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EDITORIAL

Increasing the relevance of laparoendoscopic single-site surgery

Introduction

Early in its infancy, the practice of laparoscopy was undertaken with some trepidation because of fear that it was risky. Clearly that has changed. We are now in the midst of an era where laparoscopy is commonly used in surgery. For some operations, such as cholecystectomy and anti-reflux surgery, laparoscopy is nearly uniformly applied (1–3). For other areas of surgery, such as colectomy, use of laparoscopy is on the rise.

Laparoscopy has moved beyond simple operations into application with complex procedures. Now, laparoendoscopic single-site surgery (LESS) surgery offers advancements beyond laparoscopy, and it may herald a paradigm shift in surgery. However, questions about the relevance of LESS remain.

Relevance implies many things: significance, importance, weight, meaningfulness, application, and consequences, to mention a few. To achieve relevance, LESS surgery must be significantly different and better than conventional laparoscopy, and the public and medical communities must be aware of it so that it is requested, learned, and applied. How will all of this happen? Achieving relevance in the medical world has no distinct algorithm. Traditional laparoscopy has gained in popularity and relevance within the surgical realm over the past two decades, while LESS operations are novel and on the brink of implementation within "advanced" surgical practices. To be truly relevant, LESS surgery needs to be within the practice and repertoire of all general surgeons across the United States and beyond. Relevance of LESS surgery will increase by raising the awareness and application of LESS surgery within the surgical community. Catalyzing this awareness starts with clearly defining LESS surgery.

Background

LESS surgery is laparoscopic surgery undertaken through a single point of access (i.e. one incision), usually through the umbilicus (4–16). First and foremost, LESS surgery is about "no scar." The premise of LESS surgery is that an incision in the umbilicus can be completely hidden and that the same operations commonly undertaken utilizing conventional laparoscopy can be safely undertaken through the umbilicus alone (4–16). The focus of LESS is on cosmesis and safety. Inherent in this is the notion that patients will *love* LESS surgery, and thus, more patients will demand this type of surgery. However, "no scar" does not totally define LESS surgery.

There is more to LESS surgery than simply cosmesis. Decreased postoperative pain, decreased hospital length of stay, reduced wound infections, and reduced incisional complications are a few of the clinical measures that have conventionally promoted laparoscopy over open operations (17–20). Relative to conventional laparoscopy, LESS surgery may be promoted by these same measures, as it offers similar advantages, with the added benefit of "no scar."

LESS surgery provides equal access to all quadrants of the peritoneal cavity and pelvis. For example, when employing conventional laparoscopy, it is difficult to perform a pelvic operation such as a hysterectomy after undertaking an operation in the upper abdomen such as a cholecystectomy. A cholecystectomy generally involves multiple incisions and trocars placed in the upper abdomen. The initial trocar placement is ill suited for exposure and dissection once the cholecystectomy is complete and attention turns to the pelvis. With equal access to all quadrants, LESS surgery promotes "bundling" of procedures such as combining a cholecystectomy with a hysterectomy or an anti-reflux procedure with a tubal ligation. Equal access to all quadrants promotes more complex operations not widely undertaken with laparoscopy such as a pancreaticoduodenectomy or a total abdominal colectomy. LESS surgery offer the ability to expand procedures (not easily) undertaken with conventional laparoscopy. Moreover, LESS surgery can be the cornerstone on which multitrocar/multi-incision laparoscopy is undertaken. For instance, a difficult operation started with LESS surgery can be converted to more conventional (i.e. multitrocar/multi-incision) laparoscopy with the addition of trocars in unapparent places such as lateral to the anterior axillary line.

Implications of LESS surgery

There are many questions about LESS surgery. Does it lead to less postoperative pain? Is length of hospital stay and confinement reduced after LESS surgery? Relative to conventional laparoscopy, how does LESS surgery lead to

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a quicker return to regular activities? Does converting conventional laparoscopy's multiple incisions at multiple sites to a single incision at the umbilicus lead to fewer incision problems such as hernias and infections? Will there be a particular role for LESS surgery with hybrid procedures such as laparoscopy and NOTES (21,22)? Can LESS surgery be thought of as a building block for multi-incisional laparoscopy? In other words, can operations be initiated with LESS surgery techniques and have trocars and ports added so that ultimately there are fewer incisions than had conventional laparoscopy been performed?

