Focus

The development of laparoscopy and its application to pelvic floor repair

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Abstract: We present a brief overview of how laparoscopy evolved from a purely diagnostic to a therapeutic procedure. Emphasis is given to the many innovative developments that led to its application to correct pelvic floor dysfunction with its range of anterior, apical and posterior defects. It may serve to reflect on how current methods and techniques can still be improved to deal with pelvic problems that are likely to become more prevalent as our population ages.

Key words: History; Laparoscopy; Laser; Pelvic Floor Repair; Operative laparoscopy; Videolaparoscopy.

INTRODUCTION

Although attempts to visualize the viscera "per vias naturales" date back to Hippocratic times,[1] recorded attempts to do so transabdominally, named ventroscopy by von Ott in 1901, coelioscopy by Kelling in 1902, and laparoscopy by Jacobeus in 1911, only started in the last century.[2] Innovative as these approaches were, it took a great deal of ingenuity from several people to develop the instruments and techniques that have given laparoscopy the diagnostic and therapeutic scope that it has today.

In this paper we briefly mention these early developments before tracing the innovations that led to the use of laparoscopy for the treatment of pelvic organ prolapse, an approach that might seem to be counter-intuitive at first sight.

The ebb and flow of early laparoscopy

Much of the early developments in laparoscopy as they relate to gynaecology have been well documented[1-4] and the main innovations made in the first half of the last century are briefly summarized in Table 1. They came somewhat to a standstill in the 1940s, as culdoscopy (endoscopy via the posterior vaginal fornix) surged in popularity, especially in the USA where it found a great advocate in Te Linde.[2] Pelvic organ visualization with the culdoscope was limited, though, until Decker described the knee-shoulder position in 1946. [2]

After World War Two, resurgence in gynaecological laparoscopy was led by Frangenheim in Germany and Palmer in France, from where it spread to the English-speaking world. Its resurgence was facilitated by important innovations. In 1943, Fourestier and colleagues, in Paris, had introduced the cold light source, which overcame the need for and dangers of a hot light bulb at the end of the scope.[2] In 1953, Hopkins introduced the rod lens system which improved visual clarity, the angle of vision, and the depth of field.[2] In the early 1950s, Frangenheim designed laparoscopic instruments and made the first purpose-built CO_2 insufflator.[4] He also popularized tubal cautery, as did Palmer, who wrote extensively on gynaecologic laparoscopy and described the use of the Palmer forceps, which is still in use today. Steptoe wrote the first English monograph on laparoscopy in 1967.[5]

Monopolar, bipolar and beyond

Monopolar diathermy was introduced in the early 1950s for tubal sterilisation.[3] Strangely enough, complications from burns did not lead to safer alternatives for many years. They only came with the development of bipolar coagulation by Frangenheim in Germany [4]and Rioux and Cloutier in Canada[6] and with the introduction of the even safer thermocoagulation by Semm in Germany.[7] Eventually, mechanical occlusion methods emerged for tubal sterilisation which totally eliminated electrosurgical risks. The best-known of these is the Filshie clip, first reported in 1981 and still in use today.[8]

In the meantime, thermocoagulation and the development of the endosuture developed in 1977, led Semm to develop new instruments and techniques which widened the range of operative procedures.[9] These now included ablation of endometriosis, adhesiolysis, adnexectomy, myomectomy, ovarian cystectomy, and salpingotomy for ectopic pregnancy as well as appendicectomy.[9]

The veni, vidi, vici of videolaparoscopy

In the mid-1980s, the development of the modern chip camera and closed circuit television allowed through-the-lens viewing to be replaced by video monitoring. These advances came to fruition in the practice of videolaparoscopy, which was popularized by Nezhat[10] and rapidly replaced naked eye laparoscopy by the early 1990s.

Videolaparoscopy avoided the operator's back-breaking posture of lateral flexion that was needed to peer down the laparoscope and which inevitably limited the duration of laparoscopic procedures. It had other major advantages. The camera could be held by an assistant permitting the surgeon to operate with both hands, an essential prerequisite for the development of laparoscopic suturing and prolapse repair. Everyone in the operating theatre could view the procedure facilitating a team approach and better teaching. Surgery could be recorded on video tape and used as a permanent record. New techniques could easily be shown to colleagues. This helped to spawn the formation of multiple societies of gynaecological endoscopy around the world, including the Australian Gynaecological Endoscopy Society (AGES) in 1990.

Videolaparoscopy also had many advantages over laparotomy. It magnified pelvic and abdominal anatomy enabling microsurgical procedures. The pneumoperitoneum improved microvascular haemostasis, giving a dryer and cleaner operating field. Surgical access and visualization were better in areas that were difficult to reach with open surgery, such as the pouch of Douglas and the posterior leaf of the broad ligament. For the patients, operative laparoscopy gave a better cosmetic result, less postoperative pain, a shorter convalescence, and it caused fewer adhesions than open surgery.

