

Laparoscopic Suturing as a Barrier to Broader Adoption of Laparoscopic Surgery

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ABSTRACT

Background: Laparoscopic surgery is increasingly replacing the open procedure because of its many patient-related benefits that are well aligned with policies and programs that seek to optimize health system performance. However, widespread adoption of laparoscopic surgery has been slow, in part, because of the complexity of laparoscopic suturing. The objective of this study was to review the clinical and economic impacts of laparoscopic suturing in key procedures and to assess its role as a barrier to the broader adoption of laparoscopic surgery.

Database: A medical literature search of MEDLINE, EMBASE, and BIOSIS from January 2010 through June 2016 identified 47 relevant articles.

Conclusion: Laparoscopic suturing and intracorporeal knot tying may result in extended surgical time, complications, and surgeon errors, while improving patient quality of life through improved cosmesis, diet toleration, and better bowel movements. Despite advancement in surgical techniques and the availability of newer surgical tools, the complexity of laparoscopic suturing continues to be a barrier to greater adoption of MIS. The results of the study underscore the need for development of proficiency in laparoscopic suturing, which may help improve patient outcomes and reduce healthcare costs.

Key Words: Adoption of minimally invasive surgery, Intracorporeal suturing, Laparoscopic surgery.

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INTRODUCTION

Minimally invasive surgery (MIS) has revolutionized surgical approach, decreasing surgical trauma and improving patient outcomes. MIS includes several specialized surgical procedures, such as endoscopic, laparoscopic, and thoracoscopic surgeries, as well as robotic surgery. Laparoscopic surgeries, among the first types of MIS, are enabled by surgical instruments specially designed to reach internal organs through very small incisions. As a technique, MIS began in the 1950s with the first polypectomy performed with a rigid endoscope.¹ However, perhaps no other surgical procedure has been so profoundly affected by the advent of laparoscopic surgery than cholecystectomy. The first reported laparoscopic cholecystectomy was performed in 1987,² and within 5 years, the laparoscopic technique of performing routine cholecystectomy became a recognized alternative to open approaches.³⁻⁶ The initial rapid adoption of laparoscopic surgery for performing cholecystectomy was related to patient demand, rather than the performance of clinical trials. Today, laparoscopy is being used for many surgical procedures, and with continued technological advances and training, is now also being considered for more advanced surgical procedures.

However, the adoption of a laparoscopic or thoracoscopic approach in some surgical specialties is limited by the technical difficulty associated with MIS.⁷ Of the various technical difficulties, this review article focuses on laparoscopic suturing or intracorporeal suturing in laparoscopic surgery. The objective of this study was to review clinical and economic impacts of laparoscopic suturing in key procedures and assess its role as a barrier to the broader adoption of laparoscopic surgery.

METHODS

A search of the medical literature was conducted to identify publications describing intracorporeal and extracorporeal suturing during laparoscopic or endoscopic surgery. The biomedical databases MEDLINE, EMBASE, and BIOSIS were searched for the period from January 2010 through June 2016. Titles were searched using terms including variations of intracorporeal suturing *or* laparo-

scopic *or* endoscopic *or* suturing *or* stitching. Terms were truncated by using wild cards to allow for pluralization and spelling variations. The results were filtered with a key word search of the full citation, abstract, and descriptor for laparoscopic *and* suturing *or* intracorporeal *or* extracorporeal.

RESULTS

Literature Search

The literature search yielded 129 articles that referred to laparoscopic suturing in the title and abstracts. Of those articles, 48 had intracorporeal suturing referenced in the title only. In addition, 21 referred to suturing in the laparoscopic versus open context. All articles were manually reviewed for relevance. References were extracted from the review articles and checked by cross-referencing with the existing article database. This method identified 6 additional articles.

In total, 206 articles were reviewed for relevance to our current topic of interest. From these, case reports, conference abstracts, and articles not directly relevant to laparoscopic suturing were excluded, which resulted in a final full-text review of 47 articles. Results are summarized below.

