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Current Developments in Laparoscopic Surgical Technology: A Summary of Progress

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Abstract

With its less invasive technique and quicker recovery periods, laparoscopic surgery—also referred to as minimally invasive surgery or keyhole surgery—has completely changed the surgical sector. Significant developments in laparoscopic methods, tools, and technology in recent years have enhanced patient outcomes and broadened the scope of surgical applications. This article offers a thorough summary of the most recent breakthroughs in laparoscopic surgery, including those related to robotic assistance, 3D visualisation, telementoring, Natural Orifice Transluminal Endoscopic Surgery (NOTES), Single-Incision Laparoscopic Surgery (SILS), and NOTES.

History and Background

Since laparoscopic surgery's invention in the early 20th century, a lot has changed. Because the process is less invasive, it is a preferred option for a variety of surgical treatments, including appendectomy, cholecystectomy, and hernia repair. The breadth and utility of laparoscopic surgery grow along with advancements in technology and surgical methods.

Laparoscopic surgery's development

The history of laparoscopic surgery begins in the early 1900s, when Georg Kelling carried out the first laparoscopic operation in 1901. Since then, the field has seen several developments, starting with Harold Hopkins' creation of the first laparoscope with a rod lens system in 1953 and the launch of the Charge-Coupled Device (CCD) camera in the 1980s. Recent years have seen further technical developments that have improved laparoscopic surgery.

A second growth phase was identified for surgical robots and image guidance. Starting in the 1990s and continuing through the years 2000 and beyond, their growth followed progressive and exponential patterns. The cause of this developmental pattern is likely to be complex. Despite various difficult engineering hurdles, these technologies are committed to continuous improvements to meet clinical demands.

The third and most recent growth phase started in 2000 and ended in 2000, concerning NOTES and SILS. Although interest in NOTES peaked in the latter part of 2000, SILS has maintained its appeal. The decline in creativity and enthusiasm in the approach as well as the stark distinction between inventors and adopters are contributing factors to the plateau with NOTES. In contrast, SILS is an advanced technology with tools used by specialists in mainstream practice and perhaps growers in robotics, which may complement SILS.

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Robotic surgery has seen some of the biggest improvements in MIS over the past decade. While military surgery began in the 1970s, robotics was first adopted for surgery in large hospitals in the 1990s. Robotics and computer science have enhanced surgeons' ability to perform complex surgeries more accurately and precisely. Operating rooms now feature Virtual (VR) and (3-D) owing to the constantly developing optics and computer science technology [6]. This makes it possible to create patient-specific models that facilitate planning and training for difficult surgeries using a VR platform before the procedure is carried out. The mental representation of anatomical information was improved by the 3D virtual model.

The evolution of laparoscopic surgery

Laparoscopic cholecystectomy

A skilled surgeon conducts LC, which has long since become the preferred method for treating cholelithiasis [7]. The rate of biliary trauma persists to be higher than that of open surgery. However, LC offers more benefits owing to less postoperative pain, shorter hospitalization, and higher quality of life [8]. LC guidelines are now well established and include providing general surgeons with proper training. In the history of laparoscopic surgery, LC established itself as a pioneer of new developments. With several improvements in robotics, telemedicine, and instrumentation, more advances are anticipated [8,9]. Which resulted in the development of a direct vision endoscope that he employed for laparoscopic cholecystectomy. His groundbreaking achievements were rejected by the German Surgical Society, and it was only after the broad adoption of laparoscopic cholecystectomy by his French colleagues that it was finally accepted by the Society. It was not until 1997 that he understood the revolutionary approach to cholecystectomy. Amid objections from a large portion of the medical profession, the vision of a few surgeons has widened the scope of minimally invasive surgery [10].

