INTRODUCTION

Laparoscopy (from Ancient Greek (lapara), meaning "flank, side", and (skopeó), meaning "to see") is an operation performed in the abdomen or pelvis through small incisions (usually 0.5–1.5 cm) with the aid of a camera. It can either be used to inspect and diagnose a condition or to perform surgery ***(Stephen et al., 2004)***.

There are a number of advantages to the patient with laparoscopic surgery versus an open procedure. These include reduced pain due to smaller incisions, faster healing, shorter recovery time and faster return to work ***(Cuesta et al., 2008)***.

Laparoscopy can be dated to over 100 years ago when George Kelling from Dresden, Germany introduced a cystoscope into the peritoneal cavity of a living dog and insufflated air to enhance the view. In 1901, Von Art did the first inspection of abdominal cavity using a speculum and a candle light ***(Hatzinger et al., 2005).***

In the ensuing several decades, numerous individuals refined and popularized the approach further for laparoscopy. The start of computer chip television camera was a seminal event in the field of laparoscopy. This technological innovation provided the means to project a magnified view of the operative field onto a monitor and, at the same time, freed both the operating surgeon's hands, thereby facilitating performance

of complex laparoscopic procedures. Prior to its conception, laparoscopy was a surgical approach with very few applications, mainly for purposes of diagnosis and performance of simple procedures in gynecologic applications ***(Lehman et al., 2008).***

In 1950 the first diagnostic laparoscopy was done by Raoul Palmer. During mid-1970s, Hans Linderman and Kurt Semm developed thermacoagulation, laparoscopic suturing, and the automatic electronic insufflator. In 1985, the first laparoscopic cholecystectomy was done by Erich Muhe in Germany ***(Muhe et al., 1992).***

Prior to 1990, the only specialty performing laparoscopy on a widespread basis was gynecology, mostly for relatively short, simple procedures such as a diagnostic laparoscopy or tubal ligation. The introduction in 1990 of a laparoscopic clip applier (rather than a single load clip applier that would have to be taken out, reloaded and reintroduced for each clip application) made general surgeons more comfortable with making the leap to laparoscopic surgery ***(Walid & Heaton, 2004).***

Laparoscopic surgery underwent many advances towards becoming less invasive by reducing the number of working ports. In recent years, successful attempts to reduce the number of the traditionally used four or five ports have been reported. These techniques include needlescopic surgery, natural orifice

transluminal endoscopic surgery and single incision surgery (***Park et al., 2007).***

These efforts are some of the fundamentals of the natural orifice trans-luminal endoscopic surgery (NOTES) approach, which removes trans-abdominal incisions completely, but NOTES is technically challenging and current instruments need to be further improved. As a bridge between traditional laparoscopic surgery and NOTES, the recent focus has been on the development of single-incision laparoscopic surgery (SILS) to further minimize the invasiveness of laparoscopic surgery by reducing the number of incisions ***(Marescaux et al., 2007).***

Single incision laparoscopy is a minimally invasive surgical procedure performed through one incision. The technique started to evolve in 1990s. In 1992, the 1st single-incision laparoscopic appendectomy was done by Pelosi ***(Pelosi & Pelosi, 1992).***

In 1997, the first single incision laparoscopic cholecystectomy was done by Navarra using two transumbilical trocars and three transabdominal gall bladder stay sutures ***(Navarra et al., 1997).***

Single incision laparoscopic operations include: diagnostic laparoscopy, cholecystectomy, appendectomy, repair of all types of hernia (hiatus, inguinal and ventral),

fundoplication, splenectomy, nephrectomy, varicocelectomy and some types of colonic resections ***(Kalloo et al., 2004).***

Laparoscopic surgery has progressed rapidly in the last 2 decades. However, the desire to seek perfection for smaller scars, less pain (preferably in a single site), shorter recovery, and earlier resumption of routine activity has led to the performance of laparoscopic procedures through a single small incision. This had made the field of single incision laparoscopy one of the most promising topics in surgical research ***(Ponsky et al., 2009).***

AIM OF THE WORK

To study single incision laparoscopic surgery regarding current applications, advantages, disadvantages and future developments.

