Laparoscopy

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Laparoscopy (from Ancient Greek *(lapara)*, meaning 'flank, side', Germany, is an operation performed in the abdomen or pelvis using small incisions (usually 0.5–1.5 cm) with the aid of a camera. The laparoscope aids diagnosis or therapeutic interventions with a few small cuts in the abdomen.

Laparoscopic surgery, also called *minimally invasive surgery* (MIS), *bandaid surgery*, or *keyhole surgery*, is a modern surgical technique. There are a number of advantages to the patient with laparoscopic surgery versus the more common, open procedure. These include reduced pain due to smaller incisions, reduced hemorrhaging and shorter recovery time. The key element is the use of a **laparoscope**, a long fiber optic cable system which allows viewing of the affected area by snaking the cable from a more distant, but more easily accessible location.

Laparoscopic surgery includes operations within the abdominal or pelvic cavities, whereas keyhole surgery performed on the thoracic or chest cavity is called thoracoscopic surgery. Specific surgical instruments used in a laparoscopic surgery include forceps, scissors, probes, dissectors, hooks, and retractors. Laparoscopic and thoracoscopic surgery belong to the broader field of endoscopy.

There are two types of laparoscope.

1. a telescopic rod lens system, usually connected to a video camera (single chip or three chip)
2. a digital laparoscope where a miniature digital video camera is placed at the end of the laparoscope, eliminating the rod lens system

The mechanism mentioned in the second type is mainly used to improve the image quality of flexible endoscopes, replacing traditional fiberscopes. Nevertheless, laparoscopes are rigid endoscopes. The rigidity is required in clinical practice. The rod-lens based laparoscopes dominate overwhelmingly in practice, due to their fine optical resolution (50 µm typically, dependant on the aperture size used in the objective lens), and the image quality can be better than that of the digital camera if necessary.

The second type of laparoscope is very rare in the laparoscope market and in hospitals.

Also attached is a fiber optic cable system connected to a "cold" light source (halogen or xenon), to illuminate the operative field, which is inserted through a 5 mm or 10 mm cannula or trocar. The abdomen is usually insufflated with carbon dioxide gas. This elevates the abdominal wall above the internal organs to create a working and viewing space. CO_2 is used because it is common to the human body and can be absorbed by tissue and removed by the respiratory system. It is also non-flammable, which is important because electrosurgical devices are commonly used in laparoscopic procedures.[

Procedures

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Surgeons perform laparoscopic stomach surgery.

Laparoscopic cholecystectomy is the most common laparoscopic procedure performed. In this procedure, 5–10 mm diameter instruments (graspers, scissors, clip applier) can be introduced by the surgeon into the abdomen through trocars (hollow tubes with a seal to keep the CO_2 from leaking). Over one million cholecystectomies are performed in the U.S. annually, with over 96% of those being performed laparoscopically.

Rather than a minimum 20 cm incision as in traditional (open) cholecystectomy, four incisions of 0.5–1.0 cm, or more recently a single incision of 1.5–2.0 cm, will be sufficient to perform a laparoscopic removal of a gallbladder. Since the gallbladder is similar to a small balloon that stores and releases bile, it can usually be removed from the abdomen by suctioning out the bile and then removing the deflated gallbladder through the 1 cm incision at the patient's navel. The length of postoperative stay in the hospital is minimal, and same-day discharges are possible in cases of early morning procedures.

In certain advanced laparoscopic procedures, where the size of the specimen being removed would be too large to pull out through a trocar site (as would be done with a gallbladder), an incision larger than 10 mm must be made. The most common of these procedures are removal of all or part of the colon (colectomy), or removal of the kidney (nephrectomy). Some surgeons perform these procedures completely laparoscopically, making the larger incision toward the end of the procedure for specimen removal, or, in the case of a colectomy, to also prepare the remaining healthy bowel

to be reconnected (create an anastomosis). Many other surgeons feel that since they will have to make a larger incision for specimen removal anyway, they might as well use this incision to have their hand in the operative field during the procedure to aid as a retractor, dissector, and to be able to feel differing tissue densities (palpate), as they would in open surgery. This technique is called hand-assist laparoscopy. Since they will still be working with scopes and other laparoscopic instruments, CO_2 will have to be maintained in the patient's abdomen, so a device known as a hand access port (a sleeve with a seal that allows passage of the hand) must be used. Surgeons who choose this hand-assist technique feel it reduces operative time significantly versus the straight laparoscopic approach. It also gives them more options in dealing with unexpected adverse events (e.g., uncontrolled bleeding) that may otherwise require creating a much larger incision and converting to a fully open surgical procedure.