These questions are telling but remain unanswered. Only through further study of LESS surgery will the answers become apparent. However, early experience with LESS surgery suggests that many of the perceived benefits, such as decreased postoperative pain, shorter hospital stay and a quicker return to regular activities, are indeed real. Additionally, our experience indicates that incision problems are not frequent after LESS surgery and that incisional hernias at the umbilicus are no more common after LESS surgery than after conventional laparoscopy. The cosmesis associated with LESS surgery is very favorable relative to conventional laparoscopy. While admittedly not all patients care much about cosmesis after laparoscopic surgery, some patients care a lot. Additionally, emphasizing its low level of invasiveness and its unapparent scarring, early advocates of NOTES have embraced transumbilical LESS surgery techniques to promote safety with NOTES.

There are other advantages to LESS surgery that are more consumer-oriented. For example, surgeons who embrace LESS surgery will gain attractively marketable skills that promote practice development. Patients will seek LESS surgery because of the perception that cosmesis is associated with other advantages such as reduced pain and a quicker return to usual activities. They may also equate the quality of the operation undertaken with the appearance of the incision and scar. Similarly, patients may associate the cosmetically appealing nature of LESS surgery with the "elegance" of the surgeon and the surgeon's ability to provide first-class treatment in general.

To increase the relevance of LESS surgery, awareness of the surgery must be raised and LESS surgery must be more commonly applied. Ultimately, the increased relevance and application of LESS surgery will be market driven, similar to what occurred with laparoscopy. Shortly after its emergence in the late 1980s, surgeons often claimed that there was no need for laparoscopy in their practices because they could undertake many procedures, such as cholecystectomy, with a very small incision. Those surgeons have since retired, gone out of business, or adopted laparoscopy. In the general sense, there is no need for general surgeons who do not have laparoscopic skills.

Introducing and implementing LESS surgery

Currently, it seems that LESS surgery will become relevant through a number of factors including patient demand, surgeon acceptance, practice development, and industry support. It is not a matter of *if* the relevance of LESS surgery will increase, but rather of *how* it will increase. This is *the* issue.

LESS surgery will become more relevant because of greater public awareness. Marketing for LESS surgery will occur at all levels by all parties. To raise professional awareness, industry will promote its innovative products for specific facets of LESS surgery and will play a major role in educating surgeons and introducing competition into a given geographic area by training a few regional thought-leaders. Also, major presentations at national meetings will be a driving force for the adoption of LESS, as will an increasing number of publications in peer-reviewed journals supporting the advent and application of LESS surgery.

Surgeons will increase public awareness of LESS surgery by employing it in their practices and promoting it; in turn, this will allow surgeons to highlight their position as early adopters of innovative procedures and techniques. By presenting information about new developments in surgery, the media, including print and television, will be involved as well. Additionally, patients will promote the spread of LESS surgery by relating their successful outcomes to friends and neighbors and, at the same time, promoting the hospitals and physicians that provided such advanced and optimal care.

Demand from the public, and thus from surgeons, as well as industry support will lead to a greater number of training opportunities, and as more surgeons become adept at LESS surgery, it will become more widely available and commonplace. Ultimately, increased public awareness of LESS surgery and its increased application will likely go hand in hand.

Promoting conventional laparoscopy

LESS surgery can only be widely implemented after the widespread application of laparoscopy. As understanding of the principles of surgery is paramount before undertaking laparoscopy, understanding the risk, ramifications, and potential complications, as well as the conduct of, laparoscopy is important prior to application of LESS surgery. Laparoscopic surgery is generally employed more by general surgeons than by gynecologists. However, within general surgery there is a relatively large variance

in the use of laparoscopy. For example, surgeons focusing on the foregut (e.g. cholecystectomy, anti-reflux surgery, and splenectomy) utilize laparoscopy more frequently than do surgeons that focus on hindgut such as colorectal surgeons. For LESS surgery to become more relevant, utilization of laparoscopy must increase, meaning more surgeons will need to perform colectomies and hysterectomies with laparoscopy. Ultimately, the increased application of laparoscopy will promote the application of LESS surgery.

It will take time for the standard of care to change, and this will involve great efforts on many fronts. Firstly, there needs to be a plan to improve the application of laparoscopy across disciplines, which requires education and training across disciplines and areas of expertise within disciplines. This must occur before the application of LESS.