Benefits of Laparoscopic Surgery

The laparoscopic approach to surgery relies on visualization and manipulation with a 2-D video on a screen that is obtained by passing an endoscope into the body cavity. Similarly, execution of surgical manipulation is performed by passing instruments through a trocar and working at a distance from the opening. The laparoscopic approach has several inherent benefits compared to open surgery. The primary benefits are earlier patient recovery, shorter hospital stay, fewer postoperative complications, and greater patient satisfaction.^{8–20}

For example, compared to open cholecystectomy, the laparoscopic procedure results in decreased postoperative pain and a decreased need for postoperative analgesics. Hospital stays that typically were about 1 week have been reduced to less than 24 hours, and patients are able to return to full activity within 1 week rather than the 1 month required for recovery after open cholecystectomy.^{8,9}

With the gradual replacement of the traditional open approach with the laparoscopic technique across bariatric,

colorectal, and gynecologic surgical situations, significant patient benefits have remained a consistent finding. The laparoscopic Roux-en-y gastric bypass, considered the gold standard for weight loss surgery, provides patients with superior weight loss, and excellent resolution of the associated comorbidities.^{10,11} Likewise, clinical benefits provided from laparoscopic colorectal operations include decreased complications, mortality, and readmission rates, shorter hospital stays, and a decreased need for skilled nursing care.^{12–16} Others have demonstrated that laparoscopic surgeries improve cosmesis, reduce postoperative pain, and facilitate a rapid return to normal activities.³ Finally, compared to open hysterectomy, the total laparoscopic hysterectomy (TLH) results in reduced patient morbidity related to the smaller incisions and lower blood loss, and patients experience a lower infection rate with fewer postoperative adhesions.^{17–20}

Laparoscopic surgery allows the surgeon a better view of the anatomy and, in performing TLH, fibroids, adhesions, and endometriosis, can be identified and accurate dissection is better facilitated.²¹ Laparoscopic surgery also enables the treatment of endometrial and cervical cancers.^{22,23} Similarly, laparoscopic colectomy is being increasingly adopted for treatment of benign and malignant colonic lesions,^{24–28} and similar oncological outcomes have been demonstrated for intracorporeal versus extracorporeal anastomosis.²⁹

Laparoscopic Suturing as a Key Barrier to Widespread Adoption of Laparoscopic Surgery

Even though the laparoscopic approach has improved the patient's experience significantly, widespread adoption of it remains limited. For example, although for the treatment of gynecological diseases laparoscopic surgery is generally considered equivalent or superior to laparotomy, less than 60% of benign ovarian masses in adolescents are treated with laparoscopy³⁰ and fewer than 15% of hysterectomies are performed by this method.^{31–33}

Laparoscopic surgery can be challenging to master and requires a different set of skills from open surgery. The surgeon has a limited range of motion and must enter the body cavity through a small incision and use instruments with limited visibility in a crowded surgical field. The tool endpoints move in the opposite direction to the movement of the surgeon's hands because of the pivot point, making movements nonintuitive and difficult to learn.³⁴ Visualization of the procedure occurs using a 2-dimensional monitor at a distance with limited haptic feedback.^{35–37} In addition, the proximity to critical anatomical

structures and the limitation in regaining control of an emergent situation without direct access to the anatomical structure adds to the complexity of the laparoscopic approach.³⁸

Recently, Weizman et al³⁹ conducted a survey of practicing gynecologists to identify challenges that impede more widespread adoption of laparoscopy. According to their study, the key factor that limits use of laparoscopy includes laparoscopic suturing along with other technical and practical limitations (**Table 1**). It should be noted that even the surgeons who perform most of their own laparoscopic cases rather than referring for laparoscopy, rated laparoscopic suturing as the most limiting factor of all potential barriers. They also looked at the likelihood of avoiding laparoscopy by conducting a logistic regression analysis and confirmed that laparoscopic suturing increases the likelihood of avoiding laparoscopy by an odds ratio (OR) of 2.41, along with other key limiting factors.

Although suturing is a basic skill for all surgeons, laparoscopic suturing and knot tying can be tedious, time-consuming, and frustrating. Laparoscopic suturing is probably the most difficult skill to master in the MIS environment because of the limitations of laparoscopic surgery, such as altered depth perception, 2-dimensional vision, counterintuitive movements, dependence on visuospatial skills, and small working field.^{40,41}

Even for surgeons who are considered experienced in laparoscopy, suturing and knot tying often have been ranked as a significant barrier.³⁹

In sacrocolpopexy, the laparoscopic approach offers reduced morbidity, shorter hospitalization, and decreased postoperative pain. However, the barriers to greater adoption of the laparoscopic approach include longer operating time and the need for advanced laparoscopic surgical skills, including suturing.⁴² The technical challenge of laparoscopic sacrocolpopexy is also suggested by Gabriel

et al,⁴³ who concluded that the lack of endoscopic suturing skills is the cause of lengthy learning curves and long operation times.

