SBV AHEAD

REVIEW ARTICLE

ADVANCES IN LAPAROSCOPY

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INTRODUCTION

It was in 1987 that French surgeon Phillipe Mouret performed the first laparoscopic cholecystectomy and made an epistemological leap, and ushered in the era of laparoscopic surgeries. Though deemed a revolution or a laparoscopic explosion, it was in every sense a gradual evolution from the traditional large incisions to minute or no incision surgeries. At first, this pace was seemingly slow owing to either limitations in technology or scepticism of the medical and surgical fraternities, not to forget the steepness of the learning curve. But this persistent growth has led to a profound and dramatic change in the scene of surgery today.From a single eyepiece rigid scope to a 3-dimensional, multi-image capturing robotic ensemble, it has been a long journey with many advances. This paper focuses on the advances pertaining to advances in imaging, ergonomics and advances in gastrointestinal surgery only. Robotic surgery is another big leap. Laparoscopy in many different fields of surgery has taken major strides. This paper does not address these advances.

Imaging in Laparoscopy

"Stereopsis is the phenomenon of perception of an object of three dimensions by means of the two dissimilar pictures projected by it on the two retinae …" said Wheatstone in the late 1800s. Single eyepiece rigid scope provided a monocular view. This meant that only the operating surgeon would peer through his instrument to glance at the interiors of the abdomen using one eye. There was no magnification or recording and there was discomfort due to posturing and being glued continuously to the eye piece.

The introduction of television removed most of this handicap and when relayed onto a screen via a camera, it gave birth to "videoscopic" viewing. This monocular vision and screen viewing meant that the surgeon was denied of the normal binocular vision of depth perception, thereby the laparoscopists unintentionally trained themselves to see only in 2 -dimensions. The present technology has sought out to fill this lacuna. Though stereoptic scopes were used as early as 1922, they did not gain popularity till the last decade.

The old system offered either a telescopic rod lens system that connected to a video camera (single-chip or three-chip) or a digital laparoscope where a charged coupled device (CCD) is used.

Single chip cameras meant that sensors for red, green and blue light were contained on a single CCD chip. Triple chip designs utilise a prism located in the camera head unit to split the incoming image into red, green and blue components, and direct those beams of light into three separate CCD chips. If there was blood in the peritoneal cavity, the image of the three-chip camera was superior.

The video monitor displayed the final image with the final resolution which was the end result of what the wire cables would relay. There was visual-motor axis disruption, pictorial depth anti-cues, spatial disorientation, all of which brought down a surgeon's efficiency. This explained the steepness of the learning curve.

To provide the surgeon a 3 -dimensional picture, the newer systems simply mimic the dual lens system of the human eyes. This is what robotic surgery offers

by attempting to send the view from each laparoscopic lens separately to each of the surgeon's eyes.

"Chip on the tip" technology places small camera chips at the tip of the laparoscope and then transmits it to an image processor. The technology for 3D characteristics has an additional image processor. Single channel systems split the view of the operating field from a single point with a prism or a filter and therefore attempt to excerpt two perspectives of the field.

Dual channel systems produce two truly different view which are transmitted separately to each eye independently. The two lenses of the stereoscope are separated by 6 mm and have a focal length of around 10 cm, providing a true binocular image.

Early projection systems used active shuttering projection where the operator wears an active shuttering glasses and alternate left and right views are displayed at high frequency on a display. Robotic systems evolved to use a fixed viewing environment wherein the observer has a separate image displayed to each eye. More recently there has been the experimental development of complex waveform projection systems, auto stereoscopic "glass-free" displays and holographic displays. High quality experimental studies have shown that the latest 3D systems using dual channel stereo-endoscopes and passive polarizing technology provide a "near natural" view. However, their clinical application has yet to be addressed with Level 1 evidence.

Ergonomics in Laparoscopy

Ergonomics is "the concept of designing the working environment to fit the worker, instead of forcing the worker to fit the working environment." It has been very well shown that ergonomic interventions positively affect health outcomes. Compared with other surgical approaches, laparoscopy creates unique musculoskeletal risks for surgeons.