Laparoscopic appendectomy

Laparoscopic Appendectomy (LA) has become more common over the past 10–15 years because of better diagnostic results and a decreased risk of wound complications. Compared with open surgery, the primary benefits of LA include a quicker recovery and return to regular activities, an improved cosmetic result, and an early start of oral intake. The advent of multichannel glove ports has made it feasible to perform increasingly complex endoscopic procedures such as Single-Incision Laparoscopic Appendectomy (SILA) [9]. Intracorporeal Laparoscopic Appendectomy (ICLA) are Intracorporeal Laparoscopic Appendectomy (ICLA). In the first technique (ICLA), two 5-mm working ports were positioned far beyond the midline, and a 10-mm supraumbilical port was used to generate pneumoperitoneum. A parallel layout of the instruments means that performing ICLA requires more technical expertise. Still, a number of studies have demonstrated that this strategy yields good results [10,11]. In children undergoing Open Appendectomy (OA), research comparing laparoscopy-assisted Single-Port Appendectomy (SPA) revealed that SPA required a considerably longer operating time than OA (60.8 min vs. 57.4 min), but SPA required a shorter hospital stay (4.4 days vs. 5.9 days) [11,12]. A type of SILA known as an "ECLA," or video-assisted appendectomy, entails all of the preliminary procedures of an ICLA, such as the creation of a pneumoperitoneum and the identification and skeletonization of the appendix. The process of the second phase of ECLA is nearly identical to that of open appendectomy, with the appendix exteriorized through a 10-mm port in the right iliac fossa. Although other studies have recently reported the application of the same strategy utilizing a single periumbilical port [12, 13,14,15], this approach usually requires two to three ports.

Operative hernial repair

Initially identified in 1993 with less dissection, less bacterial infection, and fewer days of hospitalization, laparoscopy for hernias is currently progressing rapidly.

In the imprisoned form, laparoscopic surgery is usually the initial course of therapy. Laparoscopic hernia repair can also be used to manage acute complications, relieve symptoms, and avoid complications [12,16].

Seroma formation has emerged as a particularly common postoperative consequence. All participants in a single, small prospective trial had seromas detected by ultrasonography. Thankfully, the majority of seromas resolved on their own [13, 14]. Surgical Site Infections (SSI) were significantly lower in the laparoscopic approach, with rates as low as 1.1% and 10% in laparotomy. Less tissue injury and smaller cuts are beneficial [14-30].

The most recent approach was released in 2003 and several methods have evolved over time. For example, Trans Abdominal Preperitoneal Hernia (TAPP) repair requires preperitoneal mesh implantation to minimize the severe inflammatory reaction caused by close contact between the mesh and intra abdominal viscera. According to Prasad et al. [15,16], there were a few minor problems, such as 6% collection, 4.4% post-surgery retention, 2.9% intestinal perforations, 4.4% SSI, and a 3% challenge rate, but no serious outcomes were reported.

The laparoscopic retrorectal/preperitoneal repair technique was developed at the beginning of the 2000s by Miserez and Penninckx. After stress is released, this technique effectively releases myofascial tissue [16,17].

Dulucq developed the Totally Extra Peritoneal (TEP) hernia repair technique in 1991 and is currently the most popular method. This method offers tension-free mesh strengthening of the groin through laparoscopic surgery [18,19,20-53].

Peritoneal leakage causes compression of the preperitoneal dissection area and CO_2 loss into the peritoneal cavity up to 50% of the time. Nonetheless, a large body of studies has suggested that the TEP approach yields encouraging outcomes. A study conducted by Tamme et al. [19] on 5203 TEP in 3868 people over a period of 7.5 years revealed a slight morbidity and recurrence rate associated with TEP. In another trial, the frequency of emphysema under the skin and postoperative edema were higher in the TEP group than in the TAPP group. However, neither had any repetition.