In a review of published literature regarding pancreaticoduodenectomy (PD) for pancreatic adenocarcinoma, Baker et al⁴⁴ suggest that the demanding technical requirements of performing a minimally invasive PD have proven a very steep hill to climb for most surgeons in their attempt to improve outcomes after major pancreatic resection. For laparoscopic PD, the authors suggest that the pancreatic and biliary anastomosis requires meticulous and precise suturing skills that are not easily mastered.

Complexities of Laparoscopic Suturing

Complications related to suturing during laparoscopic surgery can vary, depending on the specific surgery being performed. For instance, suturing during vaginal cuff closure is considered a rate-limiting step for laparoscopic hysterectomy, and suturing difficulties can result in vaginal cuff dehiscence. Uccella et al⁴⁵ found a higher incidence of vaginal dehiscence for laparoscopic (0.64%) as compared to open transvaginal (0.18%) cuff closure. A possible explanation is that the magnified view during laparoscopic surgery causes the surgeon to use too little tissue and tension in closure.⁴⁵ On the other hand, suturing of excessive tissue during vaginal cuff ligation can induce too much tension and cause ureteral obstruction by kinking.⁴⁶ Thus, urinary tract injury is one of the inherent risks associated with TLH.

The extended surgical time needed to perform laparoscopic suturing and knot tying is a universal challenge for laparoscopic surgeons. Analyses in numerous studies have shown that a longer duration of anesthesia is associated with negative outcomes (hospital stay of >10 d, with a morbid condition or death), postoperative nausea and vomiting, thromboemboli, postoperative infection, postoperative core hypothermia, postoperative cardiopulmonary complications, and death in cosmetic surgery.⁴⁷ Procter et al⁴⁸ in an analysis of a database of 299,359 surgical operations across 173 hospitals, found that operative duration is independently associated with increased risk-adjusted infection complications and length of stay.

Within the urology discipline, laparoscopic pyeloplasty is one of the most commonly performed reconstructive surgeries where laparoscopic suturing is related to the clinical outcome.⁴⁹ Prolonged procedure times, intense concentration, and complex suturing are associated with surgeon fatigue and more frequent errors.³ In this procedure, the use of continuous suturing as opposed to inter-

Table 1.

Most Limiting Aspects for Surgeons Performing Laparoscopic Gynecologic Surgeries³⁹

Aspect

- Lack of case volume
- Discomfort with unexpected scenarios
- Video-eye-hand coordination
- Depth perception
- Laparoscopic suturing

rupted suturing has been shown to reduce suturing time from 64 to 55 minutes ($P < .001$).⁵⁰ Whereas the use of continuous laparoscopic suturing is commonplace in adult pyeloplasty surgery, it is still not routine for pediatric pyeloplasty, in part because of the small operating space.⁵⁰

Benefits and Potential of Laparoscopic Suturing

The benefits of laparoscopic suturing have been demonstrated in colorectal surgery. Hellan et al⁵¹ showed those benefits in a retrospective review of data collected from records of 80 consecutive patients who underwent laparoscopic right hemicolectomy. The researchers found that the incision length was significantly shorter in the intracorporeal group, compared with the extracorporeal group, and that an intracorporeal anastomosis may also be associated with fewer wound-related complications when compared with extracorporeal anastomosis. Their findings also suggested an advantage of the intracorporeal anastomosis in obese patients with a short or very heavy mesentery, thanks to its technique eliminating the need to exteriorize heavy mesentery and large specimens through a small incision in a thick abdominal wall.

A case-control study⁵² showed that intracorporeal anastomosis for right colectomy resulted in improved cosmesis (shorter incision length) and patient comfort, despite no difference in the major short-term outcomes compared with extracorporeal anastomosis. This study particularly highlighted improved postoperative outcome by indicating that for the intracorporeal anastomosis (totally laparoscopic colectomy) group versus the extracorporeal (laparoscopic-assisted colectomy) group, there was significantly less postoperative vomiting, with reinsertion of a nasogastric tube, earlier return to normal diet toleration, and earlier return of bowel movement.