Laparoscopic surgeons fix their head and trunk placing strain on the neck and trunk. This static positioning causes less weight shifting compared to open surgery. Though open surgeries are being replaced by laparoscopic procedures, the tables are not so friendly as to accommodate for various positions and body habitus of the surgeon. The fulcrum effect necessitates exaggerated arcing movements, arm abduction or forced rotation movements to create fine movements inside the abdomen. Laparoscopic surgery also causes greater eye strain compared with open surgery. Laparoscopic ergonomics has, therefore, to be learnt and practiced by surgeons. This is done preferably, first, at a simulated setting rather than in the operating room. Factors like optimal working instrument angles, instrument grips, table height, monitor position, and surgeon positioning are considered and form the basis of current ergonomic guidelines for laparoscopic surgeons. 'Work-related musculoskeletal disorders' is the term preferred to address the injuries in which the work environment and performance of work contribute significantly to the condition.

Ergonomic interventions are being targeted at modifying awkward postures of surgeons, awareness and education, setting guidelines, optimising instruments and developing tables and consoles which have more degrees of movement. Several novel innovations have been developed. These include modified scopes or instrument handles which favour minimal effort and posturing for efficient outcome and have been the focus of change in recent years.

Laparoscopy in Acute Abdomen and Trauma

Laparoscopy today has faced many technological improvements, perfection of laparoscopic instruments, the development of modern laparoscopic techniques and the acquisition of these skills by growing number of surgeons in elective surgeries. However, laparoscopy for emergency surgery is still considered too challenging and is not usually recommended.

Acute abdomen or trauma face technical difficulties due to various reasons such as hemoperitoneum or large purulent collections and adhesions or even fitness for general anaesthesia. Planning an emergency laparoscopic approach is often difficult especially during a night shift as the procedure is restricted by time as well as by the accessibility of equipment and surgical personnel, especially in rural hospitals. Even so, the potential advantages of laparoscopy, its safety, both as a diagnostic procedure and therapeutic procedure for acute abdomen have been established today.

Laparoscopy can be safely performed in various situations commonly encountered. Acute complicated appendicitis with purulent abscess or diffuse peritonitis, or gangrenous or perforated cholecystitis can similarly be managed laparoscopically.

A perforated peptic ulcer (PPU), now a rarer entity can also be approached laparoscopically wherein it may diagnose the cause of acute abdomen and allow closure of perforation, and subsequently permit lavage of the peritoneal cavity. This minimally invasive approach proves to be advantageous by causing less postoperative pain, faster recovery and earlier return to work.

Laparoscopy has presently shown excellent usefulness in cases of peritoneal carcinomatosis, allowing diagnosis as well as palliative treatment when appropriate. No longer does the patient require large midline incisions when even peritonitis is present.

Laparoscopy has also revolutionized the approach to complicated bowel pathology, even when intestinal perforation is present. Recent studies show that laparoscopic lavage is equally effective for perforated diverticula or purulent peritonitis as in open surgeries with lesser incidence of wound infection.

Colorectal

It was not only laparoscopic cholecystectomy or appendicectomy, but in all other abdominal diseases, the advantages of laparoscopy have been well delineated. In Colorectal surgeries, the enthusiasm for minimally invasive techniques grew slower than expected. The application of laparoscopic methods was not easy owing to the complexity of colorectal surgeries, requiring large-size specimen removal, highly effective vascular control and ability to obtain adequate oncological margins for various multi-quadrant surgeries, and the construction of an anastomosis. This hesitation has now been reduced owing to advanced instrumentation, documented evidence on outcomes and more importantly, the understanding of the surgical technique despite the long learning curves.