I - HISTORY AND DEVELOPMENT OF LAPAROSCOPIC SURGERY

Historical background:

• Early Development:

The use of speculum-type intracorporeal viewing devices dates to the Greco-Roman period, when Hippocrates (c. 460-377 BeE) performed anoscopy for diagnosis of fistula and hemorrhoids. However, technical limitations of light transmission and optical clarity inhibited use of such devices until the early nineteenth century, when Phillip Bozzini developed the Lichtleiter (light conductor) in 1805. This instrument employed a candle, mirrors, and various specula for viewing the rectum, vagina, urethra, and bladder ***(Underwood, 2004).***

The next major advance came in 1853 when Antonin Desormeaux developed his versatile endoscope that burned gazogene (alcohol and turpentine) as a light source and employed a lens system for narrowing and intensifying illumination of the visual field. Such scopes led to the development of internal speculum tip mounted platinum loop light sources, first invented in 1867 by Bruck, a dentist in Breslau, Poland. This device replaced and dramatically improved upon the previous external combustion light sources but was plagued by the problems of the thermal injury and

flare, which required angling the viewing lens away from the light source, severely limiting the visual field ***(Davis & Filipi, 1995).***

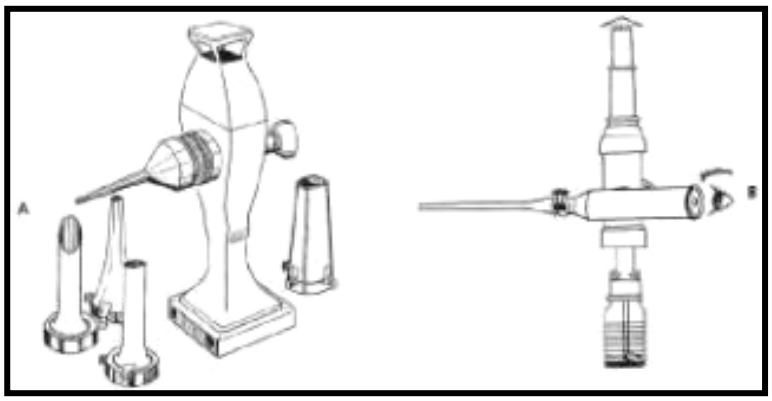

Figure 1: Showing (A) Original Lichtleiter with various specula. (B) Desormeaux endoscope *(From Underwood, 2004).*

Major breakthroughs during the late nineteenth century included the development of the incandescent bulb by Thomas Edison and the three-lens optical system by ***Maximillian Nitze and Reinecke***, both in ***(1879)***. Integration of these two technologies allowed the development of the first viable endoscopes\cystoscopes concomitantly by several individuals, including Newman of ***Glasgow in (1883); Leiter in (1886) and Nitze in (1887)***.

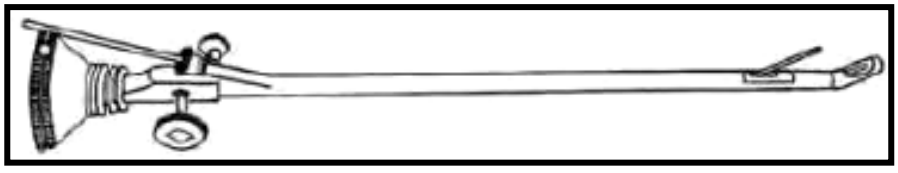

Figure 2: Showing Nitze cystoscope with incandescent globe and instrument channel for ureteral probe *(From Underwood, 2004).*

As a result of this early technology, most open cavity endoscopic procedures (i.e., those with access through natural orifices) had become common clinical practice by the end of the nineteenth century. It was not until the twentieth century; however, that closed-cavity endoscopy was attempted ***(Underwood, 2004).***

• Development of Diagnostic Laparoscopy and Thoracoscopy:

Laparoscopy (from the Greek lapro: the flank, and skopein: to examine) was first performed in 1901 by George Kelling of Dresden, Germany, using a Nitze cystoscope in a dog. He used it to peer into the abdomen of a dog after first insufflating it with air. Kelling named the procedure Kolioskopie and described it in a report published in Miinchener Medizinische Wochenschrift in January 1902. Interestingly, as a correlate to current health care motivations, Kelling later reported that his use of the laparoscope had rapidly escalated in the postwar period as a result of the sparse economic resources in Germany. His reasons were basic: smaller incisions, quicker recovery, and shorter, less costly hospital stay ***(Paolucci et al., 1997)***.

Figure 3: Showing Kelling performing Laparoscopy in a Dog *(From Paolucci et al., 1997).*

Eight years later in the same publication, Hans Christian Jacobaeus of Stockholm, Sweden, reported the first laparoscopy in humans, describing the endoscopic diagnosis of intraabdominal tuberculosis, cirrhosis, syphilis, and malignancy ***(Jacobaeus, 1910 and Litynski, 1996)***.