Conceptually, the laparoscopic approach is intended to minimise post-operative pain and speed up recovery times, while maintaining an enhanced visual field for surgeons. Due to improved patient outcomes, in the last two decades, laparoscopic surgery has been adopted by various surgical sub-specialties, including gastrointestinal surgery (including bariatric procedures for morbid obesity), gynecologic surgery, and urology. Based on numerous prospective randomized controlled trials, the approach has proven to be beneficial in reducing post-operative morbidities such as wound infections and incisional hernias (especially in morbidly obese patients), and is now deemed safe when applied to surgery for cancers such as cancer of colon.

Laparoscopic instruments.

The restricted vision, the difficulty in handling of the instruments (new hand-eye coordination skills are needed), the lack of tactile perception, and the limited working area are factors adding to the technical complexity of this surgical approach. For these reasons, minimally invasive surgery has emerged as a highly competitive new sub-specialty within various fields of surgery. Surgical residents who wish to focus on this area of surgery gain additional laparoscopic surgery training during one or two years of fellowship after completing their basic surgical residency. In OB-GYN residency programs, the average laparoscopy-to-laparotomy quotient (LPQ) is 0.55.

The first transatlantic surgery (Lindbergh operation) ever performed was a laparoscopic gallbladder removal.

Laparoscopic techniques have also been developed in the field of veterinary medicine. Due to the relative high cost of the equipment required, however, it has not become commonplace in most traditional practices today but rather limited to specialty-type practices. Many of the same surgeries performed in humans can be applied to animal cases – everything from an egg-bound tortoise to a German Shepherd can benefit from MIS. A paper published in JAVMA (Journal of the American Veterinary Medical Association) in 2005 showed that dogs spayed laparoscopically experienced significantly less pain (65%) than those that were spayed with traditional "open" methods. Arthroscopy, thoracoscopy, cystoscopy are all performed in veterinary medicine today. The University of Georgia School of Veterinary Medicine and Colorado State University's School of Veterinary Medicine are two of the main centers where veterinary laparoscopy got started and have excellent training programs for veterinarians interested in getting started in MIS.

Advantages

There are a number of advantages to the patient with laparoscopic surgery versus an open procedure. These include:

- Reduced hemorrhaging, which reduces the chance of needing a blood transfusion.
- Smaller incision, which reduces pain and shortens recovery time, as well as resulting in less post-operative scarring.
- Less pain, leading to less pain medication needed.
- Although procedure times are usually slightly longer, hospital stay is less, and often with a same day discharge which leads to a faster return to everyday living.
- Reduced exposure of internal organs to possible external contaminants thereby reduced risk of acquiring infections
- There are more indications for laparoscopic surgery in gastrointestinal emergencies as the field develops

Although laparoscopy in adult age group is widely accepted, its advantages in pediatric age group is questioned. Benefits of laparoscopy appears to recede with younger age. Efficacy of laparoscopy is inferior to open surgery in certain conditions such as pyloromyotomy for Infantile hypertrophic pyloric stenosis. Although laparoscopic appendectomy has lesser wound

problems than open surgery, the former is associated with more intra-abdominal abscesses

Disadvantages

While laparoscopic surgery is clearly advantageous in terms of patient outcomes, the procedure is more difficult from the surgeon's perspective when compared to traditional, open surgery:

- The surgeon has a limited range of motion at the surgical site, resulting in a loss of dexterity.
- Poor depth perception.
- Surgeons must use tools to interact with tissue rather than manipulate it directly with their hands. This results in an inability to accurately judge how much force is being applied to tissue as well as a risk of damaging tissue by applying more force than necessary. This limitation also reduces tactile sensation, making it more difficult for the surgeon to feel tissue (sometimes an important diagnostic tool, such as when palpating for tumors) and making delicate operations such as tying sutures more difficult.
- The tool endpoints move in the opposite direction to the surgeon's hands due to the pivot point, making laparoscopic surgery a non-intuitive motor skill that is difficult to learn. This is called the *fulcrum effect*.
- Some surgeries (carpal tunnel for instance) generally turn out better for the patient when the area can be opened up, allowing the surgeon to see "the whole picture" surrounding physiology, to better address the issue at hand. In this regard, keyhole surgery can be a disadvantage.

