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Examining Recent Technological Developments in the Laparoscopic Surgery

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Abstract

Laparoscopic Surgery (LS) has several advantages that make it easier for a patient to resume regular daily activities and return to work. These advantages include a quick recovery, a short hospital stay, decreased postoperative pain, discomfort, and limitations, and better cosmetic results (less scarring). Between August 2021 and April 2023, a comprehensive literature search on laparoscopic procedures was carried out using a number of Internet-based search engines and databases, 126 artefacts in all were found. The quality and content of the articles were meticulously evaluated by two unbiased reviewers. The remaining publications were evaluated and graded based on their titles and abstracts after duplicate data-containing articles were removed. We gathered information from 49 papers after doing a thorough analysis to create this evaluation. With the aid of "EndNote" (Thomson Reuters, New York, NY, USA), the bibliography was kept current.

The vast number of academic studies in this area revealed that LS has developed as the preferred approach for almost all abdominal surgeries. For a number of operations, including the fundoplication for gastroesophageal regurgitation illness, bariatric surgery for weight loss, and cancer resection, Level I result highlighting the benefits of LS over open surgery have been described. Later, the list of medical procedures that advanced LS could perform was expanded to include urology, gynecology, hepatectomy, and pancreatectomy. However, patients who potentially feel increased abdominal pressure during LS should be extra cautious. Recent developments that show promise include single-incision laparoscopic surgery, natural orifice transluminal endoscopic surgery, and robot-assisted laparoscopic surgery.

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Introduction

Philippe Mouret performed the first laparoscopic cholecystectomy in 1987. Laparoscopic Surgery (LS) is currently the gold standard for treating a range of abdominal conditions, including gynecological issues, cholecystitis, and appendicitis [1]. A quick recovery, a brief hospital stays, decreased postoperative pain, discomfort, and limitations, and better cosmetic results (less scarring) are only a few of the advantages of LS that make it simpler for the patient to resume regular daily activities and return to work [2,3]. Regarding some conditions that were previously believed to be contraindicated for LS, such as cancer, obesity, abdominal hernia, pregnancy, prior laparotomies, prior abdominal surgeries, and bowel perforation with generalized peritonitis, this surgical procedure has undergone tremendous and exciting advancements over the past few decades [4].

Thanks to exact scientific methodology, Minimally Invasive Surgery (MIS) treatments are rapidly developing, and new methodologies are constantly being presented. Despite the advantages of these techniques, surgeons still have a number of technical obstacles to overcome. Laparoscopic treatments have less mobility than open surgeries due to the long, inflexible surgical instruments' poor ergonomic designs, the operating system's usage of pedals, the fixed surgical ports for the instruments, and the arrangement of screens [5]. Due to all of these problems, surgeons would become physically exhausted and more susceptible to musculoskeletal problems. Laparoscopic surgeons need substantial training, knowledge, and practice to overcome the procedural technical obstacles [6]. To address surgical objectives and overcome technological constraints, advanced, planned training programs are needed for laparoscopic operations because of their steep learning curve [7]. Modern surgical methods, tools, and techniques have been created to enhance the dexterity, accuracy, and ergonomics of surgery as well as the working conditions for medical professionals [8]. Laparoscopic surgical procedures, which are less intrusive than conventional open surgery, have recently grown in popularity. In order to solve the aforementioned issues in the field of MIS, this

