nephropathy has also been reported to be a major cause of renal failure in 21% of boys and 25% of girls.[46] Although many of the children can be managed with prophylactic antibiotics until the vesicoureteral reflux resolves with maturation, there are still a number who require surgical treatment.

Over the last few decades, various surgical techniques have been described including cystoscopic subureteric injection of substances such as Teflon and silicone (STING procedure). This has been shown to be a simple and well-tolerated procedure in children.[46] However, results have shown that many require repeated injections especially for high-grade reflux. There were also concerns with migration of the injected materials.[47] This procedure has therefore lost

overall popularity but is still used mainly for low-grade reflux.

Open ureteric reimplant have been described for treatment of vesicoureteral reflux and can be separated into intravesical and extravesical techniques. The Cohen intravesical technique has been very popular with a reported success rate of 96%.[48] However, as this technique involves splitting open the bladder, it is not surprising to find a high association with bladder spasms leading to severe pain and urinary incontinence.[49] The Lich-Gregoir extravesical technique did not require splitting of the bladder and has reported success rates of 90% to 99%[49] but despite this, there were reported concerns regarding postoperative voiding inefficiency.[50,51]

With the advent of laparoscopic surgery, a whole new technique combining the advantages of intravesical reimplantation with minimally invasive surgery has been achieved by creating a pneumovesicum by insufflation of the bladder with carbon dioxide.[52] The bladder is a naturally occurring cavity, which is potentially distensible and is therefore theoretically suitable for insufflation. Pig models have shown that the creation of a carbon dioxide pneumovesicum has insignificant effect on cardio-respiratory function as well as the bladder and renal function.[53] This method boasts the advantages of being wholly endoscopic and extraperitoneal. It only requires one 5 mm camera port, one 5 mm working port and one 3 mm working port. The ureter is mobilised wholly within the bladder and reimplant performed using the Cohen transtrigonal technique. Preliminary results have shown that this is a safe and effective approach with results comparable to the open technique. As the wounds are smaller, patients usually have little complaint of pain and can be discharged within 24 hours after surgery.[52]

Bladder Reconstruction and Bladder Neck Procedures

Management of urinary incontinence in children remains a challenging topic in paediatric urology and involves many aspects of surgery as well as surgical options. Laparoscopy has found its role into bladder reconstructive surgery as well as bladder neck surgery in recent years.

Laparoscopic autoaugmentation, or detrusorrhaphy, is a technique that involves dividing the bladder muscle and dissecting free of the mucosa enabling the development of a large bladder diverticulum. This has been reported in children both performed transperitoneally and

extraperitoneally and has the advantage of not requiring any gastrointestinal segments.[54] However, long-term results have not been consistent. Laparoscopic enterocystoplasty has also been reported in children using stomach or bowel.[54] However, these operations require high laparoscopic skills and still remains in its early development.

With recent advances in laparoscopic surgery and development of the pneumovesical approach, bladder neck reconstruction surgery can be performed without the opening up of bladder. Bladder neck reconstruction can be performed in a similar fashion to the open technique by wrapping the inner bladder mucosa over a urethral stent to elongate the bladder neck. The defect can also be closed effectively from within. This procedure is technically feasible although in its early stages and long-term results are still awaited.[55]

Another option is the laparoscopic bladder neck sling procedure.[55] This is performed laparoscopically via an intraperitoneal, extravesical approach. The bladder is freed from the anterior abdominal wall all the way down to the bladder neck and a synthetic SIS sling is passed round the bladder neck twice. The two ends of the sling are then stapled to the pubic bone with staples. This approach has the advantage of offering a very clear magnified visualisation of the bladder neck deep down in the pelvis enabling careful and meticulous dissection around the bladder base. This eliminates the risk of complications associated with the transvaginal and suprapubic approaches where dissection around the bladder neck is performed without proper vision. However, long-term follow-up is also as yet to be reported.