Risks

Some of the risks are briefly described below:

- The most significant risks are from trocar injuries during insertion into the abdominal cavity, as the trocar is typically inserted blindly. Injuries include abdominal wall hematoma, umbilical hernias, umbilical wound infection, and penetration of blood vessels or small or large bowel.

The risk of such injuries is increased in patients who have a low body mass index or have a history of prior abdominal surgery. While these injuries are rare, significant complications can occur, and they are primarily related to the umbilical insertion site. Vascular injuries can result in hemorrhage that may be life-threatening. Injuries to the bowel can cause a

delayed peritonitis. It is very important that these injuries be recognized as early as possible

- Some patients have sustained electrical burns unseen by surgeons who are working with electrodes that leak current into surrounding tissue. The resulting injuries can result in perforated organs and can also lead to peritonitis.
- There may be an increased risk of hypothermia and peritoneal trauma due to increased exposure to cold, dry gases during insufflation. The use of surgical humidification therapy, which is the use of heated and humidified CO_2 for insufflation, has been shown to reduce this risk
- Many patients with existing pulmonary disorders may not tolerate pneumoperitoneum (gas in the abdominal cavity), resulting in a need for conversion to open surgery after the initial attempt at laparoscopic approach.
- Not all of the CO_2 introduced into the abdominal cavity is removed through the incisions during surgery. Gas tends to rise, and when a pocket of CO_2 rises in the abdomen, it pushes against the diaphragm (the muscle that separates the abdominal from the thoracic cavities and facilitates breathing), and can exert pressure on the phrenic nerve. This produces a sensation of pain that may extend to the patient's shoulders. For an appendectomy, the right shoulder can be particularly painful. In some cases this can also cause considerable pain when breathing. In all cases, however, the pain is transient, as the body tissues will absorb the CO_2 and eliminate it through respiration
- Coagulation disorders and dense adhesions (scar tissue) from previous abdominal surgery may pose added risk for laparoscopic surgery and are considered relative contra-indications for this approach.
- Intra-abdominal adhesion formation is a risk associated with both laparoscopic and open surgery and remains a significant, unresolved problem. Adhesions are fibrous deposits that connect tissue to organ post surgery. Generally, they occur in 50-100% of all abdominal surgeries, with the risk of developing adhesions being the same for both procedures. Complications of adhesions include chronic pelvic pain, bowel obstruction, and female infertility. In particular, small bowel obstruction poses the most significant problem. The use of surgical humidification therapy during laparoscopic surgery may minimise the incidence of adhesion formation. Other techniques to reduce adhesion formation include the use of physical barriers such as films or gels, or

broad-coverage fluid agents to separate tissues during healing following surgery.

Robotic laparoscopic surgery

A laparoscopic robotic surgery machine.

In recent years, electronic tools have been developed to aid surgeons. Some of the features include:

- Visual magnification — use of a large viewing screen improves visibility
- Stabilization — Electromechanical damping of vibrations, due to machinery or shaky human hands
- Simulators — use of specialized virtual reality training tools to improve physicians' proficiency in surgery
- Reduced number of incisions

There has been a distinct lack of disclosure regarding nano-scale developments in keyhole surgery and remote medicine, a "disparity of disclosure" which does not correlate with the rapid advancements in both the medical and nanotechnology fields over the last two decades.

Robotic surgery has been touted as a solution to underdeveloped nations, whereby a single central hospital can operate several remote machines at distant locations. The potential for robotic surgery has had strong military interest as well, with the intention of providing mobile medical care while keeping trained doctors safe from battle

Non-robotic hand guided assistance systems

There are also user-friendly non robotic assistance systems that are single hand guided devices with a high potential to save time and money. These assistance devices are not bound by the restrictions of common medical robotic systems. The systems enhance the manual possibilities of the surgeon and his/her team, regarding the need of replacing static holding force during the intervention.