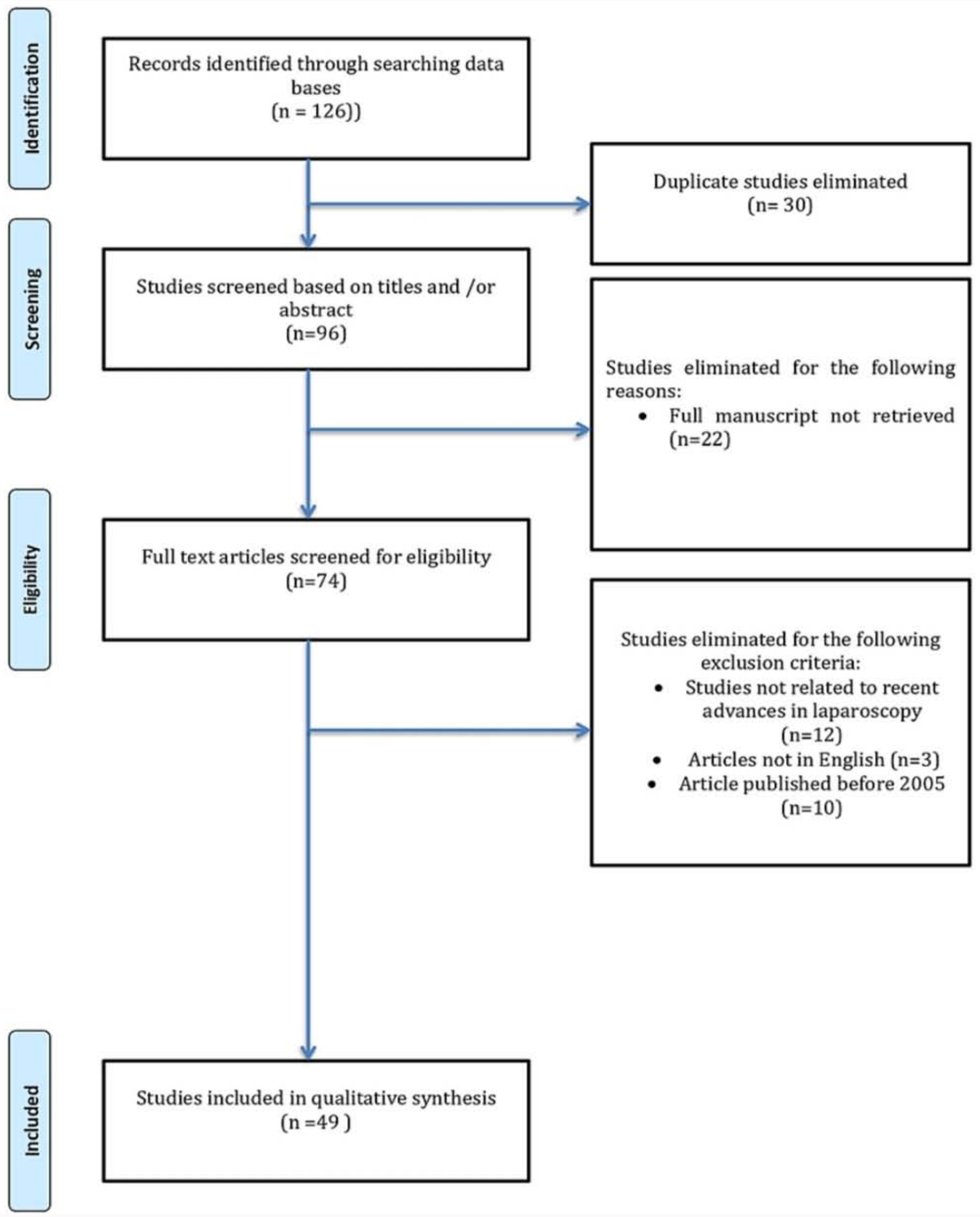

Figure 1: Displays the laparoscopic surgery Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flowchart.

review will closely examine contemporary surgical techniques and technologies employed in laparoscopic surgeries.

Methods

Between April 2021 and October 2023, a comprehensive literature search was carried out using a number of web-based search engines, including Google Scholar, and Bibliographic databases (PubMed, PubMed Central, MEDLINE, Medknow, EMBASE, Scopus, CINAHL, and AMED). Only articles published between the years 2005 and 2021 and written in the English language were included in the search. It used the following keywords and phrases: "Laparoscopic surgery OR laparoscopy AND Recent trends OR latest trends OR recent advancements"; "Laparoscopic Appendectomy AND Recent trends OR new technique"; "Minimally invasive surgery AND abdomen OR pelvis"; "Keyhole surgery AND abdomen OR pelvis." The review of the literature was done by three authors. Initially, 126 artefacts in all were found. The quality and content of the articles were meticulously evaluated by two unbiased reviewers. The remaining 96 papers were scrutinized and graded based on their titles and abstracts after duplicate data-containing articles were eliminated. We gathered information from 49 papers after doing a thorough analysis to create this evaluation. "EndNote" (Thomson Reuters, New York, NY) was used to maintain bibliographies (Figure 1).

Figure 1 displays the laparoscopic surgery Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flowchart.

Results

Appendectomy with laparoscopy

Laparoscopic Appendectomy (LA) has grown in popularity over the past 10 to 15 years as a result of better diagnostic outcomes and a reduced risk of wound complications. The main benefits of LA over open surgery include a quicker recovery and return to normal activities, a better aesthetic result, and an earlier start to oral intake. Single-Incision Laparoscopic Appendectomy (SILA) is now an option for trickier endoscopic procedures because of the recent development of multichannel glove ports [9]. Extracorporeal Laparoscopic Appendectomy (ECLA) and Intracorporeal Laparoscopic Appendectomy (ICLA) are the two methods used in SILA. In the first method (ICLA), two 5-mm working ports are positioned far from the midline, and a 10-mm supraumbilical port is used to generate pneumoperitoneum. The parallel instrument layout makes the ICLA more challenging and technically sophisticated. But numerous studies have demonstrated that this strategy produces fruitful results [10,11]. In a study comparing laparoscopically assisted Single-Port Appendectomy (SPA) to Open Appendectomy (OA) in children, the surgical time was found to be significantly longer in SPA than OA (60.8 min *vs.* 57.4 min), even though the hospitality was shorter in SPA (4.4 days *vs.* 5.9 days) [11]. The ECLA, also known as "Video-Assisted Appendectomy," is a type of SILA that incorporates all of the preoperative steps of the ICLA, such as the development of pneumoperitoneum and the identification and skeletonization of the appendix. The appendix is exteriorized during the subsequent step of ECLA using a 10-mm port in the right iliac fossa, and the surgery goes virtually identically as it would with an open appendectomy. Although using this strategy with just one peri-umbilical port has recently been observed in several publications [12,13], this strategy frequently requires two to three ports.

Transluminal natural orifice endoscopic surgery

Natural Orifice Transluminal Endoscopic Surgery (NOTES), which permits access to the peritoneal cavity through natural orifices without any incisions or without entering through the anterior abdominal wall, is another new advancement in laparoscopic surgery. This procedure is carried out utilizing endoscopic procedures that are currently accessible, with equipment placed in one body cavity, frequently the peritoneal cavity [14]. Through a natural entry, such as the mouth, anus, vagina, or urethra, or sporadically by incisions to establish internal orifices, the cavity is accessible with an endoscope [15]. Hybrid NOTES procedures, which are widely used in conjunction with laparoscopic tools, combine a NOTES technique with direct transcutaneous access to the cavities [16]. The transesophageal, transgastric, transcolonic, transvaginal, and transvesical methods have all been used to access the peritoneal cavity.

The stomach, a modified Seldinger dilatation, or the Percutaneous Endoscopic Gastrostomy (PEG) technique are the surgeons' top choices for NOTES. There are some restrictions when using the vaginal vault in female patients to access cavities [17]. Transrectal surgery, which makes use of TEMS technology, is another treatment employed. However, these methods demand the highest level of attention for both access and closure. The use of NOTES during an appendectomy might lead to fewer scars, less pain following the procedure, the avoidance of hernias, and a quicker recovery [16]. Given the extremely small number of individuals who have received this type of treatment, it is challenging to study the NOTES findings in great detail. The transvesical procedure has a lower technical barrier and complication rate (3%-8%), according to NOTES registries [18]. The NOTES approach can now be used to perform many bariatric procedures, including Sleeve Gastrectomy (SG) and gastrojejunostomy surgery. This is due to the fact that hybrid NOTES procedures decrease abdominal port locations, whereas NOTES surgeries avoid abdominal wall incisions [19]. This is obviously relevant in Singapore, as one of the port sites needs to be expanded in order to remove the gastric residue from it.