Natural Orifice Endoscopic Transluminal Surgery (NOTES)

Another important development in the last ten years is NOTES, which has been the biggest advancement in surgery since the first laparoscopic cholecystectomy in the Phillipe Mouret of France in 1987 [54]. However, the approach first gained notoriety thanks to Kalloo et al. in 2004 [55]. Before anyone attempted to purposely break the muscle layer, endoscopic mucosal resection seemed to have occurred. These pages since then, several NOTES procedures have been performed, including the primaril several he vagina, rectum, and stomach as the portal of

entry into the peritoneal cavity. The public viewed NOTES favorably because it was the first "scarless" surgery favorably made available.

However, NOTES has several obstacles. Among them are challenges in esthetics, anastomotic procedures, spatial orientation, steep learning curve, lack of instrument triangulation, hemorrhage control, and prevention of bleeding transmission to the transluminal pathway. NOTES has several benefits, although at the same time. It could even work as a substitute for a laparoscopic treatment in a patient who is ineligible for one, leaves no scars, causes less outward pain, is less expensive, and has other advantages in competition to laparoscopic procedures and avoids great resecti completion; to laparoscopic past ten years, NOTES has run into more issues than fixes, which the industries are still working to resolve [25,26,-32]. As a result, both its use and popularity plateaued. The first nonrandomized study comparing diagnostic laparoscopy and transgastric peritoneoscopy will be published with comparable outcomes after careful selection of parts. This study proved the value of NOTES while putting some of its unique features to the test; however, it did not increase the overall safety of NOTES Positives and negatives the absence of noticeable scars and possibly quicker recovery durations are NOTES's primary benefits. However, the method has drawbacks, including the requirement for extensive endoscopic expertise and the limited availability of specialised instruments.

To make these processes easier, platforms and instruments created especially for NOTES have been developed. Some examples of the technology used for NOTES are magnetic anchoring systems, specialised suturing instruments, and flexible endoscopes. Use in Clinical Settings NOTES has been used in numerous surgical operations, including gastrectomy, appendectomy, and cholecystectomy. Even though the method is still developing, it has enormous potential for minimally invasive surgery in the future.

Laparoscopic Surgery Using 3D Visualisation During laparoscopic surgery, 3D visualisation technologies may provide better depth perception and spatial orientation.

Benefits and drawbacks

The improved depth perception that comes with 3D visualisation is its main benefit, since it can decrease surgical time and increase surgical accuracy. The requirement for specialised equipment and possible ocular fatigue are significant drawbacks, though.

Laparoscopic systems in 3D

There are now a number of 3D laparoscopic systems available, giving doctors the option of using passive or active 3D technology. Whereas shutter glasses synced with the display are used in active systems, polarised glasses are used in passive systems. The goals of both systems are to enhance spatial orientation and depth perception during surgery.

Virtual and mixed worlds

During an operation, Augmented Reality (AR) provides the surgeon with additional information by combining computer-generated visuals with real-time imaging. This technology can aid in preoperative planning, intraoperative guiding, and postoperative assessment.

Laparoscopic surgery using teleproctoring and teleelementoring

Utilising telecommunication technology, telementoring and teleproctoring enable remote guidance and support during surgical procedures. This can help with laparoscopic surgery knowledge exchange, skill development, and quality control.

Benefits and drawbacks

Benefits of telementoring and teleproctoring include better patient outcomes, easier access to professional advice, and the chance to exchange best practices. The requirement for dependable internet connections, possible technological problems, and worries about data security are among the drawbacks.

Systems of remote presence

During laparoscopic surgeries, skilled surgeons can coach and proctor less experienced colleagues in real time through the use of remote presence technology. To provide real-time direction and feedback, these systems frequently make use of audio transmission, high-definition video streaming, and even telestration.

Laparoscopic pancreatic surgery

A variety of pancreatic disorders can now be treated with laparoscopic surgery, owing to recent technological advances in surgical techniques [54]. Owing to its ease of use and avoidance of an astomosis, laparoscopic distal pancreatic resection, which Gagner first reported in 1996, has gained considerable traction [55].

Laparoscopic single-incision surgery

There is still no official name for the relatively new minimally invasive technique. Single-Incision Laparoscopic Surgery (SILS), used in this essay, will be used. The phrase "Single-Port Access" (SPA) surgery is one of the earliest.