Some of the features are;-

- The stabilisation of the camera picture because the whole static workload is conveyed by the assistance system.
- Some systems enable a fast repositioning and very short time for fixation of less than 0.02 seconds at the desired position. Some systems

are lightweight constructions (18 kg) and can withstand a force of 20 N in any position and direction.
- The benefit – a physically relaxed intervention team can work concentrated on the main goals during the intervention.
- The potentials of these systems enhance the possibilities of the mobile medical care with those lightweight assistance systems. These assistance systems meet the demands of true solo surgery assistance systems and are robust, versatile, and easy to use.

History

Hans Christian Jacobaeus

It is difficult to credit one individual with the pioneering of the laparoscopic approach. In 1901, Georg Kelling of Dresden, Germany, performed the first laparoscopic procedure in dogs, and, in 1910, Hans Christian Jacobaeus of Sweden performed the first laparoscopic operation in humans.

In the ensuing several decades, numerous individuals refined and popularized the approach further for laparoscopy. The advent of computer chip-based television cameras was a seminal event in the field of laparoscopy. This technological innovation provided the means to project a magnified view of the operative field onto a monitor and, at the same time, freed both the operating surgeon's hands, thereby facilitating performance of complex laparoscopic procedures. Prior to its conception, laparoscopy was a surgical approach with very few applications, mainly for purposes of diagnosis and performance of simple procedures in gynecologic applications.

The first publication on modern diagnostic laparoscopy by Raoul Palmer appeared in 1947, followed by the publication of Hans Frangenheim and Kurt Semm, who both practised CO_2 hysteroscopy from the mid-1970s.

In 1972, Clarke invented, published, patented, presented, and recorded on film laparoscopic surgery, with instruments marketed by the Ven Instrument Company of Buffalo, New York.

In 1975, Tarasconi, from the Department of Ob-Gyn of the University of Passo Fundo Medical School (Passo Fundo, RS, Brazil), started his experience with organ resection by laparoscopy (Salpingectomy), first reported in the Third AAGL Meeting, Hyatt Regency Atlanta, November

1976 and later published in The Journal of Reproductive Medicine in 1981. This laparoscopic surgical procedure was the first laparoscopic organ resection reported in medical literature.

In 1981, Semm, from the gynecological clinic of Kiel University, Germany, performed the first laparoscopic appendectomy. Following his lecture on laparoscopic appendectomy, the president of the German Surgical Society wrote to the Board of Directors of the German Gynecological Society suggesting suspension of Semm from medical practice. Subsequently, Semm submitted a paper on laparoscopic appendectomy to the *American Journal of Obstetrics and Gynecology*, at first rejected as unacceptable for publication on the grounds that the technique reported on was "unethical," but finally published in the journal *Endoscopy*. The abstract of his paper on endoscopic appendectomy can be found at here. Semm established several standard procedures that were regularly performed, such as ovarian cyst enucleation, myomectomy, treatment of ectopic pregnancy and finally laparoscopic-assisted vaginal hysterectomy (nowadays termed as cervical intra-fascial Semm hysterectomy). He also developed a medical instrument company Wisap in Munich, Germany, which still produces various endoscopic instruments of high quality. In 1985, he constructed the pelvi-trainer = laparo-trainer, a practical surgical model whereby colleagues could practice laparoscopic techniques. Semm published over 1000 papers in various journals.[4] He also produced over 30 endoscopic films and more than 20,000 colored slides to teach and inform interested colleagues about his technique. His first atlas, *More Details on Pelviscopy and Hysteroscopy* was published in 1976, a slide atlas on pelviscopy, hysteroscopy, and fetoscopy in 1979, and his books on gynecological endoscopic surgery in German, English, and many other languages in 1984, 1987, and 2002.

In 1985, Erich Mühe performed the first laparoscopic cholecystectomy. Afterward, laparoscopy gained rapidly acceptance for non-gynecologic applications.