Trans-anal minimally invasive surgery

Endoscopic microsurgery in order to perform Local Excision (LE) of distally rectal tumors before the 1980s, surgeons employed posterior para sacral incision, trans sphincteric, and transanal techniques. Rectocutaneous fistula and anal incontinence, on the other hand, are more severe adverse effects associated with the operations. The first Transanal Endoscopic Microsurgery (TEM) was created in 1983 by Gerhard Buess, who purposely extended the LE to the adjacent rectum despite severe limitations and unfavorable results. TEM outperforms conventional LE regarding survival rate, resection quality, and recurrence rate. However, because TEM needed a rigid proctoscope, a laparoscopic cam., and specific tools, the procedure's difficulty and raised price make it a less encouraged procedure [20]. Technology and surgical expertise are evolving due to the development of minimally invasive surgery today. Little-to-no invasive Transanal Surgery (TAMIS), the most modern method, was created by Atallah et al. [21] in 2009. This procedure creates co-existing laparoscopic equipment, such as triangulated instruments and 360° high-definition optics; as a result, it is thought that TAMIS would improve the quality of resections and lengthen disease-free survival.

These procedures were contrasted in various literature regarding re-operative repairment and post-surgery complications.

Melin et al. [22] observed comparable results during the most recent TAMIS technique. For TAMIS, more flexible tools and wider visualization are advantageous. These benefits make it possible to get a bigger specimen and finish the procedure faster. Although TAMIS offered a shorter surgical time and setup time, other assertions by Stipa et al. [23] found that specimen quality and perioperative problems were similarly effective. Suturing is the fundamental issue with both procedures. It has been suggested to use an endo-GIA stapler, intra-, and extra-corporeal suture-tying, to get over the challenges. Inadequate suturing tension and instrument collisions continue to make it difficult for surgeons to provide the best possible outcome.

As a result, numerous publications question the low comparability of TEM and TAMIS with negligible variances. The current assertion that TAMIS is a viable alternative may be overly optimistic. Future advances are still desired for improving therapeutic outcomes, lowering the high cost, and operator flexibility. This extension is a comparatively amazing step forward that keeps pace with rapid technological advancement and has the potential to be used in robotic surgery or non-invasive surgery. The emergence of laparoscopic facilities around the world, as well as the establishment of minimally invasive instruction curriculum, heralded the start of the laparoscopic age. The procedures are now carried out in operating rooms equipped expressly for laparoscopy.

Laparoscopic surgery with a single incision

This cutting-edge technique has been referred to in the literature under various names, including transumbilical or laparoendoscopic single-site surgery, single-port laparoscopic surgery, and single-port access surgery [24]. Compared to traditional laparoscopic surgery, fewer ports have various benefits, such as improved cosmetic results, reduced pain and suffering, faster healing, shorter hospital stays, and fewer port-related issues. However, beyond cosmesis, no additional noteworthy benefits of SILS have been identified by recent clinical investigations across a variety of surgical specialties [25,26]. The value of SILS is not supported by Level I or II evidence, and most reported case series only provide Level IV evidence [27]. SIL-SP, or single-incision laparoscopic splenectomy, is growing in acceptance despite the paucity of published case reports. The conversion to open rate, operating time, and median estimated blood loss were all significantly reduced when SIL-SP was used in comparison to traditional laparoscopic splenectomy [28]. Spleens are currently removed using the Conventional Multiport Laparoscopic Surgery Splenectomy (CMLS-SP) technique [29]. The fact that this approach needs more incisions than SIL-SP is a considerable disadvantage. According to a study by Choi et al. comparing the clinical outcomes of SIL-SP with CMLS-SP, there were no appreciable variations in the time of the surgery, gas passage, diet, postoperative pain, or postoperative hospital stay. However, in CMLS-SP scenarios, blood loss was significantly reduced [30].

Laparoscopic cholecystectomy technique

In modern medicine, Laparoscopic Cholecystectomy (LC), a less invasive surgical procedure, is commonly used to remove the gallbladder. To carry out this treatment, four tiny abdominal incisions are used to insert a surgical video camera and long surgical instruments [31]. For a number of disorders, such as cholecystitis (acute or chronic), acalculous and symptomatic cholecystitis, cholelithiasis, biliary dyskinesia, gallstone pancreatitis, and gallbladder masses or polyps, this treatment has taken the place of open cholecystectomy. General surgeons frequently use LC to treat conditions involving the Common Bile Duct (CBD) and other conditions, including stones. Cholecystocholedocholithiasis is currently generally treated by single-stage laparoscopic CBD Exploration (LCBDE) during LC, despite the fact that advanced laparoscopic surgical skills are required to complete the procedure [32]. The incidence of bile duct injury is somewhat higher in the LC than in the open method, according to the research by Connor and Garden [33]. LC is still recommended as a therapeutic choice for CBD stones since it reduces postoperative pain and suffering, shortens hospital stays, improves cosmetics, and increases patient satisfaction [34]. Moreover, despite the rarity of CBD injury during LC, it could be avoided with intraoperative cholangiography [35]. In Saudi Arabia, 91.5% of all gallbladder removal surgeries were performed Laparoscopically (LC), compared to 5.8% of instances where open surgery was employed and 2.7% of cases where LC to open technique conversions occurred during the process [36].

Laparoscopic weight loss technique

This treatment has become more popular among doctors. After LC, it is the second most common laparoscopic procedure. To treat obesity, a variety of bariatric operations have been utilized, including intestinal bypass surgery, Vertical Banded Gastroplasty (VBG), and Laparoscopic Adjustable Gastric Banding (LAGB). The development of cutting-edge bariatric surgery methods, however, has led to the discontinuation of many of these treatments [37]. The majority of countries have been treating obesity with Laparoscopic Sleeve Gastrectomy (LSG), a standard bariatric surgical procedure, for the past six years. Laparoscopic Roux-en-Y gastric bypass (LRYGBP), One Anastomosis Gastric Bypass (OAGB), Mini-Gastric Bypass (MGB), and LAGB are further modern laparoscopic techniques [38-40]. Before more sophisticated treatments like biliopancreatic diversion (BPD) with duodenal switch or LRYGBP, the fully restrictive bariatric surgery LSG has been suggested as a viable first-stage operation. 75% to 80% of the stomach is removed during surgery, leaving only a stomach sleeve. This area of the stomach limits the patient's initial meal intake, which causes significant weight loss. LRYGBP is a treatment that is frequently used after LSG. After this treatment, a tiny gastric pouch forms that skips a significant portion of the small intestine, limiting the amount of food that may be eaten [37]. LSG and LRYGBP lost the same amount of weight after three months, but at six and nine months, LSG's weight loss was clearly larger [20,21]. According to a recent Middle Eastern survey, the procedures most frequently used to treat obesity and weight loss were LSG, LRYGB, OAGB/MGB, and LAGB [22]. 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 [39].

