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History and Utility of Single Port Laparoscopy, Robotic Assisted Laparoscopy, and Vaginal Laparoscopy (vNOTES) in Gynecologic Surgery

Conor J. Corcoran and Stephen H. Bush

Abstract

Minimally invasive gynecologic surgery is a rapidly growing field, with new modalities and methods being explored constantly. Since the inception of laparoscopic surgery, the goal has been to minimize incision size, which has been further extrapolated to focus on less incisions with Laparoendoscopic Single-site Surgery (LESS). Single site surgery has several advantages, disadvantages, and historically relevant utility. Throughout the ensuing text, the nuances of LESS will be explored and described in detail. Our purpose in this chapter is to explore the history and utility of single site surgery. We hope to set the stage for the extensive coverage and contents of the text to elaborate on LESS and its use in modern Gynecology.

Keywords: minimally invasive surgery, gynecology, surgery, laparoscopy, novel techniques

1. Introduction

From the very beginning, the field of surgery has been full of innovators who have made tireless efforts to optimize and innovate the art form, with each generation of surgeons seeming to reach new heights. The field of minimally invasive gynecologic surgery is no different. These achievements have touched almost all facets of minimally invasive surgery, including laparoscopy, robotic assisted laparoscopy, and natural orifice transluminal endoscopic surgery (NOTES). Laparoscopy has become ubiquitous in gynecologic surgery, most procedures that previously required laparotomy may now be accomplished in this fashion. This is in stark contrast to a few decades ago, where open procedures were the standard of care. Specifically, gynecology in particular has been a forefront for minimally invasive techniques, and one of the quickest specialties to accept laparoscopy. The rapid incorporation of minimally invasive techniques across the specialty of gynecology is likely secondary to two major reasons. First, the relationship between many surgeries and pre-menopausal ovaries leads to a traditionally younger patient population than many other specialties. Second, the exclusively female nature of gynecologic surgery patients means that patients may be more concerned with cosmesis than patients of other specialties.

In that same spirit of advancement, single site surgery has been implemented in Gynecology for the past five decades, with the first single port surgery described as early as 1969 [1]. These “single port” surgeries utilized mono-channel laparoscopic ports with instruments that have sheathed channels built into the polearm. Some physicians still routinely perform this modality of laparoscopy, particularly for tubal occlusion as was originally described in the landmark 1969 case report. The technique was utilized and commonly performed with various tools, ports, and techniques. The culmination, perhaps, was the first single port total laparoscopic hysterectomy, completed in 1991 [2]. For all intents and purposes, procedures similar to this technique dominated single port laparoscopic hysterectomy until 2009 [3, 4], with relatively few other techniques being described.

The modern description of single site laparoscopy revolves around the use of a larger, multichannel port, termed LESS (Laparoendoscopic Single-site Surgery). There were a multitude of studies reported in 2009 with varying methods, results, and outcomes. The general consensus from these texts were that LESS was a feasible and safe surgical method, with no significant increase in perioperative complications. Interestingly, the only field to have documented cases of modern single site surgery prior to gynecology was urology in 2007 [5], which is an intimately related field of medicine.

There are various descriptions of single site techniques. Most authors describe the fundamentals revolving around the concept of an approximately 3 cm umbilical incision into which a larger single port with multiple laparoscopic entry points within that port. Frequently, a wound retractor is placed at this peritoneal entry in order to protect the skin edges and provide an anchor for the port. From here, there are a wide plethora of surgical devices, tools, and specialized equipment described in the literature and surgical textbooks. Importantly, traditional static laparoscopic tools, which are readily available at most surgical theaters, are able to be used as in standard laparoscopy. This allows affordability and ease of access for most surgeons, thus preventing institutional limitations for single site.

LESS procedures have shown promise. Single site has distinct advantages: demonstrating improved cosmesis, decreased blood loss, and decreased complications [6, 7]. While many authors describe different techniques, specimen retrieval is usually facilitated within the single site incision, which may be inherently larger than traditional laparoscopic periumbilical incision. This is incredibly useful in situations where the specimen is large, allowing the surgeon to preoperatively plan a single site procedure if this scenario is anticipated. Those familiar with traditional laparoscopy will know the conundrum of extending the periumbilical incision versus morcellation, which may be circumvented because of the larger fascial incision used in single site procedures.

