

## Laparoscopic General Surgery – The Journey So Far

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**Abstract**

**Background:** Laparoscopic surgery has evolved in a relatively short time to become a popular and integral part of the surgical armamentarium. An overview of developments which have taken place since its inception is presented.

**Methods:** The PubMed database was searched for all English language literature. Further references were obtained through cross-referencing the bibliography cited in each work and using books from the authors' collection.

**Conclusion:** Laparoscopic surgery has developed rapidly, initially from a basically diagnostic procedure to a therapeutic one which is currently challenging time-honoured traditional methods of surgery. Technological advancements and enthusiasm as well as the desire for scar less surgery appear to be poised to push even further the frontiers of this discipline.

**Keywords:** Laparoscopic surgery, laparoscopy

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Laparoscopy (Greek: lapara, the flank; skopein, to view) describes a surgical technique that allows access to the abdomen through small incisions to diagnose and treat abdominal disease<sup>1</sup>. The routine procedure of examining body cavities was over a century ago, a feat which had not been achieved. The specialized instruments available today had not been developed. Illuminating body cavities was a major obstacle. Philip Bonzzini, a German, built the *Lichtleiter*, an instrument with illumination for examining a cavity. Antoine Jean Desormeaux, a French, used a lamp with alcohol and turpentine fuel for illumination of genitourinary tract. The Russian Dimitri Oskarovich Ott using a speculum and a head mirror first examined the abdominal cavity through a posterior vaginal incision and called it *ventroscopy*.

George Kelling a German, using a cystoscope with pneumoperitoneum in a dog however is credited as performing the first true laparoscopy calling his procedure *coelioscopy*<sup>2</sup>. By 1910 Hans Christian Jacobaeus, a Swede internist, had performed the procedure on 17 patients and coined the term laparoscopy<sup>3, 4</sup>. In 1911 Bertram M. Bernheim performed the first laparoscopy in United States using a 1.2cm proctoscope and called the procedure *organoscopy*. Orndoff in 1920 designed the pyramidal sharp tip trocars that facilitated access into abdominal cavity. Zollikofer, a Swiss gynaecologist introduced carbon dioxide as insufflating agent because of its relatively fast absorption and non support of combustion in 1924. In 1938 a Hungarian physician Janos Veress introduced a spring loaded blunt tip needle with a sharp edge for inducing pneumothorax in treatment of tuberculosis. The needle which now bears his name was recognized as an effective means of inducing pneumoperitoneum. The major applications of laparoscopy to this point were diagnostic.

Fervers a gynaecologist performed laparoscopic adhesiolysis in 1933, while another Swiss Boesch performed the first laparoscopic tubal sterilization procedure in 1936. Professor Harold Hopkins developed the rigid rod lens system that improved significantly vision with the scope. The light source was also removed from the tip reducing the incidence of burns. Kurt Semm, a German gynaecologist in 1960 invented an automatic CO<sub>2</sub> insufflator, he also provided several other devices including endoloop, suction-irrigation devices, tissue morcellators and a training device. In 1983, he performed the first laparoscopic appendectomy.

It is interesting to note that general surgeons were not innovators in the design and initial development of laparoscopic surgery.

This perhaps was due to the essential conservatism of surgeons, and also laparoscopic surgery at this time was cumbersome requiring that the surgeon hold and peer into the laparoscope with one hand while performing the surgery with the other. The assistant was unable to see and anticipate the surgeon during the procedure. The German Erich Muhe performed the first laparoscopic cholecystectomy under these conditions in 1985. With the development of the computer chip video camera images could now be shown on a monitor, documented and training done. In 1987 Phillippe Mouret, a French performed the first video-assisted laparoscopic cholecystectomy in Lyons, France<sup>4</sup>. This resulted in a surgical revolution with performance of many laparoscopic cholecystectomies and within 7 years after it was first performed had become the procedure of choice for uncomplicated cholelithiasis<sup>5</sup>.