The use of CO2 to create a pneumoperitoneum was first recommended in 1924 by Richard Zollikofer of Switzerland. CO2 was preferred over air and nitrogen because of its nonflammable nature and rapid reabsorption by the peritoneum. The preferred route of insufflation was the Veress needle, introduced by ***Janos Veress of Hungary*** in ***(1938)***. This device incorporates a spring-loaded blunt obturator at its tip, which protects the internal viscera from the sharp needle tip. This device was originally intended for thoracic use in thoracocentesis to produce therapeutic pneumothorax; however, it quickly found favor among laparoscopists and today remains the preferred insufflation needle in many operating suites ***(Underwood, 2004).***

Figure 4: Showing Verses needle *(From Underwood, 2004)*.

• Development of Therapeutic Laparoscopy and Thoracoscopy:

Therapeutic applications for the endoscope were quickly realized in thoracic surgery as a result of the prevalence of tuberculosis in the early 1900s. The thoracoscope was used to lyse pleural adhesions to produce therapeutic pneumothorax (Open thoracotomy was not yet an option, since the endotracheal tube for selective ventilation had not yet been developed). Therapeutic laparoscopy evolved more slowly. In 1929 Kalk first described a dual trocar technique that he used for liver biopsy in, the German Kalk designed a lens system with a 45-degree scope to permit better inspection of the abdominal viscera ***(Kalk et al., 1929)***, and in 1933 a German general surgeon, Carl Fervers, was the first to report laparoscopic lysis of abdominal adhesions for bowel obstruction ***(Underwood, 2004)***.

Since the early 1930s laparoscopic tubal ligations have been performed by gynecologists around the world. Notably, in the United States the preferred abdominal endoscopic procedure through the mid-twentieth century was culdoscopy, as developed by American gynecologists Decker and Cherry. In Europe, gynecologists preferred the abdominal approach and called it gynecological celioscopy ***(Mori et al., 1995)***.

In 1937, the Hungarian Veress first described the use of a Veress needle for the creation of pneumoperitoneum ***(Veress et al., 1938).***

Figure 5: Veress needle *(Vecchio et al., 2000)*

Other gynecological applications of laparoscopy emerged both in the United States and Europe, fostering the development of the requisite instrumentation to perform these procedures (such as the first CO2 insufflator, developed by Hans Frangenheim of Germany in the late 1950s) as well as many general surgical procedures that remain popular today. The 1960s and 1970s brought two major developments that were essential to the widespread use of laparoscopy. The first was the introduction in 1960 of the rod-lens system by Harold Hopkins of England. This system increased the light transmission of previous scopes by approximately 80-fold. The second, in 1963, was cold light transmission via fiber optic cables developed by gastroenterologist Hirschowitz in Ann Arbor, Michigan. The combination of these two technologies positioned laparoscopy as a viable therapeutic modality for a variety of problems ***(Underwood, 2004)***.

As the array of clinical indications expanded, the sources of complications such as subcutaneous emphysema, air embolism, visceral perforation, bleeding, bums, hemodynamic and pulmonary compromise, and infection were more clearly delineated and addressed ***(Underwood, 2004).***

The automatic gas insufflator and the direct visualization technique of trocar placement were developments that directly addressed many complications in this burgeoning field. The automatic insufflator was designed by gynecologist and engineer Karl Semm in 1966 and greatly reduced the adverse effects of pneumoperitoneum, such as hemodynamic or pulmonary compromise and hypercarbia ***(Underwood, 2004).***

The technique of cut-down and direct visualization of the peritoneal cavity before placing a blunt obturated trocar was introduced by ***Hasson*** in ***(1974)*** and was called ober laparoscopy or the Hasson technique. This device and technique greatly reduced the incidence of visceral injury sustained from blind peritoneal trocar insertion ***(Underwood, 2004).***

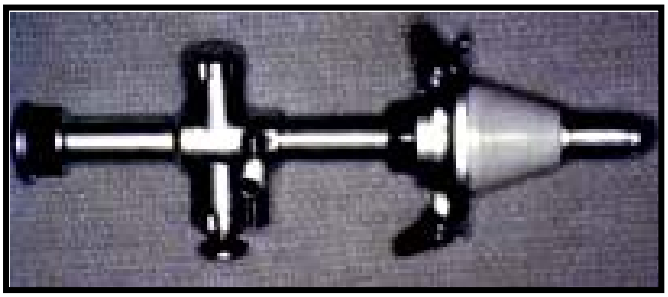

Figure 6: Showing Hasson's cannula *(From Underwood, 2004).*

Semm has played a major role in the development of laparoscopy, or, as he originally called it, operative pelviscopy. He introduced not only the automated insufflation system but also many other devices and techniques, such as the pretied suture endo-loop, the laparoscopic clip applier, the high-flow irrigator, and many operative instruments that serve specific needs in laparoscopy ***(Underwood, 2004)***.