Several trials have addressed the oncological safety of the laparoscopic approach. The Clinical Outcomes of Surgical Therapy (COST) trial, Colon cancer Laparoscopic or Open Resection (COLOR) and Conventional versus Laparoscopic Assisted Surgery In Colorectal Cancer (CLASICC) have all demonstrated that there was no compromise in lymph node clearance, with similar overall and disease-free survival rates between the open and laparoscopic groups. Even large, multicentre, prospective, randomized trials have shown that the concerns of oncological clearance or recurrence have been similar to open surgery in rectal carcinoma, with respect to circumferential resection margin involvement rates. The laparoscopic approach to rectal cancer for a complete mesorectal excision demands unique and advanced technical expertise. Laparoscopic approach groups go a step further to establish lesser blood loss, quicker bowel recovery and lesser hospital stay but the operation times are longer.

Hand-assisted laparoscopic surgery (HALS) includes a minilaparotomy—made through either a mid-line or Pfannenstiel incision, with consequent placement of a hand port to permit insertion of the surgeon's hand into the peritoneal cavity. This allows tactile sensation that is missing with laparoscopy. Easier dissection and retraction has been shown with HALS. However, HALS technique may encourage blind and blunt dissection of the rectum, which contradicts the fundamental principles of total mesorectal excision (TME). Any deviation from established oncological principles, which in this case involves precise, sharp dissection in the areolar tissue plane under direct visualization, puts the approach at risk of local recurrence. HALS has been demonstrated to be inferior due to this aspect. As long as the surgeon is sufficiently trained and has sound knowledge of the oncological principles, laparoscopic colectomy can be as safe as an open surgery. Laparoscopic anterior resection and abdominoperineal resection are technically more challenging than other colonic surgeries. Patient risk factors such as obesity, previous pelvic radiation or prior abdominal surgery are not a contraindication to a minimally invasive approach despite adding difficulty for the surgeon.

Hepatobiliary

The recent practice of laparoscopic in the field of hepatobiliary disease has seen a tremendous change compared to the technique first established more than 2 decades ago. Technology has overcome many challenges and the surgical outcomes have been excellent.

The scope of laparoscopic liver resection has seen a considerable change since the early 1990s. It was at first, used for resection of small and superficial lesions. Today, laparoscopic left lateral sectionectomy has become a standard operation and more complex liver operations are being performed. The most ideal situation for laparoscopic liver resections have been solitary lesions anatomically situated in the peripheral liver segments especially for tumours less than 5 cm.

Major laparoscopic liver resection is the resection of three or more segments of liver and minor is the resection of one or two liver segments. Major resection is in the phase of exploration and development, with a steep

learning curve and a large scope for continued innovation both in operative techniques and post-operative care. Most studies performed on liver operations laparoscopically have been observational with low quality evidence.

Major hepatic resection is made proficient only by a thorough comprehension of the segmental anatomy and its relationship to the major vascular structures. Blood loss is one of the most important factors influencing postoperative outcome from hepatic resection. As the number of hepatectomies have increased, so too have the techniques to minimise blood loss, including the armamentarium of surgical devices available to facilitate the different aspects of liver surgery. Ultrasonic scalpels, bipolar cautery forceps, and staplers, and cavitron ultrasonic dissector are the devices being used at present.

In laparoscopy, the surgeon approaches caudally - which provides a better exposure around the great vessels and hilar structures including identification of the Glissonian pedicle at the hilum. Understanding of various transections ensures better identification of vascular structures. Advances in technology of surgical instruments and optimal patient positioning has made resections in posterosuperior segments feasible. Development of superior haemostatic devices, with better understanding of hemodynamic and anticoagulation mechanisms in the post-operative period has made minimally invasive hepatectomy a safe procedure in the hands of a skilful surgeon.

The present treatment of common bile duct stones remains a constant debate between use of endoscopic cholangiopancreatography (ERCP) and common bile duct exploration. Stones in the CBD can be managed in a single- stage procedure by laparoscopy itself. This is the most appealing concept as it reduces postoperative stay and total costs. Hence laparoscopic bile duct exploration has been increasingly advocated in the primary management of common bile duct stones in spite of its technically challenging nature.