In 1994 the automated endoscopic system for optimal positioning (AESOP), the first robot for use in clinical surgery was approved by the Food and Drug Administration (FDA) as a robotic camera holder. Then the Zeus surgical system with hand like motions was invented but limited by the FDA to surgical assistant<sup>6</sup>. The da Vinci robotic system was approved in 2000 for intra-abdominal surgery, and by 2004 prostatectomy was a commonly performed robotic procedure<sup>7</sup>.

Advantages of laparoscopic surgery for the patient include reduced blood loss, less pain and discomfort because of the small incisions<sup>8</sup>. Thus analgesic and blood transfusion-related complications are lower. Wound related complications such as cellulitis, infection, dehiscence and incisional hernia are also lower<sup>9</sup>. Postoperative adhesions may be reduced because operation is performed within the body cavity reducing desiccation rough handling and retraction common in open surgery. These reduce metabolic response to trauma and encourage early mobilization resulting in reduced muscle atrophy and bone loss, reduced risk of chest infection and deep vein thrombosis. Patient's self image is also better because of the smaller scars. For the surgeon the advantages are less obvious. Certainly there is less risk of transmission of infection from patient to surgeon due to reduced direct contact<sup>8</sup>.

The magnified image may provide clarity not common in open surgery.

The disadvantages for the patient are the increased risk of specific complications associated with laparoscopic surgery e.g. common bile duct injury in laparoscopic cholecystectomy. Limitations for the surgeon include the 2-dimensional images that lack depth cues and affect perceptual judgement of anatomic structures. The camera operator determines the focus tilt and stability of the image and may follow the natural eye movements of the surgeon<sup>1,10</sup>. The smaller visual field compared to open surgery requires special mental and physical skills<sup>11</sup>. Restricted movements of instruments in trocars on the anterior abdominal wall result in poor ergonomics for the surgeon and assistant. This leads to uncomfortable working positions with resultant fatigue and occasionally, neuropraxia<sup>12,13,14</sup>. Initial learning curve is steep and discourages some established surgeons from acquiring the skill<sup>15</sup>. Laparoscopic procedures are also slower than open ones and there is loss of tactile feedback.

The indications for laparoscopic surgery continue to expand; most open surgeries now have laparoscopic versions and others can be 'laparoscopically assisted'. Now laparoscopic surgery is performed in virtually every area of surgery and specialty. From performance of only diagnostic procedures, it has expanded to involve therapeutic laparoscopic surgery which are now the main indications in general surgery. This rapid development is demonstrated by 2 articles 20 years apart describing indications of laparoscopy in general surgery at the time (table i)<sup>1, 3</sup>. Note that general surgery laparoscopy in 1974 was diagnostic. The anecdotal surgeries are established now.

Contraindications have decreased or become more relative as laparoscopic surgery developed. Current contraindications are shown in table III<sup>1</sup>.

**Table I: comparison of indications for laparoscopy in general surgery in 1974 and 1994**

Gomel 1974 <sup>3</sup>	Soper and Jones 1994 <sup>1</sup>
Diagnosis of abdominal trauma especially in polytrauma patients	<b>Accepted:</b> Diagnostic laparoscopy Laparoscopic cholecystectomy
Acute abdomen	
Suspected appendicitis	<b>Gaining Acceptance:</b> Appendectomy
Pancreatitis	Exploration of common bile duct
Intraperitoneal carcinomatosis and tuberculosis	Repair of inguinal hernia
Unclear hepatobiliary conditions	Resection of colon
Chronic liver disease and liver tumours	Operations for gastroesophageal reflux Operations for peptic ulcer disease
	<b>Anecdotal Experience:</b> Splenectomy Adrenalectomy Gastrojejunostomy Cholecystoenterostomy Pancreatic resection

Common general surgeries performed laparoscopically are shown in table II.