Due to numerous potential benefits, single-incision and laparoscopic cholecystectomy have been compared in several trials. SILS demonstrated a safe and practical surgery with reduced postoperative discomfort and enhanced cosmetic results, despite the increased expenses, extended procedure duration, and complex technology [35].

The length of the hospital stay, complications, and operation time were all examined in many analysedresearchs contrasting SILS and traditional laparoscopy for appendex. They resutling that there were no treatment difference between the two groups. Therefore, SILS appendectomy not exist to be better or more advantageous than a traditional laparoscopic appendectomy, but it is still technically possible, safe, and reliable [36].

In the literature, various terms have been used interchangeably for this recent technique that includes Single-Incision Laparoscopic Surgery (SILS), single-port laparoscopic surgery, single-port access surgery, and transumbilical or laparoendoscopic single-site surgery [20]. Reducing the port count has shown many advantages over traditional laparoscopic surgery, including superior cosmetic outcomes, decreased discomfort and pain, faster recovery period, shorter hospital stay, and lesser port-associated complications. However, recent clinical studies in a variety of surgical specialties have failed to find substantial.

Advantages and disadvantages

The main advantage of SILS is reduced scarring and potentially faster recovery compared to traditional laparoscopic surgery. However, SILS can be technically challenging due to limited triangulation and instrument crowding, requiring additional training and expertise [10].

Laparoscopic anti-reflux surgery

Recent advancements in laparoscopic fundoplication procedures have rekindled interest in the surgical management of Gastro Esophageal Reflux Disease (GERD), as demonstrated by the publication of noteworthy clinical series [40]. The question of whether laparoscopic colonic resection and laparoscopic inguinal hernia repair could have different or unique outcomes from traditional operations has been raised [41]. The anterior 180-degree Dor fundoplication, the posterior 270-degree Toupe fundoplication, and the entire posterior 360-degree Nissen fundoplication are the three current laparoscopic anti-reflux surgical techniques. Laparoscopic Nissen fundoplication (LNF) has become the anti-reflux surgery gold standard for patients with unmanageable and persistent GERD. Comparing Partial Fundoplication (PF) to LNF, research yields contradictory outcomes. PF was reported to result in better functional results and fewer reoperations in two meta-analyses [42,43]. However, a number of retrospective studies suggested the LNF because of its superior reflux management [44,45]. The clinical effects after LNF appear to be unaffected by the split status of the short gastric veins. To reduce fundus tension and mobilize the fundus, it is still advised to separate the short stomach veins, even with the advent of new energy sources. However, 2.85%–4.4% of LNF cases experience resurgence, and the majority of them require revision surgery [46].

Laparoscopic bariatric surgery

Laparoscopic weight-loss procedure cutting-edge and cutting-edge surgical method for treating obesity is the Laparoscopic Sleeve Gastrectomy (LSG) [20]. The first LSG was performed in 1999 by Gagner et al. [21]. The stomach's larger curvature is lessened, resulting in a structure of the stomach and the elimination of the hunger-inducing hormone ghrelin. Since there is no need for an intestinal bypass or anastomosis, this treatment is note worthy.

The duodenal switch, also known as the anastomosis of the gaster with the small bowel's distal end, disconnects the duodenum. The proximal ileocecal valve is then joined to the biliopancreatic limb, resulting in quick absorption. The technique results in a 50 cm alimentary canal and a 400 ml stomach pouch overall [22].

One leak and one hemorrhage were among the 2.9% significant problems that affected 148 patients who had LSG, according to a retrospective analysis. From 4 to 27 months, Baltasar et al [23]. Found a 3.2% death rate and a 63.1% excess BMI decrease. LSG has certain drawbacks, such as a second-stage procedure with greater BMI, raised risk of leakage, and insufficient weight reduction.