As such, although difficult, acquiring and mastering laparoscopic suturing skills can be important requirements for delivering better and more efficient surgical care for patients through the adoption of minimally invasive approaches. Such skills can be acquired with extensive training, based on the principles of modeling, repetitive practice, and formative feedback.^{53,54}

The continued introduction of tools to aid in developing the skills needed to perform laparoscopic surgery proficiently have helped some to facilitate adoption of the technique across multiple surgical disciplines. Because laparoscopic suturing is an essential skill for performing laparoscopic surgery, needle drivers, knot pushers, and knot-tying devices have been developed to facilitate the

process and help reduce operative time and surgeon fatigue. Needle drivers are used to grasp and manipulate needles and allow free-hand suturing within the body. Free-hand suturing is considered an essential skill for the urologist performing reconstructive procedures such as laparoscopic pyeloplasty, laparoscopic partial nephrectomy, and laparoscopic radical nephrectomy.⁵⁵

More sophisticated suturing devices have been developed to further aid in acquiring laparoscopic suturing skills and include the Endo Stitch (Medtronic, Mansfield, Massachusetts, USA), the Suture Assistant (Ethicon Endo-Surgery, Cincinnati, Ohio, USA), and the da Vinci Robotic system (Intuitive Surgical, Sunnyvale, California, USA). Endo Stitch is an automated suturing device that uses traditional surgical technique, but does not involve a steep learning curve. The da Vinci Robotic system was developed largely to aid in the improvement of laparoscopic suturing with its 3-dimensional visualization, 7-*df* wristed motion, and improved ergonomics. The attributes of the da Vinci Robotic system have led to its attractiveness to surgeons in the gynecological field, where vaginal cuff closure remains a challenging procedure. However, a lack of haptic feedback and high cost still limit its widespread use. Integral to the evaluation of the effectiveness of any new tool should be an analysis of the costs relative to the overall benefits.

DISCUSSION

Despite advancement in surgical techniques and the availability of newer surgical tools, the complexity of laparoscopic suturing and intracorporeal knot tying continues to be a barrier to greater adoption of MIS approaches for many procedures—thus, often compromising potential patient benefits. This concern is an increasing one, in view of the recent trends driven by healthcare delivery and financing policies across the globe and in the United States.

For example, improving the quality of care while controlling cost is a major focus for The Centers for Medicare and Medicaid Services (CMS) in the United States. Their value-based purchasing (VBP) system links hospital payments to quality of inpatient care, rather than solely to the quantity of services provided. Thus, improved patient outcome data from performing laparoscopic surgical procedures could positively impact a hospital's quality assessment. As an example, laparoscopic hysterectomy has been associated with a lower incidence of infections,^{17–20} and hospitals performing more laparoscopic procedures, as opposed to open hysterectomies, may earn a more favorable quality score and higher payment percentage as a result.

In fact, CMS has added surgical site infections²⁶ after colon surgery and abdominal hysterectomy as measures that contribute to a hospital's total performance score (TPS).⁵⁶

Quality of hospital care is also being evaluated from the patients' perspective with a standardized survey instrument entitled the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS)⁵⁷ survey. The HCAHPS survey provides a mechanism to identify hospitals that perform procedures, such as laparoscopic surgery, that may provide patient benefits such as decreased length of hospital stay, decreased pain, and reduced pain management medication, among others. Improvement in surgeons' ability to suture laparoscopically and tie knots intracorporeally could serve as a significant motivator for providers to convert to more MIS procedures, where appropriate.

Although improvements in laparoscopic suturing could serve as a motivator for providers, difficulty with the skill is but one of several barriers. These other barriers include, but are not limited to, surgeons' performing an insufficient number of cases to maintain their skills, management of unexpected surgical events, video-eye-hand coordination, and altered depth perception.³⁹

Although reviews and assessments highlight the problem, it is necessary for the medical community to continue to improve surgical techniques and establish education centers to continue to refine their programs and for suppliers to develop new cost-effective technologies to aid the surgeons. A unified approach is needed across the healthcare industry to address these barriers to laparoscopic surgery, including laparoscopic suturing.

CONCLUSION

Laparoscopy has revolutionized surgery by decreasing surgical trauma and improving patient outcomes. Although it has become the procedure of choice for routine gall bladder removal, it has not yet been widely adopted across surgical disciplines. This slow rate of broad acceptance is caused, in large part, by the steep learning curve required for the surgeon to develop new skills, such as laparoscopic suturing. Education programs have been implemented that are providing more life-like experiential training to novice laparoscopic surgeons. Likewise, the introduction of mechanical suturing devices has facilitated laparoscopic suturing and knot tying, and at the same time, decreased the steep learning curve that is often seen as a barrier to adoption of laparoscopic surgery. Consequent with the development of proficiency in performing

laparoscopic surgery, favorable clinical and economic outcomes can be expected for patients and healthcare facilities well aligned with the goals of healthcare delivery and financing policies.

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