Laparoscopic Excision of Ureterocele/ Caecoureteroceles

Over the past years, management of ureteroceles especially ectopic ureteroceles with a duplex system and obstructed or refluxing moieties has remained a challenge to paediatric urologists. Many adopt a simple approach with either the use of endoscopic incision of ureterocele alone or combined with a partial nephrectomy. Any bladder level surgery was therefore left alone with the rationale that some may get better or otherwise it could be performed when the child is older. However, many reports have shown unsatisfactory long-term results of these techniques alone with a need for subsequent surgery in 23% of patients with intravesical ureteroceles (70% single system) and 100% of those with extravesical ureteroceles (97% duplex).[56] The

high rate of vesicoureteral reflux post-operatively has also led to many problems. This has therefore swung the pendulum back towards more traditional radical total surgical reconstruction. This involves a one-stage partial nephrectomy along with excision of the ureterocele and ureteric reimplant. A primary success rate of greater than 85% and a complication rate of less than 10% have been reported.[57] One concern with this approach has been the need for two incisions. However, this can now be overcome by performing it laparoscopically in a single setting. With well designed port-sites, the laparosope can be swung from the upper to the lower abdomen allowing the surgeon to operate on both the upper and the lower pathologies in the same setting and has the further advantage of providing a close-up view deep down in the pelvic cavity that may not be easily accessible with traditional open techniques.[58]

Discussion

The benefits brought about by laparoscopic surgery in adults have been widely reported in the literature. There are reduced wound complications, less post-operative pain, shorter hospital stay, better cosmesis and earlier return to normal activities. Some reports have suggested that these advantages are less significant in children as their earlier return to normal activity has less socioeconomic impact.[59] However, we believe that these advantages apply in children just as much as in adults from a parents' perspective. Parents are always concerned on whether their child will suffer any pain after the operation and how big the wounds are, second to whether the operation is necessary. Although laparoscopic surgery may not be far superior to open surgery in performing the same procedure, it does answer to some of the major parental concerns. However, this only applies if the complications brought about by laparoscopic surgery are no more than that reported in open surgery.

There are limited reports regarding the safety of laparoscopy in children and in urological cases. In 1996, Peters et al[59] carried out a survey among American paediatric urologists. Of more than 5400 laparoscopic urological cases surveyed, complications were reported in 5.38% of cases. Complications reported included subcutaneous emphysema and preperitoneal insufflation as well as great vessel lacerations and small bowel injury. However, some practitioners would argue that preperitoneal insufflation and subcutaneous emphysema should not be considered as complications, and excluding these, the complication rate was only 1.18%. There were no deaths

reported. They found comparable complication rates between practitioners performing only diagnostic and those performing operative laparoscopy. They stated that the significant predictors of complications included the experience of the operator and the access technique. The exclusive use of the Veress needle had the highest complication rate. Therefore to minimise the complication rate, supervised training and experience in safe technique of laparoscopic surgery was important.

The number of surgeons performing laparoscopic surgery has been rising over the years. In a 1996 survey, Peters et al[59] found that 75% of paediatric urologists in America were performing laparoscopic surgery. Of these, 100% were performing diagnostic procedures and 48% were performing operative procedures. With the experience gained through diagnostic laparoscopy, it will not be surprising to see more and more laparoscopists moving towards performing more skilled operative procedures.

From the scope of operative surgery now performed, we can appreciate some of the technical advantages of laparoscopic surgery over open surgery in paediatric urological cases. For those who have observed or performed the procedures, there is little argument that the magnified view of deep cavities, such as the pelvis and bladder neck region, is far superior to that seen in open surgery. Not only does this aid the surgeon but greatly benefits the assistants and trainees. With advances in laparoscopic instruments especially in terms of size, maneuverability and variety, the laparoscope can often reach deep and small cavities with more ease than the surgeon's hands. As the array of the surgical instruments continues to evolve, new and innovative laparoscopic procedures will continue to become increasingly available. The ability to provide surgical care in association with either outpatient or short stay appears to be cost effective and appropriate state-of-the art medical care.