While LSG is a good procedure for declining the BMI, in people with a BMI > 55 and severely overweight, it is also rather safe. Due to poorly defined rules, longer results and LSG functions may be performed, and this procedure still needs to be further investigated [24]. In a meta-analysis comparing LSG and LRYGB, it was found that the LRYGB group had an advantage in terms of determining weight loss (%EWL), dyslipidemia, and hypertension at 5 years [25]. Salminen et al.'s supporting meta-analysis [26]. Noted a five-year follow-up of LRYGB upper % EWL over LSG. They discovered no appreciable differences between the two groups complication rates in the prospective trial, Despite each approach's supremacy, LSG and LRYGB are both safety treatments followed by satisfactory outcomes and cures of comorbidity [27]. On the other hand, several primary and revisional surgical methods were established. The Single-Anastomosis Duodenal-Ileal Switch (SADIS), developed by Sánchez-Pernaute in 2007, is essentially a modification of BPD/DS [28]. It is intended to be a less complex procedure with fewer anastomoses and a comparable weight loss result to BPD/DS. One Anastomosis Gastric Bypass/Mini Gastric Bypass (OAGB-MBG), which exhibits a favorable result in longer follow-up, is another potent option. Rutledge invented this method under the name MBG, which Carbajo changed to OAGB in 2005 [29]. Numerous research compared the effectiveness and results of these methods. According to Badshah et al [30]. SADIS and OAGB-MBG were equally successful as correction methods concerning weight loss, nutritional defect, and little upper GUT comorbidity. The OAGB-MBG is beneficial for cases with initial DM type II, according to a different comparison investigation. 60% of patients experienced DM resolution in OAGB-MBG after 12 months, while 65% experienced it after 15 months. Instead, at 12 and 15 months, respectively, 75% and 80% of SADIS patients [31]. As a result, both techniques are advantageous and promising for bariatric surgery].

Laparoscopic cancer resection

Individuals with the beginning of stomach cancer or those in need of supportive services are thought to benefit most from laparoscopic gastrectomy. As a result of this therapy, patients can expect reduced recovery times, less pain following surgery, and an overall higher quality of life [47]. Numerous wealthy nations frequently do laparoscopy-assisted distal gastrectomy with extracorporeal anastomosis [48]. Laparoscopic colorectal cancer resection has demonstrated several short-term benefits, including an acceptable oncological prognosis with reduced recurring rates, in multiple research studies [49,50]. In the past several years, encouraging clinical findings for colorectal cancer resection have been demonstrated by methods such as NOTES and Single-Incision Laparoscopic Surgery (SILS) [51,52-60]. Laparoscopic Cancer Resection (LCR) proved to have a much greater survival rate than open curative resection (90.3% vs. 76.7%) in a Saudi Arabian study comparing the two procedures' survival rates for possibly curable colon cancer [53].

Laparoscopic hepatic surgery

It has been discovered that laparoscopic liver resection has better oncological results and fewer postoperative problems than open surgery. For the treatment of hepatocellular cancer, laparoscopic hepatic surgery needs to be demonstrated as a secure and reliable substitute for open liver resection [56]. To ascertain the oncologic and patient-centered outcomes of these innovative technologies, more investigation is required. When treating colorectal liver metastases, a recent meta-analysis revealed that laparoscopic surgery plus radiofrequency ablation is preferable to excision alone [57-62].

Automated surgery - robotic surgery

Robotic surgery has the potential to be used in a much wider range of settings than only the operating room where the robot

is used. The current technology allows telesurgery to be performed remotely without the requirement for the surgeon to be present in the operating room physically.

Which established a precedent for global telesurgery. Additional weightless environments have been used for robotic surgery research [48,49]. Given the present speed and quality of web-based signal transmission, it would be possible to do remote surgery on any space station or other facility circling the Earth. Currently, operations farther from the moon would call for more sophisticated telecommunication.