**Table II Common laparoscopic general surgery procedures**

Therapeutic	Diagnostic
1. Cholecystectomy	1. Intra-abdominal trauma
2. Appendectomy	2. Acute abdomen
3. Hernia repair	3. Staging of malignancy
4. Splenectomy	
5. Cardiomyotomy	
6. Fundoplication	
7. Oesophagectomy	
8. Peptic ulcer surgeries	
9. Colorectal surgeries	
10. Pancreatic surgeries	
11. Enterostomies	
12. Hepatic resection	
13. Bariatric surgeries	

**Table III: contraindications to laparoscopic surgery<sup>1</sup>**

<b>Absolute:</b>	<p>Uncorrected coagulopathy</p> <p>Poor risk for general anesthesia</p> <p>Inability to tolerate a laparotomy</p>
<b>Relative:</b>	<p>Prior abdominal surgery</p> <p>Peritonitis; previous or acute</p> <p>Obesity</p> <p>Pregnancy</p> <p>Unreducible abdominal/inguinal hernia</p> <p>Umbilical abnormalities</p> <p>Abdominal aortic/iliac aneurysm</p> <p>Severe pulmonary disease</p> <p>Intestinal obstruction</p>

Laparoscopy for trauma had been proposed by Estes in 1942<sup>16</sup> but was uncommon probably due to the cumbersome instruments of the time. Studies have shown that laparoscopy is useful in evaluating abdominal trauma<sup>17, 18, 19</sup>, and can be a confirmatory investigation for traumatic diaphragmatic hernia<sup>20</sup>. However a recent analysis of laparoscopy in trauma shows that it is an excellent screening tool for stable patients after acute trauma, but is limited as a diagnostic tool because of the large number of injuries missed and its therapeutic role in trauma is inconclusive<sup>21</sup>.

Although abdominal ultrasound scan, CT and MRI currently are used extensively to investigate intra-abdominal lesions due to their non invasiveness, laparoscopy is also useful. While these imaging investigations may miss lesions less than 1-2cm, laparoscopy may detect lesions of 1mm on peritoneal surfaces and can aid more accurate biopsy<sup>22</sup>. Combined with laparoscopic ultrasound it is helpful in evaluating solid viscera like the liver for metastasis<sup>23</sup>.

Laparoscopic cholecystectomy is the commonest laparoscopic procedure performed by general surgeons worldwide and 98% of all cholecystectomies performed in Europe and America are laparoscopic<sup>24</sup>. It is now the treatment of choice of symptomatic gall stones<sup>25</sup>.

Patients have less pain, reduced hospital stay and return to work early<sup>26, 27, 28</sup>. However there is a higher risk of common bile duct injury<sup>29-33</sup>. Common bile duct exploration via intraoperative cholangiogram or laparoscopic ultrasound with retrieval of stones can also be performed.

The role of laparoscopy in the evaluation of young women of childbearing age with right iliac fossa pain was established relatively early by studies done in 1980<sup>34</sup>. Before videolaparoscopy, appendicectomy by necessity was laparoscopic-assisted, where the surgery was done after the inflamed appendix was visualized, by making a small incision on the anterior abdominal wall over it. The results of laparoscopic appendicectomy from studies are good<sup>35,36</sup> though mere visualization of the appendix is unreliable in determining appendicitis<sup>38</sup>. For now it remains unclear whether there is any advantage in relation to time taken and postoperative duration in hospital between laparoscopic and open appendicectomy<sup>39, 40</sup>. Laparoscopic appendicectomy may however in the long term be associated with less postoperative adhesions<sup>41</sup>.

Laparoscopic hernia repair was first performed by Ralph Ger in 1982<sup>42</sup>. Randomised studies conducted later to determine whether laparoscopic repair was superior to open in inguinal hernia gave conflicting reports<sup>43,44</sup>.

A review of studies done comparing the two concluded that if mesh was used for inguinal hernia, laparoscopic repair took longer time, was associated with more serious complications, was more expensive, had a steeper learning curve but caused less chronic pain for patients and long term recurrent rates were similar for both, but laparoscopic groin hernias were better repaired by experts. Laparoscopic repair of bilateral groin hernias may be better especially when recurrent. For ventral hernia more studies are required before valid conclusions can be drawn<sup>45</sup>.