Of course, there are many drawbacks to single site modalities. These are elucidated in detail throughout this text. The general issues encountered include: instrument clashing, surgeon comfort, inability to triangulate, concerns for hernia rates, and anatomical limitations. Ironically, many of these technical issues were encountered by surgeons with the advent of laparoscopy itself, when open technique was the standard method of operating. Only time and practice will tell if single site surgery will achieve the standardization that other minimally invasive methods have achieved. Thus, most authors feel that we are experiencing a trial period in real clinical applications which will ultimately determine if single port laparoscopy will be a lasting standard or be relegated to the fad of a bygone era by future surgeons.

2. Single site laparoscopy

Interestingly, a large meta-analysis recently showed that across 6 major medical centers, the most common LESS procedure is cholecystectomy [8]. To that end, it

has been estimated that 96% of all cholecystectomies are performed laparoscopically [9], which lends itself to being a well-vetted laparoscopic modality ideal for single site surgery. What this overall represents is the rapid progress in all surgical fields in minimally invasive surgery. Indeed, with this growing captivation dominating the surgical fields of medicine, it is ever vital to construct and discuss the various modalities to provide a semblance of standardization. This has historical significance. Look, for example, at the landmark 1929 Richardson hysterectomy paper, which revolutionized hysterectomy technique. It set the tone of a generation of Gynecologists, which alongside antibiotics transformed a surgery that was considered highly dangerous into what is now: a generally safe and routine surgical procedure. It is our responsibility to produce such literature in order to advance the field.

While it is evident LESS has mass appeal, the significance of LESS in gynecology is particularly impactful. Its first applications in gynecology can be traced to adnexal surgery after provisional studies demonstrated safety [3, 4]. While its utility is rapidly expanding within the field of gynecology, a contemporary look into the available literature demonstrates a need for ongoing elucidative research.

As discussed above, the term LESS appeared in Gynecologic literature in 2009. LESS has been used for hysterectomy, myomectomy, and gynecologic malignancy. Many modifications have been made since that time and an equally broad assortment of variations have been described. The details of these will be discussed later in this book.

3. Single port robotic

Single port robotic assisted gynecologic surgery was next in the progression of single site procedures in gynecologic surgery. As has been well documented, the LESS procedure is limited by the technical difficulty, loss of triangulation, instrument clashing and reduced visualization. The robotic platform mitigates some of these limitations for single site surgery. The first semi-robotic LESS (R LESS) procedure was reported by Kane and Stepp in 2010 using a SILS port (Covidien, Mansfield, MA) and two ViKY Systems devices (Endocontrol Medical, La Tronche, France) to control the endoscope and vaginal manipulator. A total laparoscopic hysterectomy was then preformed using laparoscopic instruments [10].

The Da Vinci Single Site platform (Intuitive Surgical, Sunnyvale, CA) was approved by the FDA in 2013 for single site gynecologic surgery through the umbilicus. The da Vinci Si Operative system (Intuitive Surgical) compatible platform consists of a 2.5 cm semi-rigid silicone device with five separate lumens. The lumens were originally conceived to include one for the robotic camera, two for the curved robotic instrument sleeves, one for the insufflation port and one for accessory instrumentation administered by an assistant surgeon (**Figure 1**). The curved cannulas allow semi-rigid instruments to be placed through them. This crossing technique effectively reverses the left/right control of the instruments, requiring the device's software to convert the controls for same-sided hand-eye control so the surgeon's contralateral eye is controlling each arm. As a result of this the triangulation issue encountered with non-robotic LESS platforms is much diminished, and there is a notable decrease in instrument clashing.

There are several other single-port devices available for single site access. These include the above mentioned SILS Port Multiple Instrument Access Port (Covidien, Mansfield, MA), as well as GelPort (Applied Medical, Rancho Santa Margarita, CA), and Uni-X Single Port system (Pnavel Systems, Cleveland, OH), and Quad Port (Advanced Surgical Concepts, Bray, Ireland). The GelPort device (**Figure 2**) has been used more recently, for reduced port R-LESS with two incisions. A traditional umbilical incision and one additional lateral abdominal wall incision for one of



Figure 1.
Depiction of robotic arm positioning and orientation with single site surgery.

the robotic arms, allowing for a robotic laparoscope, instrument and assistant port through the umbilical incision.