The length of the hospital stays, complications, and operation time were all examined in many analyzed research's contrasting SILS and traditional laparoscopy for appendix. They resulting that there was 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 [40].

Surgery for laparoscopic reflux

The publication of extensive clinical research has been prompted by recent developments in laparoscopic fundoplication operations, which have aroused interest in the surgical management of Gastroesophageal Reflux Disease (GERD) [23]. Following laparoscopic colonic resection and laparoscopic inguinal hernia repair, the likelihood of additional problems not seen with open surgery has been suggested [41]. The Toupet fundoplication, a 360-degree whole posterior wrap, the Dor fundoplication, an anterior 180-degree wrap, and the Nissen fundoplication are a few of the available laparoscopic anti-reflux surgery treatments. For patients with uncontrollable and persistent GERD, Laparoscopic Nissen Fundoplication (LNF) has emerged as the gold standard in anti-reflux surgery. Partial Fundoplication (PF) had fewer reoperations and better functional outcomes than LNF, according to two meta-analyses. However, certain retrospective investigations [42,43] endorsed it due to the LNF's superior reflux control. Regardless of whether the short gastric arteries are split or not, the clinical outcomes of LNF appear to be the same. Despite the development of alternative energy sources, it is still recommended to separate the short stomach veins in order to mobilize the fundus and reduce fundus tension. 2.85% to 4.4% of people who receive LNF experience recurrence, and the majority of these patients require revision surgery [44].

Laparoscopic cancer ablation

The gold standard for individuals with early-stage stomach cancer or those in need of palliative care is laparoscopic gastrectomy. Shorter hospital stays, less postoperative discomfort, and greater quality of life are benefits of this strategy [45]. In many developed nations, laparoscopically assisted distal gastrectomy with extracorporeal anastomosis is a common treatment [46]. The short-term benefits of laparoscopic colorectal cancer resection and acceptable oncological outcomes with lower recurrence rates have been demonstrated in numerous clinical trials [47,48]. For the excision of colon cancer, recent procedures like NOTES and Single-Incision Laparoscopic Surgery (SILS) have demonstrated great clinical results [49,50]. Laparoscopic Cancer Resection (LCR) showed a much greater survival rate than open surgery (90.3% *vs.* 76.7%) for potentially curable colon cancer, according to a Saudi Arabian study [51] comparing the two methods of resection.

Pancreatic surgery using laparoscopy

Thanks to recent improvements in surgical techniques, a variety of pancreatic issues can now be treated with laparoscopic surgery [52]. Due to its straightforward process and lack of anastomosis, Gagner's 1996 invention of the laparoscopic distal pancreatic resection approach has gained favor [53].

Gynecological MIS

A. LESS benign disease

Surgery on being gynecologically requires greater surgical skill than a hysterectomy. LESS, on the other hand, is now widely used. Adnexectomy is less intrusive than benign hysterectomy. Benign adnexa excision may demand fewer specialist surgical abilities. LESS is utilized more frequently in Total Laparoscopic Hysterectomy (TLH) and Laparoscopic-Assisted Vaginal Hysterectomy (LAVH). 2015 retrospective research found that LESS was utilized for 80% of hysterectomies at a single Korean hospital [41].

In a meta-analysis, Sandberg et al. [54] compared LESS to MLS for hysterectomy in mild illness. This study comprised RCTs as well as prosper mild and retrospective cohort studies. There was no discrimination between the two categories in terms was difficulty, post-surgery pain, bleeding, or hospitalization period. The rate of major issues was 5.3% in the LESS category, 5.6% in the MLS group, and 3.4% in the cohort category.

Closing the vagina-cuff with LESS-TLH is extremely challenging due to poor triangulation and instrumental collision. Individual surgeons' cuff closure approaches show no widely accepted treatment method; nonetheless, recent advances in surgical methods and materials have increased the strength of closures and surgical expertise repairing types and manners. For instance, it is gaining favor as a cost-effective technique to use less. Despite contradictory data from other research, employing a barbed suture reduces postoperative vaginal bleeding and the risk of vaginal cuff cellulitis compared to using a standard suture [55].

Less' myomectomy is one of the most difficult procedures. Myoma excision, enucleation, closure of uterine incisions, and myoma morcellation are all difficult procedures. In contrast, a 2017 study comparing 100 LESS to MLS patients found that LESS-myomectomy was feasible and safe [42].

B. LESS gynecological cancers

Many practitioners have embraced LE gynecological to gain e advantages of minimally invasive treatments, including oncologic procedures. In 2009 [43], Fader and Escobar published the first study utilizing LESS for gynecologic oncology treatments, identify utilizing the spectrum of gynecologic malignancies and precancerous diseases as surgical indications. More studies followed, demonstrating that LESS was both safe and studies for use in Malignant conditions.

Fagotti et al. examined the impact of LESS in 100 patients with early-stage endometrial cancer in a retrospective multicentric research [44]. This was a great study on the treatment of LESS endometrial carcinoma. Following pelvic and aortic lymphadenectomy, 48 and 27 cases, respectively, had a median of 16 pelvic modal excision and 7 aortic lymph nodal removals.

Garrett and Boruta reported the first instance of LESS radical hysterectomy for cervical cancers stage cervical carcinoma underwent hysterectomy with pelvic and nodal dissection: Very good outcomes, little complication, and shorter hospitality [45]. The time of surgery was 260 min, the amount of bleeding was milliliters, co; the conversion was 9% to MLS or open surgery.