Summary

Innovative, minimally invasive procedures have been a cornerstone of urology since the first use of a cystoscope. Due to recent advances in instrumentation and laparoscopic research, a wider array of urologic procedures is now being performed routinely in paediatric population. In the hands of experienced laparoscopic surgeons, it is a safe and feasible option offering distinct advantages over traditional open techniques. With the clear advantages associated with the MIS approach, there is little doubt that most traditional

open paediatric urological procedures will soon be replaced by the laparoscopic technique in the near the future, and it will very quickly become ethically hard to justify not to do so. Paediatric urologists should therefore embrace these new advances for the benefits of our young patients.

References

1. Najmaldin A. Minimal access surgery in paediatrics. Arch Dis Child 1995;72:107-9.
2. Hopkins HH. On the diffraction theory of optical images. Proceedings of the Royal Society of London 1953;A217:408-32.
3. Gans SL, Berci G. Advances in endoscopy of infants and children. J Pediatr Surg 1971;6:199-233.
4. Holcomb GW 3rd, Olsen DO, Sharp KW. Laparoscopic cholecystectomy in the pediatric patient. J Pediatr Surg 1991;26:1186-90.
5. Rothenberg SS. Experience with 220 consecutive laparoscopic Nissen fundoplications in infants and children. J Pediatr Surg 1998;33:274-8.
6. Georgeson KE, Fuenfer MM, Hardin WD. Primary laparoscopic pull-through for Hirschsprung's disease in infants and children. J Pediatr Surg 1995;30:1017-22.
7. Steeno O, Knops J, Declerck L, Adimoelja A, van de Voorde H. Prevention of fertility disorders by detection and treatment of varicocele at school and college age. Andrologia 1976;8:47-53.
8. Schneck FX, Bellinger MF. Abnormalities of the Testes and Scrotum and their Surgical Management. In: Walsh PC, Retik AB (ed). Campbell's Urology 8th ed. Vol 3. 2002 Elsevier. pp. 3695-3697.
9. Casciola L, Ceccarelli G, Mazzoli W, et al. Varicocele. Ligation of the internal spermatic vein using laparoscopic approach. Minerva Chir 1998;53:153-61.
10. Kass EJ. The adolescent varicocele: treatment and outcome. Curr Urol Rep 2002;3:100-6.
11. Kass EJ, Stork BR, Steinert BW. Varicocele in adolescence induces left and right testicular volume loss. BJU Int 2001;87:499-501.
12. Matsuda T. Laparoscopic treatment for varicocele testis: Current Status. In Yoshida O, Higashihara S, Ohshima S, Matsuda T (eds): Urologic Laparoscopy; Tokyo Springer-Verlag, 1999.
13. Kwon ED, Sandlow JI, Donovan JF. Varix ligation. In Smith AD, Badlani GH, Bagley DH, et al (editors): Smith's Textbook of Endourology, vol 2. St. Louis, Quality Medical, 1996, pp 894-903.
14. Jarow JP, Assimos DG, Pittaway DE. Effectiveness of laparoscopic varicocelectomy. Urology 1993;42:544-7.
15. Peters CA, Kavoussi LR: Laparoscopy in children and adults. In Walsh PC, Retik AB, Vaughan ED, et al (editors): Campbell's Urology, 7th ed. Philadelphia, WB Saunders, 1998, pp 2875.
16. Denes F, Mendonc B, Costa E, et al. The role of diagnostic and therapeutic laparoscopy in intersex patients. J Endourol 1998.