The da vinci surgical system

The senhance surgical system

The Senhance Surgical System is another robotic platform designed for minimally invasive surgery. This system features haptic feedback, which allows the surgeon to "feel" the tissue they are working on, providing improved control and precision. Additionally, Senhance incorporates eye-tracking technology for controlling the laparoscopic camera, further enhancing the surgeon's capabilities during the procedure.

Robotic-assisted laparoscopic surgery

Robotically assisted laparoscopic surgery represents a significant advancement in minimally invasive surgical techniques. The use of robotic systems has enabled surgeons to perform more complex procedures with enhanced precision and control.

Advantages and disadvantages

Some advantages of robotic-assisted laparoscopic surgery include improved dexterity, precision, and visualization. The increased range of motion and stability offered by robotic arms allows for more precise and controlled movements. However, some disadvantages include the high cost of the robotic systems and the steep learning curve for surgeons.

The versius surgical system the versius surgical system

Is a compact, modular robotic system designed to provide an accessible and cost-effective solution for laparoscopic surgery. Its ergonomic design, flexible port placement, and easy-to-use interface make it an attractive option for hospitals and surgical centers looking to adopt robotic-assisted laparoscopic techniques.

Future objectives

Prospective Courses It may be possible to significantly improve learning and surgical outcomes by incorporating Artificial Intelligence (AI) and machine learning into telementoring and teleproctoring systems. AI-powered analytics may be able to offer individualised feedback, spot possible issues, and recommend different surgical techniques.

Innovations in laparoscopic surgery included not just surgeons, but also specialists and Gastrointestinal (GI) to maximise constructive creativity and technological advancement, an integrated approach must be used to the largest extent possible, respecting specialty limitations [39].

Surgeons who invented and perfected laparoscopic surgery experienced isolation in their home regions and specialisation. This rejection resembles the biblical saying "no prophet is accepted in his particular nation" (Luke 4:22). Despite the documented gains in an extensive variety of those procedures, general surgeons have struggled to fully adopt laparoscopic techniques. Invasive minimally invasive surgeries must be carefully integrated into surgical practised; otherwise, a new surgical specialty may emerge.

Laparoscopy has formed from gastroenterologic therapies implementing endoscopic appliances. NOTES has integrated the surgical and gastrointestinal routes, presumably in an encouraging manner.

Biliary damage were oftener during the early years of laparoscopic cholecystectomy than throughout open surgery [40]. Semm's intestinal harm hampered the surgical community's recognition of the laparoscopic concept. Laparoscopic surgery was viewed unethical as well as hazardous at the time. The upsides of laparoscopic surgery are explicit today. The protection of patients and moral issues ought to guide future research. It would be a mistake to regard new surgical innovations as ways that boost aesthetic consequences or the surgeon's comfort rather than as a step ahead in the continuing development of minimally invasive surgery. It is vital in this scenario to safeguard safeguards for patients and to "first, do no harm.

Fortunately AI is still in its infancy for the time being. The application of artificial intelligence for manufacturing products based on clinical judgement as well as ease of life, which will become more frequent in the future.

Conclusion

Future advances in surgical technology will alter how surgery is performed. It may be tough to forecast the future over the following ten years. The most major disadvantage of concurrent surgical capacity will not be realised as we progress from semi-assisted to fully autonomous surgery. Second-generation laparoscopic, robotic, Artificial Intelligence (AI), 3D printing, Virtual Reality (VR), and Augmented Reality (AR) technologies may serve as a better human-computer interface, cooperating with processes and providing positive results. As a result, surgery, science, and engineering must collaborate to change present efforts to improve patient care and lower the cost of surgery.

Shorter recovery periods, and better patient outcomes are the benefits of recent developments in laparoscopic surgery. The future of minimally invasive surgery is being shaped by advancements in robotic assistance, single-incision laparoscopic surgery, natural orifice transluminal endoscopic surgery, 3D visualisation, and telementoring. Future advancements in technology and surgical methods are likely to improve the effectiveness, accessibility, and safety of laparoscopic treatments.

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