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A REVIEW ON RECENT ADVANCES IN CHOLECYSTECTOMY WITH EMPHASIS ON ROBOTIC SURGERY AND ITS PERCEPTION

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ABSTRACT

Cholelithiasis is one of the most common disorders of the digestive tract encountered by general surgeons worldwide. Conventional or open cholecystectomy was the mainstay of treatment for a long time for this disease. Advent of technology and evolving need for the medical care and effective management has laid the foundation for incorporating technology with traditional surgical approach. Recently developed SILS techniques and robotic surgery are promising but their benefits remain to be determined. However, evidence-based medicine has failed to show major advantages in single incision laparotomy surgery(SILS), and the disadvantage of robotic surgery is the high costs related to purchase and maintenance of technology. This has become a multidisciplinary subject for research and development. Emphasis has always been to develop less invasive surgical procedures and technological advancement has made this possible in the present era. Laparoscopic surgery has become well developed in recent decades and is the choice of treatment in abdominal surgery. It brought about a revolutionary change in the basic concepts of surgical principles and minimal access surgery gradually started to be acknowledged as a safe means of carrying out surgeries. In an attempt to reduce surgical incisions, surgical aggression with benefits to the patients and to achieve aesthetic results of these procedures, conventional surgeries have taken a setback in the long run. This article mainly focuses on the evolving trend in the surgical practice with technology of the most commonly performed surgery worldwide i.e. Cholecystectomy.

KEYWORDS: Cholecystectomy; single port robotic surgery; SILS; recent advances; minimal access surgery; non invasive surgery; abdominal surgery.

INTRODUCTION

Gallbladder, a small pear-shaped organ located on the undersurface of liver on the right side meant to collect, store and release bile to aid in the process of digestion. Although the gallbladder performs a digestive function, it is not necessary for proper body functioning and may be removed if diseased. Cholelithiasis popularly known as Gallstones is the most common disease of the hepatobiliary system. Also, the gallbladder may, however, be removed for other reasons, such as to remove cancerous tissue.

MATERIALS AND METHODS

An extensive literature review was done on PubMed/Medline, Wiley online library, google scholar databases. The terms “cholecystectomy”, “SILS”, “Gall bladder surgery”, “laparoscopic cholecystectomy”, “robotic surgery”, were searched in title/ abstracts and resulting articles were studied in detail. A lot of literature published on this topic was found and additional data was explored and references were listed with relevance.

Historical Preview

Cholelithiasis is the most common pathology of the hepatobiliary system and by far, the commonest surgical intervention. Since the origin of the operative management of gallstones dawned in the surgical specialty, there has been a state of continuous evolution, running parallel to the evolution of surgical techniques and technical armamentarium.[1] The first case of gallstone surgery dates back to 1687 when Stal Pert Von Der Weil, who operating on a patient of peritonitis, incidentally found gallstones.[2] Open cholecystectomy technique was developed a century later by a German surgeon, Carl Johann Langenbuch.[3] Very little recognition was given to this technique but this became the gold standard for definitive surgical management of symptomatic cholelithiasis.[4] Langenbuch’s open cholecystectomy remained the gold standard for symptomatic cholelithiasis for over a century and the only major change in the operation was the introduction of operative cholangiography for the detection of common bile duct stone by Mirizzi 60 years ago.[5]

Laparoscopic cholecystectomy was introduced and this proved to be a new era in the management of cholelithiasis. Although it is well known fact that laparoscopic cholecystectomy was 'born in secret' in France few years ago,[6], It is generally believed that the procedure was probably undertaken first in Germany in 1985 using a modified laparoscope without television attachment.[7] Following this early experience, it was demonstrated dramatically that gall bladders could be removed without the intervention of a formal laparotomy and major advantages against the conventional operation were reported. Since the performance of the first laparoscopic cholecystectomy by Prof Dr Med Erich Mühe of Böblengen, Germany in 1985, to a far extent we have seen this procedure overtake the conventional open cholecystectomy as the treatment of choice in cholelithiasis.[4] Today laparoscopic cholecystectomy is one of the most commonly undertaken procedures in general surgery, with more than 500,000 surgeries performed annually over the globe.[8] In March 1987 while Dr. Mühe was completing a gynecologic laparoscopic procedure on a woman who was also suffering from symptomatic gallstones, he then adjusted his laparoscope to the sub hepatic area and he found a comparatively free and supple gallbladder, and decided to remove it laparoscopically, instead of performing a conventional surgery. He performed the procedure successfully and the patient recovered without complications. In just two years, the procedure was adopted by many other surgeons and it gained a momentum in the USA. Finally, National Institute of Health (NIH) consensus conference held in Bethesda in September 1992 concluded that laparoscopic cholecystectomy was the treatment of choice for cholelithiasis.[9] Each year, an estimated 700,000 cholecystectomies [*Source:* April 7, 2016*:* American College of Surgeons] are performed to treat complications of gallstones (cholecystitis, biliary pancreatitis). In the present day, laparoscopic cholecystectomy is considered as the gold standard for treating gallbladder diseases, but in some complicated cases the traditional "open cholecystectomy" approach is still necessary. These situations may include gallbladder carcinoma and patients with cirrhosis.[10]