Prior to Mühe, the only specialty performing laparoscopy on a widespread basis was gynecology, mostly for relatively short, simple procedures such as a diagnostic laparoscopy or tubal ligation. The introduction in 1990 of a laparoscopic clip applier with twenty automatically advancing clips (rather than a single load clip applier that would have to be taken out, reloaded and reintroduced for each clip application) made general surgeons more comfortable with making the leap to laparoscopic cholecystectomies (gall bladder removal). On the other hand, some surgeons continue to use the

single clip appliers as they save as much as $200 per case for the patient, detract nothing from the quality of the clip ligation, and add only seconds to case lengths. It must be noted that both laparoscopy tubal ligations and cholecystectomies may be performed using suturing and tying, thus further reducing the expensive cost of single and multiclips (when compared to suture). Once again this may increase case lengths but costs are greatly reduced (ideal for developing countries) and widespread accidents of loose clips are eliminated.

Gynecological diagnosis

In gynecology, diagnostic laparoscopy may be used to inspect the outside of the uterus, ovaries, and fallopian tubes, as, for example, in the diagnosis of female infertility. Usually, one incision is placed near the navel and a second near the pubic hairline. A special type of laparoscope called a fertiloscope, which is modified for transvaginal application, can be used. A dye test may be performed to detect any blockage in the reproductive tract, wherein a dark blue dye is passed up through the cervix and is followed with the laparoscope through its passage out into the fallopian tubes to the ovaries.[

Arthroscopy called **arthroscopic** or **keyhole** surgery) is a minimally invasive surgical procedure on a joint in which an examination and sometimes treatment of damage is performed using an **arthroscope**, an endoscope that is inserted into the joint through a small incision. Arthroscopic procedures can be performed during ACL reconstruction.

The advantage over traditional open surgery is that the joint does not have to be opened up fully. For knee arthroscopy only two small incisions are made, one for the arthroscope and one for the surgical instruments to be used in the knee cavity. This reduces recovery time and may increase the rate of success due to less trauma to the connective tissue. It has gained popularity due to evidence of faster recovery times with less scarring, because of the smaller incisions,Irrigation fluid (most commonly 'normal' saline) is used to distend the joint and make a surgical space.

The surgical instruments are smaller than traditional instruments. Surgeons view the joint area on a video monitor, and can diagnose and repair torn joint tissue, such as ligaments. It is technically possible to do an arthroscopic examination of almost every joint, but is most commonly used for the knee, shoulder, elbow, wrist, ankle, foot, and hip.

Types

Knee

Knee arthroscopy, or arthroscopic knee surgery, is an ineffective surgery that uses arthroscopic surgical techniques. People who undergo this surgery for "wear and tear" joint pain, including osteoarthritis and meniscal tears, usually have high hopes for the results, this is sometimes the case but from one to time the result is no better then before. That said it's always worth trying and cannot worsen the damage physical therapy.

It has, in many cases, replaced the classic open surgery (arthrotomy) that was performed in the past. Arthroscopic knee surgery is one of the most common orthopaedic procedures, performed approximately 2 million times worldwide each year. The procedures are more commonly performed to treat meniscus injury and to perform anterior cruciate ligamentreconstruction.

While knee arthroscopy is commonly used for partial meniscectomy (trimming a torn meniscus) on middle aged to older adults with knee pain, the claimed positive results seem to lack scientific evidence.

During an average knee arthroscopy, a small fiberoptic camera (the arthroscope) is inserted into the joint through a small incision, about 4 mm (1/8 inch) long. More incisions might be performed in order to visually check other parts of the knee and to insert the miniature instruments that are used to perform surgical procedures.

Osteoarthritis

The BMJ Rapid Recommendations group makes a strong recommendation against arthroscopy for osteoarthritis on the basis that there is high quality evidence that there is no lasting benefit and less than 15% of people have a small short-term benefitThere are rare but serious adverse effects that can occur, including venous thromboembolism, infections, and nerve damage The BMJ Rapid Recommendation includes infographics and shared decision making tools to facilitate a conversation between doctors and patients about the risks and benefits of arthroscopic surgery

Two major trials of arthroscopic surgery for osteoarthritis of the knee found no benefit for these surgeries. Many medical insurance providers are now

reluctant to reimburse surgeons and hospitals for what can be considered a procedure which seems to create the risks of surgery with questionable or no demonstrable benefit. However this is still a widely adopted treatment for a range of conditions associated with osteoarthritis, including labral tears, femoroacetabular impingement, osteochondritis dissecans