Rise and fall of laser laparoscopy

In 1973, Kaplan introduced the carbon dioxide (CO_2) laser into gynaecology for the treatment of cervical dysplasia.[11] By 1979, Bruhat in France had applied the CO_2 laser to laparoscopic surgery.[2] The term videolaseroscopy was coined by Nezhat and referred to laser laparoscopy with video monitoring .[10] Nezhat and Daniell[12] popularized it in the English-speaking world. In the mid-1980s, the CO_2 laser became widely adopted following a common pattern from treating dysplasia of the lower genital tract to laser laparoscopy. The adaptation of the CO_2 laser to laparoscopy required several innovations in equipment and operating technique: an articulated optical arm to deliver the laser beam from its generator to the operating laparoscope or laser probe; a laser hand piece that was leak-proof and accepted CO_2 to keep the lens free of debris; the addition of a helium-neon sighting laser to add a coloured light to the invisible CO_2 beam; the development of a smoke evacuation system whilst simultaneously maintaining the pneumoperitoneum; and the use of an instrument or fluid to absorb stray energy. Laser laparoscopy was used to vaporize endometriosis, separate pelvic adhesions, and treat tubal pregnancy by linear salpingotomy.[2]

In the 1970s and 1980s, microsurgical instruments were adapted to laparoscopy and used to perform benign adnexal surgery with diathermy or endocoagulation as energy sources.[2] These electrosurgical instruments were easier to use and less expensive than laser laparoscopy. Their uptake was so rapid that laser laparoscopy was superseded within a decade of its development. It earned laser the reputation of being 'technology in search of work.'

Learning from ectopic pregnancies

During the 1980s early diagnosis of tubal ectopic pregnancy was greatly facilitated by sensitive and rapid assays for human chorionic gonadotrophin and improvements in the availability and quality of gynaecological ultrasound. Developments in laparoscopic techniques followed pace and resulted in open salpingectomy and salpingotomy being replaced by their laparoscopic equivalents. These included use of the Endoloop® (Ethicon, Endo-Surgery, Inc.), a precursor to the development of slip knots which are now commonly used in laparoscopic prolapse surgery. The application of laser laparoscopy and electrosurgery to the treatment of ectopic pregnancy taught gynaecologists many important lessons that were relevant to laparoscopic pelvic floor repair later on. Perhaps the key lesson was that minimally-invasive surgery should strive to be technically and technologically simple and inexpensive.

This was best exemplified in the Triton (Microfrance), an instrument designed for the treatment of ectopic pregnancy by salpingostomy. The 7 mm wide shaft of the Triton incorporated three elements: a retractable monopolar needle for salpingostomy, an irrigation channel to loosen the ectopic by aqua-dissection, and a suction channel to extract it. At one French centre, the average time taken to remove an ectopic with the Triton was an impressive 8 minutes.[13]

The emergence of new procedures

The 1980s heralded the arrival of several advanced laparoscopic procedures. Starting from laparoscopically directed appendicectomy and laparoscopic cholecystectomy the range of procedures in general surgery rapidly expanded to include hernia repair, vagotomy, and bowel resection.

In gynaecology, the treatment of endometriosis progressed from coagulation to excision and, in 1989, Reich and colleagues in the USA published their landmark paper on laparoscopic hysterectomy.[14] In the same year Reich presented the technique at the first world congress of gynaecologic endoscopy in France. Despite creating a sense of incredulity in the audience, his technique was adopted rapidly and the first such procedure was performed in our unit in 1991.

TABLE 1. – Main laparoscopic innovations in the first half of the 20th century.[1-4] .

Year	Principal innovator	Innovation
1912	Jacobeus	first laparoscopy in humans
1912	Nordentoeft	trocar laparoscope
1924	Zollikofer	CO_2 insuffflator
1933	Fervers	first operative laparocopy (adhesiolysis)
1934	Ruddock	first laparoscopic female sterilisation
1937	Hope	diagnosis of ectopic pregnancy by laparoscopy
1938	Veress	Veress needle
1943	Fourestier	cold light source

A plethora of techniques for laparoscopic hysterectomy ensued around the globe leading Garry, Reich and Liu to formulate a simple classification system.[15] This categorized procedures as laparoscopically assisted vaginal hysterectomy (LAVH) if the uterine vessels were ligated vaginally, laparoscopic hysterectomy (LH) if they were secured laparoscopically, laparoscopic supracervical or subtotal hysterectomy (LSH) if the cervix was preserved, and total laparoscopic hysterectomy (TLH) if the entire procedure, including vault closure, was done laparoscopically.

The transition from the hybrid procedure of laparoscopically assisted vaginal hysterectomy to the pure total laparoscopic hysterectomy was greatly facilitated by the development of vaginal fornix presenters and safer energy sources, such as the harmonic scalpel,[16] which had less lateral thermal spread than diathermy. The prime Australian example of a vaginal fornix presenter is the tube developed by McCartney.[17] This simplified the colpotomy procedure, reduced the risk of injury to surrounding structures, and preserved the pneumoperitoneum during colpotomy, specimen removal and vault closure. McCartney's tube was later used to facilitate excision of the enterocoele sac during laparoscopic pelvic floor repair.