Finally, the authors proposed additional research to see whether LESS may be utilized in malignant tumors.

LESS has been utilized because of malignant tumor peritoneal dissemination and recurrent ovarian cancer recurrence. Even for cervical or endometrial cancer, the viability and oncologic safety of MLS are comparable to those of early ovarian cancer, which is still being debated.

Minimally invasive liver surgery

It has been demonstrated that, compared to open surgery, laparoscopic liver resection offers better oncological outcomes while posing fewer postoperative problems. Laparoscopic hepatic surgery must first be proven to be an effective and safe alternative to open liver resection in the treatment of hepatocellular cancer [56]. To fully comprehend how these cutting-edge technologies impact oncology and patient-centered outcomes, more study is required. In the treatment of colorectal liver metastases, a recent meta-analysis found that laparoscopic surgery combined with radiofrequency ablation is superior to resection alone [57].

Robotic surgery using laparoscopy

By offering better ergonomics, improved dexterity and orientation, access to a variety of instrument tips for the EndoWrist® instrument (Intuitive Surgical, Sunnyvale, CA), three-dimensional visualization, and tremor reduction, Robot-Assisted Laparoscopic Surgery (RALS) has opened up new possibilities and overcome the shortcomings of traditional LS [58]. The two procedures that were performed the most frequently over the past ten years were RALS prostatectomy and RALS hysterectomy. However, RALS has recently been used in a number of surgical procedures, including bladder diverticulectomy with ureteric re-implantation, adrenalectomy, pyeloplasty, ureteroureterostomy, and simple and radial nephrectomy [59]. According to a recent meta-analysis, RALS does not significantly outperform LS and open surgery. RALS is more expensive, requires longer surgeries, and offers less flexibility than other LS therapies [60]. However, compared to LS and open procedures, RALS has a more rapid learning curve. In a study of urologists in Saudi Arabia, it was found that 23.2% of them asserted to have completed a fellowship in RALS, and 40.2% of them employed surgical robots during laparoscopic procedures [61].

Since Zeus (Computer Motion)'s first operating room version, significantly. Modern surgical robots like the Da Vinci (Intuitive Surgical) include small mobile platforms, several operating arms, and a superior surgeon's console with grips that are ergonomically designed to mimic human hand ergonomically designed grips various robotic platforms already claim to have created compact robotic platforms already they'd move about more easily, were easier to use in remote locations, and could track the user's eyes. The eye mRemoteNG device uses a camera on eyewear to track the surgeon's eye movements and adjust the scope's position inside the patient. Amadeus Composer's scope's position from Canada and TELELAP

Alf-X (TransEnterix) from Italy are some examples.

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. One such occurrence was a surgical procedure carried out in Strasbourg, France.

Which established a precedent for global telesurgery. Additional weightless environments have been used for robotic surgery research [46,47]. 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 advantages of robotic surgery over laparoscopic surgery are questionable, mostly because of the high cost and ambiguous surgical results. Despite this, healthcare organizations and surgeons enthusiastic about cutting-edge technology continue to find robotic surgery interesting. Even if it is a drawback, this cost may alter with more advanced platforms that are quicker and easier to set up.

Much research has been done on robotic surgery in the peritoneal cavity, and it has shown to be helpful in some procedures. In colorectal surgery, robots have been utilized for more than ten years [48,49]. Robotic surgery utilized conversion to open in rectal surgery; according to a comprehensive review open-liner, neither the length of the procedure nor the morbidity or oncological results in either rectal or colonic surgery were different. Robotic surgery has relatively little advantage over laparoscopic surgery when it comes to upper gastrointestinal procedures, particularly oncological procedures like gastrectomy and esophagectomy [50,51]. However, there has been evidence of some benefit in benign upper gastrointestinal procedures, where accuracy is crucial in Heller myotomy as it declines the perforation rate. Robotic procedures have not declined outperformed laparoscopes. Pic procedures in hepatobiliary surgery. Nevertheless, there is some proof that it might help get better rates of radical R0 resection in the pancreatic. The lack of experience with liver resection makes it difficult to draw any significant conclusions at this time.

Another important development in the last ten years is NOTES, which some have called the biggest advancement in surgery since Phillipe Mouret of France performed the first laparoscopic cholecystectomy in 1987 [52]. However, the approach first gained notoriety thanks to Kalloo et al. in 2004 [53]. Before anyone attempted to break the wall muscle layer purposely, there seemed to have been an endoscopic mucosal resection.

Since then, several NOTES procedures have been carried out, primarily 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" surgical favorably made available.

NOTES faces several obstacles. Among them are challenges in several closure, anastomotic procedures, spatial orientation, a steep learning curve, a lack of instrument triangulation, hemorrhage control, and preventing bleeding transmission to the transluminal pathway. NOTES do have benefits, though, 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 resect completion; to laparoscopic past ten years, NOTES has run into more issues than fixes, which the industries are still working to resolve. As a result, both its use and popularity have reached a plateau. The first nonrandomized study comparing diagnostic laparoscopy and transgastric peritoneoscopy will be published with comparable outcomes after carefully choosing the parts. This study proved the value of NOTES while putting some of its unique features to the test, but it did not increase the overall safety of NOTES.

Access and triangulation are crucial to the success of MIS, even though the closure of an enterotomy is still a major problem. These problems have been attempted to solve by several surgeons. To enhance insufflation, orientation, retraction, instrument navigation, and solid organ manipulation, combining laparoscopy with NOTES has been proposed and tested [56,57].

Surgery that is "noninvasive" instead of minimally invasive recently advanced in robotic surgery.

CT biopsy using PUMA 200 was carried out by Kwoh et al. To accomplish Transurethral Resection of the Prostate (TURP), also known as PROBOT [58].

The success of the initial procedure then prompted Carpentier et al. to execute a mitral valve replacement surgery in Germany.

Later, when Computer Motion and Intuitive Surgical were amalgamated in 2003, the Zeus and da Vinci systems were combined. The da Vinci system became the most extensively used robotic surgery system globally with the release of the updated version [59].