17. Docimo SG, Peters CA. Pediatric Endourology and Laparoscopy. In: Walsh PC, Retik AB (eds.). Campbell's Urology 8th ed, Vol. 3, 2002, Elsevier, pp 2574-2575.
18. Denes FT, Mendonca BB, Arap S. Laparoscopic management of intersexual states. Urol Clin North Am 2001;28:31-42.
19. Abbou CC, Cicco A, Gasman D, et al. Retroperitoneal laparoscopic versus open radical nephrectomy. J Urol 1999;161:1776-80.
20. Clayman RV, Kavoussi LR, Figenshau RS, Chandhoke PS, Albala DM. Laparoscopic nephroureterectomy: initial clinical case report. J Laparoendosc Surg 1991;1:343-9.
21. Yao D, Poppas DP. A clinical series of laparoscopic nephrectomy, nephroureterectomy and heminephroureterectomy in the pediatric population. J Urol 2000;163:1531-5.
22. Borer JG, Cisek LJ, Atala A, Diamond DA, Retik AB, Peters CA. Pediatric retroperitoneoscopic nephrectomy using 2 mm. instrumentation. J Urol 1999;162:1725-30.
23. El-Ghoneimi A, Valla JS, Steyaert H, Aigrain Y. Laparoscopic renal surgery via a retroperitoneal approach in children. J Urol 1998;160(3 Pt 2):1138-41.
24. Bloom DA, Semm K. Advances in genitourinary laparoscopy. Adv Urology 1991;4:167-82.
25. Docimo SG, Peters CA. Pediatric Endourology and Laparoscopy. In: Walsh PC, Retik AB (eds). Campbell's Urology 8th ed, Vol 3, 2002, Elsevier, pp 2571-2572.
26. Cortesi N, Ferrari P, Zambarda E, Manenti A, Baldini A, Morano FP. Diagnosis of bilateral abdominal cryptorchidism by laparoscopy. Endoscopy 1976;8:33-4.
27. Jordan GH. Laparoscopic management of the undescended testicle. Urol Clin North Am 2001;28:23-9.
28. Baker LA, Docimo SG, Surer I, et al. A multi-institutional analysis of laparoscopic orchidopexy. BJU Int 2001;87:484-9.
29. Yeung CK, Sihoe JD, Tam YH, Lee KH. Laparoscopic excision of prostatic utricles in children. BJU Int 2001;87:505-8.
30. Steinbrecher HA, Najmaldin AS. Endoscopic surgery in paediatric oncology. In: Bax NMA, Georgeson KE, Najmaldin A, Valla JS (eds). Endoscopic surgery in Children. Springer 1999, p. 465.
31. Tobias-Machado M, Cartum J, Santos-Machado TM, et al. Retroperitoneoscopic adrenalectomy in an infant with adrenocortical virilizing tumor. Sao Paulo Med J 2002;120:87-9.
32. Mirallie E, Leclair MD, de Lagausie P, et al. Laparoscopic adrenalectomy in children. Surg Endosc. 2001;15:156-60.
33. Castilho LN, Castillo OA, Denes FT, Mitre AI, Arap S. Laparoscopic adrenal surgery in children. J Urol 2002;168:221-4.
34. McManus MC, Silliman C, Koyle MA. Combined endoscopic resection and brachytherapy for recurrent intrapelvic Wilms tumor. J Urol 2002;167:2540.
35. Mikkelsen SS, Rasmussen BS, Jensen TM, Hanghoj-Petersen W, Christensen PO. Long-term follow-up of patients with hydronephrosis treated by Anderson-Hynes pyeloplasty. Br J Urol 1992;70:121-4.
36. Clark WR, Malek RS. Ureteropelvic junction obstruction. I. Observations on the classic type in adults. J Urol 1987;138:276-9.
37. Nguyen DH, Aliabadi H, Ercole CJ, Gonzalez R. Nonintubated Anderson-Hynes repair of ureteropelvic junction obstruction in 60 patients. J Urol 1989;142:704-6.
38. Bauer JJ, Bishoff JT, Moore RG, Chen RN, Iverson AJ, Kavoussi LR. Laparoscopic versus open pyeloplasty: assessment of objective and subjective outcome. J Urol 1999;162(3 Pt 1):692-5.