With further evolving of surgical experience, precision and evolution of the technique, some surgeons tried laparoscopic cholecystectomy via two ports only. This mainly requiring the introduction of transabdominal approach through the anterior abdominal wall for retracting the gallbladder while dissection.[1] It also necessitates abdominal suturing with the number of these sutures varying from one to three depending on the situation and the surgeon's preference. This lead to the start and following up of the era of single port laparoscopy.[11]

Conventional Laparoscopic Procedure

The conventional laparoscopic cholecystectomy is performed by four ports; a 10mm optical port at umbilicus, a 10mm and a 5mm port in epigastrium and in the midclavicular line, respectively for the surgeon to work, and a 5mm port in the midaxillary line at the umbilical level for the assistant to retract the gallbladder fundus. The gall bladder is visualized form the optical port and the cystic duct and artery are identified, dissected, ligated, and divided respectively. Operative cholangiography is also routinely carried out at this time by some experienced practitioners.[12] The gall bladder is dissected and removed from its bed under the liver and then using electro-cautery or occasionally laser coagulation hemostasis is attained. The area is flushed with saline and thoroughly checked for any signs of bleeding which is then aspirated and the gall bladder is removed through one of the larger ports. This laparoscopic cholecystectomy procedure became an instant hit and its march ahead did not show any sign of halt. Although initially, laparoscopic cholecystectomy in pregnancy was absolutely contraindicated but now it is performed during the second trimester with low complication rates.[7] The difficulties faced in such patients include poor ergonomic situation and limited intraabdominal working space. With the establishment of safety of laparoscopic cholecystectomy in various settings and complicated scenarios, the surgical interest shifted from the procedural techniques to reducing the invasiveness and scarring caused by the procedure. With increasing experience, laparoscopic cholecystectomy has undergone many refinements including reduction in the port size and number.[13] The procedure is without doubt a feasible and effective way of removing the gall bladder, not only in uncomplicated situations but also when there are coexistent complications. In experienced hands it is possible to undertake this conventional intervention after previous abdominal surgery, in morbidly obese[10], anticoagulated[11], pediatric, or pregnant patients, when the gall bladder is acutely inflamed in patients with sickle haemoglobinopathies[7] and the rare patient with situs inversus.[13] While the developments in these procedures are being made to achieve invasive surgery less and less invasive, there are occasions where an open approach is needed. Developments are on the high to refining the open approach and make it open approach less invasive.[14]

Single site Robotic Cholecystectomy Procedure (SILS)

Single-incision laparoscopic surgery (SILS) is a recent technical advancement in minimally invasive surgery developed as a less invasive and alternative to conventional laparoscopy.[15]

A single-site robotic platform has been introduced to alleviate some of the technical challenges with laparoscopic single-site surgery.[16] Over the past five years, the Robotic da Vinci Single-Site System (Intuitive Surgical, Sunnyvale, California, United States), has been extensively developed. These single site systems have an inversion of the instruments without requiring additional and extra effort by the surgeon, featuring wider

movements and improved ergonomics, in comparison with non-robotic single-port laparoscopic operations.[17] In addition to three-dimension visualization, the precision in dissection of the anatomical structures, the position of the surgeon sitting next to the patient at the robot console, allow a more precise surgery, without forceps collisions. The initial studies demonstrated that this technique is safe, effective and can help resolve the technical limitations found in laparoscopy.[17,18] Robotic surgery presents a stable perspective, arm movements linked by computerized inversion, and instruments that allow a high degree of freedom.