The da Vinci Xi was modified in 2014; it consists of four mounted robotic arms. According to the surgeon's requirements, this improved model offers adjustable intraocular distance, finger loops, and a comfortable backrest. Through motion scaling, tremor avoidance, Three-Dimensional (3D) visualization, and an innovative user interface, high precise precision is made possible. But the main flaw of this technology is the absence of tactile feedback.

These days, robotic rivals are publicly accessible and in various phases of development (Table 1). The benefits of robotic surgery outweigh the disadvantages of laparoscopic surgery. Robotic surgery specifies the location, manages micro-anastomoses, removes hand tremors, minimizes iatrogenic problems, and improves visualization. The drawbacks of this development are its high costs, scarcity of advantages, and lack of haptic feedback. In 2002 Scarcitycaux et al. [60] completed the first transatlantic robot-assisted remote telesurgery, performing a cholecystectomy on a patient in France from New York. The procedure was completed successfully and without incident in 54 min. There were no appreciable clinical differences between robotic-assisted and laparoscopic cholecystectomy; according to the data, laparoscopic surgery was still pr; according to robotic surgery for gastrectomies- the same outcome in robotic and laparoscopic gastrectomy groups [61]: Tian et al. Laparoscopic was the most recent telerobotic spinal surgery on 12 patients using the Fifth Generation (5G) network [62]. They found that spinal surgery using a 5G remote robot was safe and practical, with no intraoperative difficulty.

Types of digestive robot systems displayed in Table 1.

They found that spinal surgery using a 5G remote robot was safe and practical, with no intraoperative difficulty.

Robot-assisted LESS surgery (R-LESS)

Even though the surgical indication for MLS has grown to include

Table 1: The currently available digestive robot systems [77].

Device	Company	Type	Feature	FDA Status, Phase
da Vinci	Intuitive Surgical Inc	Laparoscopy	Tremor filtration	Approved, Commercially available
FreeHand v1.2	Freehand 2010 Ltd	Laparoscopy	Laser guidance	Approved, Commercially available
Invendoscopy E200 System	Invendo Medical GmbH	Colonoscopy	Aseptic single-use	Approved, Commercially available
Senhance	TransEnterix	Laparoscopy	Haptic feedback, eye-sensing camera	Approved, FDA anticipated
NeoGuide Colonoscope	Intuitive Surgical Inc	Colonoscopy	3D mapping	Approved, Acquired
MiroSurge	DLR Robotics	Laparoscopy	Haptic feedback	NA, Commercially available
ViaCath System	BIOTRONIK	NOTES	Haptic feedback	NA, Commercially available
MASTER	Nanyang Technological University	NOTES	Haptic feedback, reconstruction navigation	NA, Clinical trial
SPORT™ Surgical System	Titan Medical Inc	SILS	Multi-articulated instruments	NA, FDA pending
SurgiBot	TransEnterix	SILS	Internal triangulation	NA, FDA resubmission
Versius Robotic System	Cambridge Medical Robotics	Laparoscopy	Haptic feedback	NA, Cadaveric trial
Einstein Surgical Robot	Medtronic	Laparoscopy	Unreported	Unreported

more complex gynecologic disorders, robotic minimally invasive surgery has been widely adopted in various gynecologic issues. Less than ten years ago, the first R-LESS report in gynecology detailed a breast cancer patient's risk-reducing bilateral salpingo-oophorectomy and total hysterectomy [63].

A systematic review published in 2018 explains the outcome of 810 instances of R-LESS hysterectomy for benign pathology [64]. Although intraoperative bleeding was controlled, decisive conclusions on postoperative pain and aesthetics images remained uncertain due to a lack of pertinent data. Morbidity and conversion rates were recorded in 4.9% and 2.8% of the patients, respectively. The study discovered that after 14 cases, proficiency in vaginal cuff sutures could be achieved and that a large uterus and prior abdominal surgery are the limitations of R-LESS hysterectomy.

Numerous studies have proven the effectiveness of R-LESS procedures. However, the vast majority of the researchers are individuals who conduct case studies and conduct retrospective research. More advanced research is needed on this issue.

The growing medical needs are driving the creation of ever-evolving robotic platforms. Engineers and developers are utilizing the most recent advances to improve robotic capabilities. These trends tend to rise in concert with the human goal of completely converting conventional surgery in current practice to robotic surgery. Several studies suggested that existing technologies may be improved even further to improve surgical outcomes. In numerous ways, there are many expectations for the future. The primary focus of current robotic-assisted surgery is on lowering high costs, followed by specialized robotic training and the robotic surgical society's essential requirements. Overcoming difficulties to demonstrate the practicality, safety, cost savings, and clinical benefits of robotic surgery will thus decide its survival.

[Springer Nature Customer Service Centre GmbH] uses the publisher's permission. [In surgery, endoscopy] Brian S. Peters, Priscila R. Armijo, Crystal Krause, Songita A. Choudhury, and Dmitry Oleynikov's review of emerging surgical robotic technology was published in Copyright 2018.

Growing medical needs drive the advancement of ever-evolving robotic platforms. Engineers and developers are using cutting-edge technology to improve robotic capabilities. These developments tend to rise in tandem with the human objective of transitioning from conventional surgery to robotic surgery in the current practices. Several studies have suggested that present technologies should be developed even more to improve surgical outcomes. In several ways, many people have great hopes for the future. The primary purpose of robotic-assisted surgery is to reduce high costs, followed by specialized robotic training and the essential criteria of the robotic surgical society. Overcoming obstacles in establishing robotic surgery's viability, safety, cost savings, and clinical benefits will thus determine if it endures.

[Surgical endoscopy] with permission from the publisher [Springer Nature Customer Service Centre GmbH] in Copyright 2018, Brian S. Peters, Priscila R. Armijo, Crystal Krause, Songita A. Choudhury, and Dmitry Oleynikov published a review of the novel surgical robotic technologies.

Augmented and virtual reality: The medical industry's interest in Virtual Reality (VR) and Augmented Reality (AR) has recently risen dramatically. These technologies have been used in various industries, including telecommunications, aviation, aerospace, and games. Even though VR and AR in medicine are still in their early stages of development. Virtual reality is an artificial technology created by a computer that combines real-time interaction with environments and graphics [65-67].