• Laparoscopy in General Surgery:

The link that finally brought laparoscopy into the mainstream of general surgery was the development in 1985 of the charge coupled device (CCD) silicon chip solid state image sensor-the miniature video camera. This technology allowed all members of the operating team to view the operative field simultaneously from the same video screen orientation, as opposed to the now single-eyepiece viewing of the past. In 1987 Philippe Mouret performed the first human laparoscopic cholecystectomy in Lyon, France ***(Underwood, 2004)***.

From 1989 through 1991, it is estimated that approximately 20,000 American general surgeons received training in laparoscopic techniques. Laparoscopic cholecystectomy was quickly accepted as the gold standard for removing a diseased gallbladder ***(Underwood, 2004).***

The success with laparoscopic cholecystectomy has had a significant impact on the practice of general surgery and has led to the exponential development of other applications such

as laparoscopic appendectomy, adrenalectomy, inguinal herniorrhaphy, colon resection, antireflux procedures, bariatric procedures, hepatobiliary and pancreatic procedures, vascular procedures, as well as various intrathoracic procedures ***(Underwood, 2004).***

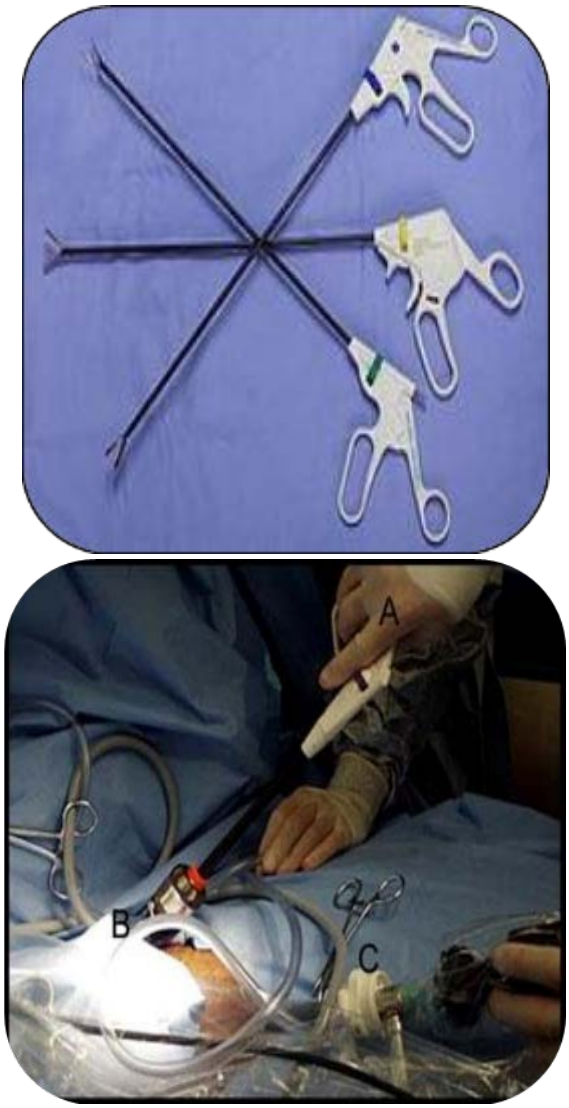

Figure 7: Modern Laparoscopic instruments *(Walid & Heaton, 2004).*

II - SINGLE INCISION LAPAROSCOPIC SURGERY

Development of single incision surgery:

Since single incision laparoscopic surgery procedures are relatively new and in evolution, many techniques happen to be described but no widely accepted standard exists. Single-incision laparoscopic surgery (SILS) was first described in the gynecology literature in 1969; tubal ligation being the first procedure routinely performed through a single incision at the umbilicus ***(Wheeless et al., 1969).***

The advent of SILS was in the field of gynecology. Wheeless reported on the first 4000 cases of SILS tubal ligation in 1969. The procedure was done using an offset eyepiece and a 5-mm working port to introduce instruments to perform the procedure. They reported that healing was “so satisfactory that no scar was grossly visible.” Since then, SILS tubal ligation has become the standard of care for elective female sterilization ***(Wheeless et al., 1969)***.

The first published report of SILS in general surgery appeared in 1992 with a SILS appendectomy by Pelosi in 25 patients ***(Pelosi & Pelosi, 1992)***.