Single-port robotic cholecystectomy is performed using the da Vinci Single-Site. The patient is placed in supine position under general anesthesia. A 2.5cm umbilical incision is made with dissection to the peritoneal cavity. The da Vinci Single-Site port is placed and pneumoperitoneum is initiated. Once the port is in position, the patient is shifted to an inclined position with slight left lateral decubitus. The robot is place over the patient's right shoulder. After introduction of the camera, the trochanters are placed under direct view. Next, docking (coupling with the robot) takes place and the fundus of the gallbladder is pulled towards the patient's right shoulder by the assistant. Exposure of calots triangle is done and dissection is carried out with the robotic hook-type forceps and Maryland-type robotic forceps. Furthermore, the identification of the cystic duct and the cystic artery is done and both structures are clipped with the Heme-o-lock and sectioned with scissors. The gallbladder is detached from the hepatic bed with the robotic hook as done in a laparoscopic procedure. After dissection from the liver bed, the gallbladder is placed in an extraction bag and removed with the access port device once the instruments and trocars have been removed. The fascia is sealed with absorbable suture and the skin is adjoined with a subcuticular closure. Hemostasis is performed with bipolar forceps or robotic hook. Lastly, the robotic instruments and the camera are removed, and the robot is disengaged. The piece is removed together with the single-port, after review of hemostasis of the hepatic bed, and a thorough inspection is done to check for any biliary leak from the cystic duct. The wound is closed in layers and the skin is sutured with intradermal stitches. This requires the use of a special port called the R-port.

Single-incision laparoscopic surgery (SILS) is a recent technical advancement in minimally invasive surgery developed as a less invasive alternative to conventional laparoscopy.[19] Gallbladder can be removed through transanal, transvaginal, transcolonic and transgastric access with flexible endoscopic instruments, but these techniques are still under development. While these developments are making invasive surgery less and less invasive, there are occasions where an open approach is needed. Developments in refining the open approach are also making an open approach less invasive.[20]

DISCUSSION

In an attempt to investigate whether laparoscopic cholecystectomy really is a major advance and the 'gold standard[21], several studies have attempted to compare the technique with the open operation. These have mostly used retrospective data relating to the conventional procedure which have drawn criticism. Despite this criticism, it is quite clear that the operating time is longer, especially during the 'learning' phase of the surgeon's experience, surgical cost is higher[22], and the incidence of major duct injury is marginally greater with the laparoscopic approach. Because of these observations it is probably too late now to carry out any properly controlled prospective studies.[23] These problems are well compensated for, however, by the facts that the patient suffers less postoperative discomfort, enjoys a shorter hospital stay and a more rapid return to work[24,25,27] and the overall cost difference is probably not significant.[22] When compared prospectively with a mini-cholecystectomy (conventional open operation carried out through a tiny incision) the laparoscopic approach seems to enjoy only marginal advantages[28] but we do not yet know the full spectrum of hazards attached to the mini-open operation. Prospective studies of these two procedures are indicated and the results of trials currently underway are awaited with interest. There is no doubt that laparoscopic cholecystectomy represents a major advance in the management of patients with gall stone disease when it is carried out by a surgeon properly trained and aware of the potential hazards.[29] If any problems are encountered during the operation the surgeon should not hesitate to convert the procedure to an open exploration. It is inevitable that even in the most experienced hands major problems will occur from time to time and careful audit of each individual surgeon's results is essential to ensure his or her track record is acceptable. Any major duct injuries must be recognized and repaired by a surgeon skilled in such techniques.

Laparoscopic cholecystectomy has been performed for more than 20 years and it represents the gold standard for treatment of cholelithiasis all over the world. During the last few years, minimally invasive technology took an important step in its evolution, enabling, besides conventional laparoscopic surgery, the operation with a single port. Since its introduction, SILS has not been used as routine, primarily due to physical limitations of this technology, which compromises triangulation, ergonomics of the procedure, and quality of the view, leading to difficulty in exposing the anatomical structures and to increased risk of lesions to the biliary tract.[18] The introduction of robotic cholecystectomy by a single port set a new landmark for SILS. The curved trochanters of the robotic system were designed to decrease the problem of triangulation and the single port with entrance for the auxiliary forceps was made for traction of the gallbladder, with no need for percutaneous sutures.[19] However, in a systematic review by Antoniou et al.,[18] 29 studies of non-robotic SILS