In the meantime, Augmented Reality (AR) augments real or live images by adding generated data [68]. These advancements significantly boost interaction and bridge the physical and digital worlds. The subsequent progress improves clinical practices and digital healthcare, ultimately enhancing patient safety and outcomes.

What unites them is the fundamental technology that allows both VR and AR to produce Three-Dimensional (3D) digital experiences. A Head-Mounted Display (HMD), stereo equipment, and data gloves are utilized in virtual reality to alter human sensory perception in a computer-generated 3D environment. In contrast, Augmented Reality (AR) gives a digital representation of real-world imagery taken by a camera and shown by a computer or a video projector [69].

The distribution of 3D digital experiences, on the other hand, is where VR and AR diverge. By employing an HMD and a virtual, interactive world, virtual reality gives a genuinely immersive experience. The real world is visible on the other side, and a holographic or transparent display overlays it, producing an extraordinary digital experience. Furthermore, both devices' digital screens provide information about the patient's condition, anatomical anomalies, and precise measurements. These advantages enable the surgeon to analyze and evaluate the patient's current position, boosting accuracy, effectiveness, and safety and, as a result, patient outcomes.

The application of virtual reality and augmented reality projection technology allows for a multidimensional evaluation of medical data. They can use 3D digital experiences to mimic and depict patient problems before simulating treatment. Shafi Ahmed, an oncology surgeon, performed the first successful live VR broadcast at the Royal College Hospital in 2016 [7]. In 2013, Onda et al. claimed that augmented reality could compute an accurate dissection and locate lesions while protecting adjacent organs and blood arteries [15].

The potential of VR and AR, along with advances in 5G connectivity, will surely accelerate and transform the surgical procedure into a completely virtual treatment. The VR and AR integrated data center enables healthcare services to grow and enter the digital era. For the medical era, virtual simulations of surgical techniques and their consequences, as well as three-dimensional reconstructions of patient data, are reaching completion. Future research and development will utilize technologies like virtual displays, haptic feedback, and robotic hand movements to meet current difficulties in these disciplines. As a result, the advancement of VR and AR makes their advancement more tempting for improving surgical efficiency and precision.

The printing of three dimensions: Both parties profit greatly from using 3D printing in the medical field. Combining imaging data with the current patient's problem will yield the optimal course of therapy, which will be used for preoperative planning and presurgical simulation. Because the Operating Room (OR) is becoming more efficient, preoperative planning may save perioperative time, hospital days, and medical costs. 3D printing is utilized intraoperatively to customize prostheses and specialty surgical equipment. These benefits help you save money while completing particular requirements in various ways [53].

A contrast investigation involving superior mesenteric vascular 3D printed models in 22 individuals getting right hemicolectomy prior to operation in the colorectal region revealed that the 3D printed models and real structure during surgery supplied accurate dimensions. According to what was found of this investigation, this strategy is a valuable complement to initial preparation and perioperative navigation [55]. Zein et al. reiterated the accuracy of the 3D-printed liver in preparation for surgery prior to real liver transplantation. A doctor can use this technology to ascertain the anatomical diversity of the current patient and secure the procedure's safety. The capacity of three-dimensional printing that establishes many anatomical variations helps medical education tremendously.

These perks, combined with the potential to transfer 3D printed models, permit medical students to absorb and learn more quickly, whichever their educational settings [9,48]. As a result, every organization has the same chance to learn something new. Aside from the realm of surgery, 3D printing has several benefits. Patient education, forensics, bioprinting, tailored 3D printed pharmaceuticals, and customizing synthetic organs are just a few of the many medical applications for 3D printing that demonstrate the new era's excitement.

4th. Machine learning: In recent years, Artificial Intelligence (AI) has infiltrated and altered the medical industry. AI is a machine-based system with cognitive and reasoning abilities capable of performing basic human decision-making tasks. The growing interest in artificial intelligence emphasizes the importance of medical practitioners limiting human error during patient assessment, diagnosis, and treatment. Cornell University, for example, used a deep learning system to identify lymph node metastases in breast cancer with excellent accuracy [9].

AI in surgery helps clinicians make difficult decisions about multimodal therapy, whether to operate, and what operation to conduct. In addition, when making decisions, surgeons must disclose any surgical risks and the likelihood of death and morbidity [6,61,68]. AI is having a big impact on image-based surgeries like radiography and endoscopy. During endoscopy, a digestive surgeon may use AI-assisted endoscopy with integrated data to diagnose the malignancy and give appropriate evidence-based treatment [16].

Byrne et al. [65] demonstrated how an artificial intelligence-assisted colonoscopy could distinguish between adenomatous and hyperplastic polyps and identify colorectal polyps. AI-assisted colonoscopy produced great results, with 98% sensitivity and 83% specificity.

Later, doctors can include real-time AI analysis of intraoperative progress into live decision-making during surgery, using vital signs, anatomical tracking, time decision, and live video to determine the current percentage of adverse events, mortality, and morbidity. Afterward, postoperative data was combined with patient data to estimate vital signs, assess postoperative needs, anticipate recurrence, and predict likely negative outcomes Chen et al.

For hospitalized patients having surgery, an AI-based Multimodal Risk Assessment Model for Surgical site infection (AMRAMS) was created. They were compared to the risk index (NNIS) [6]. The algorithm-based results showed considerable gains in accuracy and might be used to predict surgical site infections.

A physician located away from the surgical field controls the robotic devices with a 3-dimensional laparoscopic vision and unique "chopstick" devices (Figure 3). The hardware analyses the surgeon's hand movements and is thought to deliver greater accuracy and flexibility, similar to the normal wrists. However, robotic systems continue prohibitively expensive, and their benefits appear to be pertinent mainly in certain types of surgery steps, such as colorectal ablation [10] have not been standardized yet and are being performed in specialized centers.

Laparoscopic surgery through a Single Incision (SILS) has drawn the attention of the surgical community as an alternative to NOTES. Because single-incision procedures may also be performed with conventional laparoscopic instrumentation, their use has increased rapidly. Cholecystectomy, appendectomy, sleeve gastrectomy, splenectomy, and other procedures may be performed with the SILS method in selected patients [34,37]. The clinical advantages of SILS have not been well established, and there is speculation about an increased incidence of biliary complications and incisional hernias [38,40].