A 2017 meta-analysis confirmed that there is only a very small and usually unimportant reduction in pain and improvement in function at 3 months (e.g. an average pain reduction of approximately 5 on a scale from 0 to 100). A separate review found that most people would consider a reduction in pain of approximately 12 on the same 0 to 100 scale important—suggesting that for most people, the pain reduction at 3 months is not important. Arthroscopy did not reduce pain or improve function or quality of life at one yearThere are important adverse effects

Meniscal tears

One of the primary reasons for performing arthroscopies is to repair or trim a painful and torn or damaged meniscus. The technical terms for the surgery is arthroscopic partial meniscectomy (APM). Arthroscopic surgery, however, does not appear to result in benefits to adults when performed for knee pain in patients with osteoarthritis who have a meniscal tear. This may be due to the fact that a torn meniscus may often not cause pain and symptoms, which may be caused by the osteoarthritis alone. Some groups have made a strong recommendation against arthroscopic partial meniscectomy in nearly all patients, stating that the only group of patients who may - or may not - benefit are those with a true locked knee. Professional knee societies, however, highlight other symptoms and related factors they believe are important, and continue to support limited use of arthroscopic partial meniscectomy in carefully selected patients.

Hip

Hip arthroscopy was initially used for the diagnosis of unexplained hip pain, but is now widely used in the treatment of conditions both in and outside the hip joint. The most common indication currently is for the treatment of femoroacetabular impingement (FAI) and its associated pathologies. Hip conditions that may be treated arthroscopically also includes labral tears, loose / foreign body removal, hip washout (for infection) or biopsy, chondral (cartilage) lesions, osteochondritis dissecans, ligamentum teres injuries

(and reconstruction), Iliopsoas tendinopathy (or ‘snapping psoas’), trochanteric pain syndrome, snapping iliotibial band, osteoarthritis (controversial), sciatic nerve compression (piriformis syndrome), ischiofemoral impingement and direct assessment of hip replacement.

Shoulder

Arthroscopy is commonly used for treatment of diseases of the shoulder including subacromial impingement, acromioclavicular osteoarthritis, rotator cuff tears, frozen shoulder(adhesive capsulitis), chronic tendonitis, removal of loose bodies and partial tears of the long biceps tendon, SLAP lesions and shoulder instability. The most common indications include subacromial decompression, bankarts lesion repair and rotator cuff repair. All these procedures were done by opening the joint through big incisions before the advent of arthroscopy. Arthroscopic shoulder surgeries have gained momentum in the past decade. "*Keyhole surgery*" of the shoulder as it is popularly known has reduced inpatient time and rehabilitation requirements and is often a daycare procedure.

Arthroscopic view showing two of the wrist bones.

Arthroscopy of the wrist is used to investigate and treat symptoms of repetitive strain injury, fractures of the wrist and torn or damaged ligaments. It can also be used to ascertain joint damage caused by wrist osteoarthritis.

Spine

Many invasive spine procedures involve the removal of bone, muscle, and ligaments to access and treat problematic areas. In some cases, thoracic (mid-spine) conditions require a surgeon to access the problem area through the rib cage, dramatically lengthening recovery time.

Arthroscopic procedures (also endoscopic spinal procedures) allow access to and treatment of spinal conditions with minimal damage to surrounding tissues. Recovery times are greatly reduced due to the relatively small size of incision(s), and many patients are treated as outpatients. Recovery rates and times vary according to condition severity and the patient's overall health.

Arthroscopic procedures treat

- Spinal disc herniation and degenerative discs
- spinal deformity
- tumors
- general spine trauma

Temporomandibular joint

Arthroscopy of the temporomandibular joint is sometimes used as either a diagnostic procedure for symptoms and signs related to these joints, or as a therapeutic measure in conditions like temporomandibular joint dysfunction. TMJ arthroscopy can be a purely diagnostic procedure, or it can have its own beneficial effects which may result from washing out of the joint during the procedure, thought to remove debris and inflammatory mediators, and may enable a displaced disc to return to its correct position. Arthroscopy is also used to visualize the inside of the joint during certain surgical procedures involving the articular disc or the articular surfaces, similar to laparoscopy. Examples include release of adhesions (e.g., by blunt dissection or with a laser) or release of the discBiopsies or disc reduction can also be carried out during arthroscopyIt is carried out under general anesthetic.