cholecystectomies were reviewed, including 1,166 patients, and a significant increase in the mean rate of complications was identified in cases where the gallbladder was resected, as compared to the mean complication rates reported in video laparoscopic cholecystectomy.[28] In this way, the search began for technologies that might allow the operation by a single orifice with safety, precision, and low rate of complications. Initially introduced in the United States about two years ago, the robotic da Vinci Single-Site platform was introduced in Brazil, in 2014. In this study, the first four cases of single-port robotic cholecystectomy performed in Brazil. According to the initial results, the procedure seems safe and viable, having been concluded without conversions and with no postoperative complications.[29] The advantages of the robotic single port approach are better esthetic results, less postoperative pain due to the small single incision, visualization of the anatomical structures in three dimensions, stability of the instruments by the robotic platform, precision in dissections, and greater ease for the surgeon in concluding dissections made difficult by the single port.[30] Additionally, the curved robotic semi-rigid instruments provide a safe platform for the performance of the procedures and overcome restrictions and limitations, when compared to laparoscopy via a single port.[31,32] Despite the fact that this study presents a small number of patients operated on, it demonstrates the feasibility of the method and indicates the future possibility of adopting this method as gold standard in elective cholecystectomy, as is described in large reference centers for advanced surgery in the world.[33,34] This system offers distinct advantages over currently available single-port instrumentation and techniques and reestablishes some of the basic principles of laparoscopic surgery, namely triangulation of instruments, dynamic retraction, and camera placement centered on the target anatomy. This approach appears to be safe, even in difficult cases with inflammation, and has a high degree of satisfaction with the patients.[34]

Limitations

In an open abdominal operation, for example, the surgeon simultaneously observes his/her hands, the instruments, and the operative field. In LS, an image of the operating environment is obtained by inserting an endoscopic camera into the body cavity, which is displayed on a video monitor. The literature research presented in this paper has highlighted several challenges associated with LS, namely, reduced depth cues, poor hand-eye coordination, motion limitation, and diminished haptic feedback, all of which contribute to increased perceptual and cognitive load of laparoscopic surgeons. The role of SILC is still controversial. Until now, no real significant benefit has been proven: overall satisfaction is the only clear advantage of SILC, and this is mainly related to cosmetic results.

Robotic surgery is a new technology and its uses and efficacy have not yet been well established. To date, mostly studies of feasibility have been conducted, and almost no long-term follow up studies have been performed. Many procedures will also have to be redesigned to optimize the use of robotic arms and increase efficiency. Most of the disadvantages identified will be remedied with time and improvements in technology. Only time will tell if the use of these systems justifies their cost. If the cost of these systems remains high and they do not reduce the cost of routine procedures, it is unlikely that there will be a robot in every operating room and thus unlikely that they will be used for routine surgeries.

CONCLUSION

The comparison of robotic and laparoscopic surgery is difficult because the modalities are similar in terms of abdominal access and operative technique. Robotic surgery is an emerging technology, fast gaining acceptance for certain procedures. The limiting factor for almost any new technology is added cost and robotic surgery is no exception. some shortcomings of robotic surgery such as need for larger and additional ports and need for undocking the machine in case of cholangiography or change of patient position. However, as efficiency increases, learning curves are overcome and more complex procedures are performed. Most of the disadvantages identified will be remedied with time and improvements in technology. Only time will tell if the use of these systems justifies their cost. If the cost of these systems remains high and they do not reduce the cost of routine procedures, it is unlikely that there will be a robot in every operating room and thus unlikely that they will be used for routine surgeries.

Single-port robotic surgery is feasible and safe when performed by surgeons with prior experience in robotic surgery. Studies with large series of cases are necessary to establish the superiority of the single port robotic procedure as compared to the single incision laparoscopic surgery and video laparoscopic cholecystectomy. Robotic single port cholecystectomy is a safe and feasible alternative to conventional multiport laparoscopic or manual robotic approach. However, current data do not suggest a superiority of robotic SILC over other established methods. Gallbladder can be removed through transanal, transvaginal, transcolonic and transgastric access with flexible endoscopic instruments, but these techniques are still under development. Even though we have come far in the surgical management of Cholelithiasis, the field is still open for innovation.

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