Future objectives: Examining the evolution of minimally-invasive surgeries from starting point suggests they are a new and crucial field of operational medicine. NOTES, SILS, and robotic surgery are all principles, not techniques. As such, they should be regarded as stepping stones from laparoscopic surgery to as-yet unexplored areas of minimally invasive treatment procedures. Recent research projects aim at enhancing surgical progress components by exploiting laparoscopic ports. A new robotic technology mixes the single-incision strategy with robotic surgery, permitting autonomous traction, modulation of others, and dissecting with a single polycerated tool (Figure 4) [20]. The STIFF-FLOP (Stiffness controllable Flexible and Learnable Manipulator for surgical operations) endeavor, a European effort supported by the broader community, scientific, and private sectors, intends to create a describing cognitive robotic arm that, like the Octopus arm, may tighten its parts depending on what is going on [21].

Additional inquiry initiatives across the world are centered at creating autonomous robotic systems that can be utilized within a diversity of surgical situations [10].

Spreading a new technology or technique

Innovations in laparoscopic surgery included not just surgeons, but also specialists and Gastrointestinal (GI) to maximize constructive creativity and technological advancement, an integrated approach must be used to the largest extent possible, respecting specialty limitations [22].

Surgeons who invented and perfected laparoscopic surgery experienced isolation in their home regions and specialization. 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 practiced; otherwise, a new surgical specialty may emerge.

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

Biliary damage was oftener during the early years of laparoscopic cholecystectomy than throughout open surgery [23]. 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."

Nevertheless, since of unrealistic expectations, the hoopla surrounding AI in healthcare may be a trap in and of itself. This technology cannot function in the lack of human involvement and cannot solve all problems. The possibilities for surgeon substitution have been overstated in the near term, but they cannot be avoided in the long run. Human evaluation has recently reigned supreme in modern medical technology.

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.

Minimally invasive surgical techniques reduce the size of incisions necessary, reduce associated pain and infection risk, and shorten the time it takes for the wound to heal. Non-surgical therapies such as Focused Ultrasound with a High (HIFU), which uses heat from sound waves to destroy specific tissue instead of requiring surgery, are examples of minimally invasive interventions. HIFU is employed to treat osteoid osteomas, a kind of painful benign bone tumors, at Children's National Hospital.

Medical robotics technology was first used in neurosurgical drilling in 1985. Dr. Cleary described the three types of medical robots used nowadays that are as follows: • Teleoperated, a "master-slave" configuration in which a surgeon stands at a master encourage and manages a slave robot (e.g., the DaVinci Surgical System); • Cooperative, a robotic system that works collaboratively with a surgeon (e.g., Mako Smart Robotics, Stryker) to constrain the cutting-edge during knee osteotomy; and • Minimally invasive interventions are also possible with image-guided navigation devices. These systems include a computer for command and exhibition, a localizer for electromagnetic sensor surveillance, and image processing software.

An MRI-compatible concentric tube robotic system positioned on a 6-DoF promoting arm, a navigation workstation to visualize the tip of the cannula and brain/hematoma MRI images, and a user-interface device for the clinician to control the concentric tube robot to expel the clot in the brain would make up an intracerebral hemorrhage system with MRI under robotic assistance.

Georgia Institute of Technology's Yue Chen, PhD

MRI compatible robotics for in-bore techniques are currently being developed. These include shoulder arthrography systems, back pain identifying systems, long bone biopsy systems, and intracerebral hemorrhage systems. 'People wonder why an expensive MRI scanner would be utilized for minimally invasive processes, however photographs enable perfect soft tissue differentiation, MRI does not expose a patient to radiation, and other acts such as thermal therapy monitoring can be supplied,' Dr. Cleary explained. MRI in line robotics is not hampered by restricted entry in a closed-bore MRI and can conduct in-bore steps that a surgeon would not be able to accomplish logistically. Real-time MRI guidance facilitates robots to deliver an unbiased guide for instrumentation.'

Surgical technology is growing rapidly, thanks in part to consumer market changes such as high-resolution displays, the expansion of artificial intelligence, and innovative user interfaces.

'Many challenges must be overcome,' he commented. 'Creating specialized high-quality robotic systems entails combining the disciplines of mechanical design, electronics, computer science, and control. The rich and powerful static and switching magnetic fields, as well as the radio frequency pulses implemented in MRI, convey a safety risk and pose compatibility challenges. These guidelines forbid the application of obsolete robotic technology. It demands partnership between clinicians and equipment designers.

'Medical robotics offers the potential to help new minimally invasive interventions through enabling a surgeon to access the anatomy through smaller incisions and with finer precision than equipped laparoscopic equipment allow. 'Surgical technology is fast evolving, thanks in part to consumer market improvements such as high-resolution displays, the rise of artificial intelligence, and novel user interfaces,' he said.

In order to enhance cross-system interconnection, open exchange is promoted.

'The difficulty in integrating consumer-driven creativity in an operating room suit includes integration challenges that may develop when merging items from multiple companies. The regulatory environment necessitates the blessing of each particular item. If devices are to be utilized as part of an integrated system, the system has to be studied and authorized in order to ensure that integrating tools is safe. The surgeon would benefit from such an integrated approach since a single user interface could be created to operate many varied devices, rendering them more user enjoyable.

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 realized 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.

Numerous investigations in this field have shown that practically all abdominal surgical treatments propose LS as an effective strategy. Level I evidence has been used to support the superiority of Laparoscopic Surgery (LS) over open surgery for a variety of procedures, such as cancer resection, bariatric surgery for weight loss, and fundoplication for GERD. Later, the list of medical procedures that advanced LS could perform was expanded to include urology, gynecology, hepatectomy, and pancreatectomy. However, those who may have increased abdominal pressure during LS should proceed with caution. Even though robotic laparoscopy requires substantial training and extends operating time, recent improvements in NOTES, SILS, and RALS are exciting. Additional investigation is needed.

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