39. Peters CA, Schlussel RN, Retik AB. Pediatric laparoscopic dismembered pyeloplasty. J Urol 1995;153:1962-5.
40. Schier F. Laparoscopic Anderson-Hynes pyeloplasty in children. Pediatr Surg Int 1998;13:497-500.
41. Tan HL, Roberts JP. Laparoscopic dismembered pyeloplasty in children: preliminary results. Br J Urol 1996;77:909-13.
42. Schuessler WW, Grune MT, Tecuanhuey LV, Preminger GM. Laparoscopic dismembered pyeloplasty. J Urol 1993;150:1795-9.
43. Yeung CK, Tam YH, Sihoe JD, Lee KH, Liu KW. Retroperitoneoscopic dismembered pyeloplasty for pelvi-ureteric junction obstruction in infants and children. BJU Int 2001;87:509-13.
44. Yeung CK, Sihoe JDY, Olsen H, et al. Long-term follow-up on retroperitoneoscopic dismembered pyeloplasty for UPJ obstruction in infants and children. Proceedings of the 4th International Children Continence Society (ICCS) & Asia-Pacific Association of Pediatric Urologists (APAPU) Joint Meeting Dec 2002.
45. McDougall EM, Urban DA, Kerbl K, et al. Laparoscopic repair of vesicoureteral reflux utilizing the Lich-Gregoir technique in the pig model. J Urol 1995;153:497-500.
46. Puri P, Granata C. Multicenter survey of endoscopic treatment of vesicoureteral reflux using polytetrafluoroethylene. J Urol 1998;160(3 Pt 2):1007-11.
47. Aaronson IA, Rames RA, Greene WB, Walsh LG, Hasal UA, Garen PD. Endoscopic treatment of reflux: migration of Teflon to the lungs and brain. Eur Urol 1993;23:394-9.
48. McCool AC, Joseph DB. Postoperative hospitalization of children undergoing cross-trigonal ureteroneocystostomy. J Urol 1995;154(2 Pt 2):794-6.
49. Marotte JB, Smith DP. Extravesical ureteral reimplantations for the correction of primary reflux can be done as outpatient procedures. J Urol 2001;165(6 Pt 2):2228-31.
50. Fung LC, McLorie GA, Jain U, Khoury AE, Churchill BM. Voiding efficiency after ureteral reimplantation: a comparison of extravesical and intravesical techniques. J Urol 1995;153:1972-5.
51. Lipski BA, Mitchell ME, Burns MW. Voiding dysfunction after bilateral extravesical ureteral reimplantation. J Urol 1998;159:1019-21.
52. Yeung CK, Borzi PA, Sihoe JDY, Tam YH, Lee KH. Transvesicoscopic Cohen's ureteric reimplantation for dilating vesicoureteral reflux under carbon dioxide pneumovesicum: A novel technique. J Endourol (In press).
53. Yeung CK, Wang QH, Manson WG, To LKC, Karmakar M, Aun C. Physiological responses to carbon dioxide insufflation of the bladder with refluxing and non-refluxing ureters. BJUI (In press).
54. Milsom JW, Bohm B. Major operative procedures in laparoscopic colorectal surgery. In Milsom JW, Bohm B (Eds): Laparoscopic Colorectal Surgery. New York, Springer-Verlag, 1996, pp 122-123.
55. Yeung CK, Sihoe JDY. Laparoscopic Bladder Neck Reconstruction. In "Endoscopic Surgery in Children". Springer (eds): Bax NMA, Georgeson KE, Rothenberg SS, Valla J, Yeung CK (In press).
56. Shekarriz B, Upadhyay J, Fleming P, Gonzalez R, Barthold JS. Long-term outcome based on the initial surgical approach to ureterocele. J Urol 1999;162(3 Pt 2):1072-6.
57. Coplen DE, Barthold JS. Controversies in the management of ectopic ureteroceles. Urology 2000;56:665-8.
58. Yeung CK, Tam YH, Manson WG, Sihoe JDY, Lee KH. One-stage laparoscopic hemi-nephroureterectomy with excision of ureterocele and ureteric reimplantation for duplex kidneys with non-functioning upper moieties and complicating ectopic ureteroceles. BJUI (In press).
59. Peters CA. Complications in pediatric urological laparoscopy: results of a survey. J Urol 1996;155:1070-3.