With the advent of potent drugs for peptic ulcer disease, surgery is indicated mainly for complications. Laparoscopic surgery is useful in the management of perforated duodenal ulcer. Perforation can be closed by intracorporeal suturing or sealing by glues incorporating an omental patch and peritoneal lavage done<sup>46,47</sup>. Laparoscopic colectomy is a difficult procedure with a steep learning curve<sup>48,49</sup> which was first described in 1990<sup>50</sup>. For malignancy the initial concern about adequacy of laparoscopic surgery<sup>51</sup> have been largely allayed by subsequent trials<sup>52-55</sup>. These studies showed that apart from lower analgesic requirement, earlier oral intake and reduced hospital stay; the laparoscopic group did not differ significantly from the open in relation to tumour recurrence.

A detailed review of achalasia suggested that of the management options, laparoscopic cardiomyotomy may be the most effective and is usually performed along with laparoscopic fundoplication<sup>56</sup>.

Laparoscopic surgery for anti-reflux procedures has been demonstrated by both prospective and retrospective studies to be a safe and effective method for treating gastroesophageal reflux disease (GERD)<sup>57,58</sup>.

Laparoscopic splenectomy is now an established procedure<sup>59-61</sup> and the spleen can be approached anteriorly or laterally. The lateral is technically easier, but splenomegaly is still a challenge laparoscopically. Some studies have reported lower complication rates than the open<sup>62-64</sup>.

Bariatric surgery is performed for morbid obesity which is body mass index (BMI) greater than 35 or more with serious comorbidity or a BMI of 40 regardless of comorbidity state<sup>65</sup>. Surgeries can be classified generally into restrictive or malabsorptive, or a combination. Laparoscopic surgery can be applied in both classes and virtually all bariatric surgery can be performed laparoscopically. Common procedures include sleeve gastrectomy and gastric adjustable banding<sup>66</sup>.

Hand-assisted laparoscopic (HAL) surgery may be defined as an alternative laparoscopic approach in which a minilaparotomy is planned and performed to enable the surgeon to introduce his or her hand while the pneumoperitoneum is maintained and the dissection manoeuvres are performed under videoendoscopic control. The insertion of the hand restores the tactile feeling and the sensation of depth, and facilitates the exposure, traction, and retraction manoeuvres during the procedure<sup>67</sup>. Several HAL devices are available<sup>68</sup>.

Gasless laparoscopy is aimed at the abolition or reduction of positive pressure pneumoperitoneum. Initial devices which consisted of slings and hooks are being replaced by newer ones. Studies reveal reduction in adverse cardiovascular, metabolic, hormonal changes, and less post operative pain but these devices have the disadvantage of tenting with less working space, and cause injury to parietal peritoneum. It is less popular than pneumoperitoneum<sup>69</sup>.

Needlescopic surgery involves use of laparoscopic instruments of 3mm in diameter in an attempt to maximize benefits of laparoscopic surgery. Nomenclature was introduced by Gagner and Garcia-Ruiz in 1998<sup>70</sup>. Various studies have shown conflicting reports of reduced pain or no difference when compared with laparoscopic surgery<sup>71-76</sup>.

Natural orifice transluminal endoscopic surgery (NOTES) is an experimental alternative to conventional surgery where abdominal incisions and related complications are eliminated by combining endoscopic and laparoscopic

techniques to diagnose and treat abdominal pathology. It was first reported by Kalloo in 2004 and has the potential to be less invasive, safer and provide better cosmesis than other previously described procedures. It represents the future of the evolution that began with laparoscopy<sup>77</sup>. Natural orifices used include transgastric, transvaginal, transvesical, transcolonic, transoesophageal and transumbilical<sup>78</sup>.

The difficulties inherent in laparoscopic surgery with performance of complex tasks, the two-dimensional vision, restrictions from the small incisions inserted trocars and ergonomic problems are what recently introduced surgical robots are expected to solve.

Telemanipulators like the da Vinci robot are designed to allow for more complex procedures to be carried out. They are expected to overcome the limitations and disadvantages of laparoscopy but come with their own challenges. They are expensive and increase surgery time. More studies will be required to determine their usefulness in general surgery<sup>79,80</sup>.

From speculum to NOTES, from lamps to robots, the last 100 years have been revolutionary. Perhaps general surgery is about to evolve into a field that is radically different from what it has been. We are witnesses of an incredible journey of art, science, technology and human innovation.

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