Two main options have been described to perform laparoscopic CBD exploration, and both the techniques rely upon a choledocoscope. This is becoming more available in larger centres. The technique of entry to bile duct differs. The approaches may be via a transcystic approach through the cystic duct or with a choledocotomy on the bile duct itself. Clinical outcome and practicability of minimally invasive common bile duct (CBD) exploration via both approaches have been reported with high efficiency and minimal morbidity. Surgeons are expected to have skills both in laparoscopy as well as in endoscopy. A metaanalysis to compare two staged (ERCP followed by laparoscopic cholecystectomy) and single staged laparoscopic CBD exploration demonstrated equivalence in stone clearance from the CBD, postoperative morbidity, length of hospital stay, and total operative time.

Expert laparoscopic skills must be matched with individualised management of patients with CBD stones, determined appropriately on the condition of the patient, expertise of operators, and local resources. Though not advocated in the setting of sepsis, laparoscopic CBD exploration shows potential to be efficient and cost effective in the non-septic patient with CBD stones.

Hybrid Procedures

When dealing with tumours, the oncological safety margin is imperative but the removal of excessive normal tissue is unacceptable. There exists a fine line between sound margins of resection and unnecessary removal of normal surrounding tissue. Accomplishing this target is made easier by combining two well established procedures – Endoscopy and Laparoscopy.

In case of gastric tumours such as gastrointestinal stromal tumours, it becomes a challenge to determine the line of incision especially when the lesions are intraluminal. Abnormal tissue must be removed with oncological safety margins and excessive stomach wall removal results in complications and increased morbidity.

The appropriate incision line for local resection of the stomach can be determined by lesion-lifting gastrectomy, hand-assisted laparoscopic surgery, the tumour eversion method, and laparoscopic-endoscopic rendezvous resection. Endoscopic submucosal dissection (ESD) which has been popularised in the eastern part of the world for early stomach cancers has been used to convert a morbid organ-saving treatment into an equally effective minimally destructive surgical procedure. The amalgamation of these two techniques namely ESD and laparoscopy has paved way for "Hybrid "surgeries and seeks to be a less invasive and less destructive treatment of the future.

However, the open approach ispreferable in the setting of for large tumours, tumours located at

posterior gastric wall, esophagogastric junction, and the area near the pylorus, to ensure negative margins

Laparoscopic and endoscopic cooperative surgery (LECS) overrides the disadvantages of laparoscopy-only procedures. Currently, LECS has evolved into several other procedures such as laparoscopy-assisted endoscopic full-thickness resection (LAEFR) and several nonexposure techniques, such as inverted LECS, a combination of laparoscopic and endoscopic approaches to the treatment of neoplasia with a nonexposure technique (CLEANNET), nonexposed endoscopic wall-inversion surgery (NEWS), and laparoscopic transgastric surgery (LTGS).

All these advances avoid making an opening in the gastric wall leading to the peritoneal cavity. However, laparoscopy-assisted endoscopic resection (LAER) and other techniques have been dependably used for colonic polyp removal. Conventional surgical techniques have now been challenged by these combined approaches.

Laparoendoscopic full thickness resection is well-thought-out to be an appropriate decision for removal of upper gastrointestinal stromal tumours in view of technical feasibility. This is true, predominantly in GISTs, and it is superior to procedures involving endoscopy alone. Nevertheless, the sentinel lymph node concept is underdeveloped owing to the complexity of the lymphatic flow of the stomach. This makes the usage of hybrid procedures questionable. In terms of treating difficult colon polyps, laparoendoscopic collaborative procedures seem to be feasible and safe.

Conclusion

This paper outlines some of the recent concepts in laparoscopy. Understanding issues like imaging and ergonomics help the surgeon achieve better efficiency and safety. Advances described in the field of GI surgery should stimulate surgeons to learn and take up these procedures in their practice. This will improve the quality of life of our patients further.

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