The most recent development in R-Less surgery is the approval of the da Vinci SP (Intuitive Surgical, Sunnyvale, CA) platform. This platform was approved by the FDA in the fall of 2018 and was 14 years in development. There is a single 2.5 cm cannula which 3 fully wristed and elbowed instruments as well as a fully wristed endoscope pass. It is able to reach 24 cm in depth and the triangulation occurs at the tip of the instrument. Anatomy can be reached from 360 degrees from one port placement. (**Figure 3**). Although initial data supporting this device for gynecologic surgery is not yet available, there is currently significant utility in urological

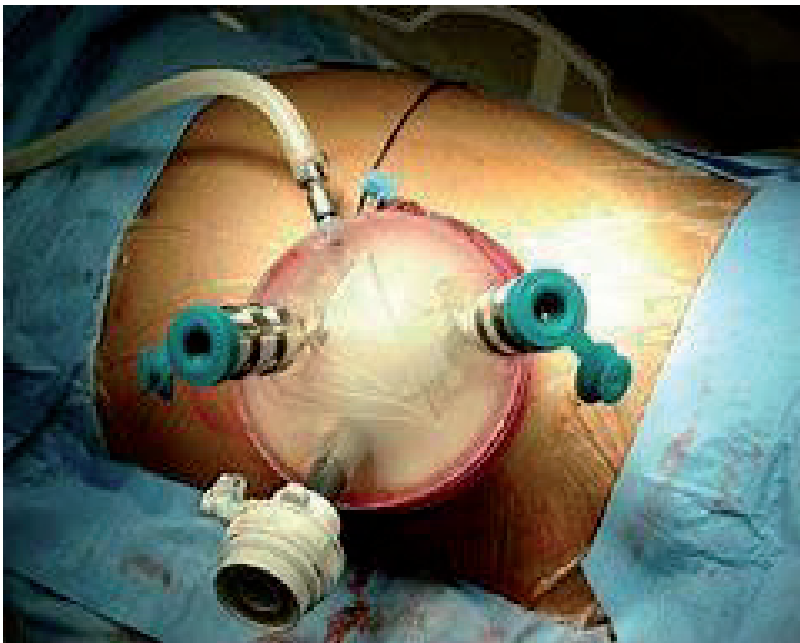


Figure 2.
Single-site Gelport ready for docking.



Figure 3.
Single channel robotic arm with multiple instruments.

surgery, and this technology clearly has the potential to further minimize the invasiveness of gynecologic surgery.

4. Vaginal natural orifice transluminal endoscopic surgery (vNOTES)

Natural orifice surgery (NOTES) originated in Gastroenterology/General Surgery circa 2004, utilizing rectal and oral endoscopy to visualize the peritoneum through specific visceral organ sites, such as the fundus of the stomach [11]. NOTES was heralded as a novel method of peritoneal access, subverting the need for skin incisions.

Approximately 10 years later, NOTES has been applied to gynecology by several authors. It was piloted first by Dr. Baekenlandt in the setting of hysterectomy, demonstrating feasibility and safety [12, 13] of the technique. It was developed further for other applications, predominately adnexal surgery via posterior colpotomy while maintaining the uterus. Although there has been limited adoption in the US, this technique has reached faster acceptance internationally, with a high percentage of laparoscopic procedures currently being completed using this method in Taiwan [14–16]. Preliminarily, many early studies have found lower blood loss, shorter hospital stay, and less postoperative pain with vNOTES procedures compared to other accepted modalities [17, 18].

For Gynecologists, it is well known that the vaginal epithelium rapidly heals. Vaginal surgery has been performed safely for generations from vaginal hysterectomies to the historic culdocentesis. In many ways, vaginal surgery has been the conventional “natural orifice” surgery. NOTES, therefore, naturally lent itself to gynecologic surgery. vNOTES is particularly useful for adnexal surgery at the time of vaginal hysterectomy, which offers safe, direct visualization of adjacent anatomy. This is particularly useful in light of the growing evidence suggesting that opportunistic salpingectomy may reduce the risk of epithelial ovarian cancers [17].

While this field is in its infancy in the United States, the technique has great potential to meaningfully impact the field of Gynecology. It combines the techniques of our predecessors with novel technology. In the opinion of some authors, this comes at a critically important time, as the classical vaginal surgical skills in Gynecology are at risk of being lost in many academic settings. Vaginal hysterectomies in general practice and in OB/GYN residencies are decreasing [15, 16] in favor of laparoscopic procedures. This is an unsettling trend, where a procedure that was once the hallmark of gynecologic surgery appears to be phasing out slowly. Many authors suggest that a strong benefit of full acceptance of vNOTES techniques in

gynecology will be the maintenance of the vaginal surgery skills. Many consider these skills and techniques of vaginal surgery to be the original first steps towards a minimally invasive culture in gynecology, and that they were seen as the original “calling card” of our field for much of the specialty’s existence.

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