The impact of laparoscopic hysterectomy on gynaecological surgery was far-reaching. Reich's main aim of reducing the proportion of hysterectomies that required open surgery was never fully achieved. However, laparoscopically assisted vaginal hysterectomy had the spin-off of improving vaginal operating skills and total laparoscopic hysterectomy became important for acquiring laparoscopic skills in pelvic dissection, haemostasis and suturing, all of which were essential prerequisites for laparoscopic pelvic floor repair.

Laparoscopic suturing widens the surgical spectrum

Significant advances in laparoscopic suturing occurred during the last three decades of the 20th century. In the 1990s these facilitated the development of techniques for pelvic floor repair, total laparoscopic hysterectomy and the treatment of operative complications, such as bowel and urinary tract injury. These techniques maintained the pneumoperitoneum by the development of novel suturing equipment and ports, direct and indirect (back-loading) methods of needle and suture introduction, and various knot-tying techniques. The latter included intracorporeal knot tying, the use of extracorporeal slip knots, and extracorporeal knot tying using knot pushers.[18]

The first report of laparoscopic pelvic floor repair came from an Italian group in 1986 which published on laparoscopic uterosacral hysteropexy.[19] In 1991, Vancaillie and

Schuessler reported laparoscopic bladder neck suspension.[20] Anatomically, the technique described was closer to a Marshall Marchetti Kranz procedure than to a Burch colposuspension. The treatment of vaginal vault prolapse by laparoscopic sacral colpopexy was first performed by Wattiez et al. in 1991.[21] In 1996, Ostrzenski published on laparoscopic colposuspension for the treatment of total vaginal prolapse,[22] and a year later Richardson, Saye and Miklos reported the first laparoscopic repair of paravaginal defects.[23] In 1997, Rosen and Lam[24] described a suturing technique for enterocoele repair which was widely adopted in Australasia.

A new century of continence surgery and pelvic floor repair

In the current millennium, there has been a strong trend to abandon Burch colposuspension in favour of synthetic mid-urethral slings for the treatment of urodynamic stress incontinence from urethral hypermobility.[25] There is also a tendency, albeit less pronounced, to replace traditional vaginal and laparoscopic repair by transvaginal pelvic floor repair augmented by grafts or mesh, especially for recurrent prolapse.[26, 27] In units with a laparoscopic interest, mesh sacral colpopexy is emerging as the most popular laparoscopic prolapse repair procedure.[28] These trends have been facilitated by improvements in laparoscopic suturing instruments, suture materials, and screw applicators, as well as the development of a variety of tapes, meshes, grafts and mesh-kits specifically designed for incontinence and prolapse surgery.

Currently, the laparoscopic pelvic floor surgeon has a wide range of procedures and techniques to choose from.[29] In the anterior compartment laparoscopic paravaginal repair is a good native tissue alternative to colporrhaphy for primary cystocoele repair.[30] Apical support failure is effectively addressed by laparoscopic uterosacral suspension with or without uterine preservation.[31] Combined apical and posterior defects can be treated by laparoscopic supralevator repair or mesh sacral colpopexy. [32]

Living through history

In our hospital, which opened in 1976, developments have followed trends seen elsewhere. In the first decade, the range of procedures was limited to diagnostic laparoscopy, ovarian cyst aspiration, diathermy of endometriosis, and tubal sterilization using fallope rings or Filshie clips. By the late 1980s, clinical trials were conducted on the treatment of unruptured tubal ectopic pregnancy using intralesional methotrexate and laser salpingostomy.[33, 34] By the mid-1990s, virtually all benign adnexal surgery was performed laparoscopically with simple instruments and electrosurgery. At the same time, laparoscopic hysterectomy and Burch colposuspension were introduced.[35, 36] By the late 1990s, total laparoscopic hysterectomy had replaced laparoscopically assisted vaginal hysterectomy and laparoscopic entry techniques were expanded.[37, 38] Concurrently, improvements in suturing instruments, extracorporeal knottying and growing experience resulted in shorter operating times, lower rates of accidental injury and fewer conversions to open surgery. Dedicated endogynaecology and urogynaecology units were established, which offer one year fellowships and yearly organize a two-day training course on laparoscopic suturing and ad hoc advanced skills symposia to learn from developments, evidence and experiences elsewhere.

From the past to the future

The prehistory of endoscopy took about 20 centuries characterised mainly by an absence of noteworthy developments. Its proper history took only one century, but it was exciting and eventful, shaped by many people with vision and ideas who laid the foundations of where we stand today. What was considered key-hole surgery at one time no longer requires an eye glued to the lens. Everyone can view and learn from what is seen through the key-hole. Inevitably, the better everything can be seen by different eyes, the more likely this will inspire a continuation of innovative thoughts that have shaped laparoscopic surgery thus far. A reassessment of pelvic floor surgery 10 years on may look very different from what it is today. We must always strive to ensure, though, that what is new is also better.

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