There are many reasons why laparoscopy has not been widely accepted in some fields of surgery. Laparoscopy involves skills that are often dissimilar to skills learned with open surgery. For example, suturing and knot tying are very different with laparoscopy than with open surgery. Also, techniques with imaging differ; seeing with a scope is not direct visualization. Instrument length and versatility are often limiting with specific procedures. Improvements in instrumentation undoubtedly will accompany an increase in the application of laparoscopy across disciplines and throughout surgery.

Centralization of care in major medical centers that provide specialized services also limits widespread adoption of laparoscopy. For example, given that certain procedures, such as Heller myotomy with anterior fundoplication for achalasia, are more commonly undertaken in large referral medical centers, it is more likely that laparoscopy can and will be utilized to complete them. The skills to do these operations may not translate to smaller hospitals, despite the applicability of these skills to more common procedures, such as cholecystectomy. Training centers are more likely to undertake laparoscopy and be early adopters of LESS surgery because of the inherent need to embrace change when training the surgeons and physicians of tomorrow.

Widespread use of laparoscopy is also limited by specialty isolation. Unfortunately, gynecologists and general surgeons do not commonly intermingle enough to promote cross-fertilization of novel techniques across specialties. Within general surgery, while proactive leaders in colorectal surgery embrace laparoscopy, surgeons undertaking colon and rectal surgery inside and outside of the specialty of colorectal surgery are generally unlikely to use laparoscopy for these procedures. Better communication between laparoscopic surgeons and colorectal surgeons undertaking operations of the colon and rectum would promote widespread application of laparoscopy. As LESS surgery builds upon the skills and technology involved in laparoscopy, there needs to be a general transition from laparoscopy to LESS surgery across disciplines. Such transference must involve the acquisition of the necessary instruments and technology including imaging, access ports, instruments, and special instrumentation, and of course, competence in using these tools. For LESS surgery, imaging will evolve into bright, high-definition flexible scopes with deflectable tips; the scopes will have to be small to minimize space at points of access. The design of instruments in imaging must aim to decrease clutter at points of access, which will require changes to how the light source joins the laparoscope and how the image leaves the laparoscope. No longer will a light source join into a laparoscope at 90°. Rather a light source will join the scope at the scope's rear and leave in a straight line to minimize clutter at the operative site. Ultimately, cordless scopes will become the standard to minimize clutter. Subsequently, the goal will be to develop cordless, wireless, and self-powered intraperitoneal imaging devices.

Development and future direction

Ports involved in LESS surgery are evolving. The recent development of multiple access ports has dramatically improved the undertaking of LESS surgery (4,23,24). These new ports allow multiple instruments to be inserted through a single incision at the umbilicus. They reduce scarring tremendously and minimize several of the earlier difficulties with LESS surgery, such as air leaks and excessive interaction among the heads of trocars. New ports designed specifically for LESS surgery can be placed through small (i.e. 12 to 14 mm) incisions. These ports avoid injury and damage to the umbilicus and the abdominal wall fascia that used to occur when multiple individual ports were placed at and near the umbilicus. The de-epithelialization and injury to the skin above the umbilicus is now uncommon.

Instrumentation is evolving, as well. LESS surgery was initially encumbered by instruments designed more for conventional laparoscopy than for laparoscopy through the umbilicus alone. As such, instruments were often not long enough. Now, long, stout, thin, and articulating and reticulating instruments are appearing. For example, there are numerous examples of small (2 mm) instruments that serve as adjuncts to LESS surgery and as a further alternative to conventional laparoscopy. These needlescopic instruments offer an alternative to conventional laparoscopy and provide a poor half brother to LESS surgery. Articulating and reticulating instruments are being developed to promote complex intraperitoneal

and intrapelvic motion with a simple turn of the wrist, but the role of these instruments needs to be fully defined. Currently, some surgeons involved in the development of LESS surgery embrace these instruments while some abhor them. We do not routinely use them. Ultimately, the utilization of articulating and reticulating instruments will depend upon how they augment the skills of general surgeons and how these surgeons adopt these advances in an effort to comfortably and safely apply innovative techniques.

Relevance of LESS surgery is also being improved as special instruments for retraction, suturing, knot tying, stapling, and many of the tasks integral to laparoscopy develop. Newly created tools and robotics, such as the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, USA), will help facilitate the implementation of LESS surgery (25). Prototype robots are already in use, and the next generation of LESS surgery involving robots is in the design stage.

Training will become an integral component with the increased utilization and relevance of LESS surgery. Surgeons who want to learn the techniques involved in LESS surgery will be the driving force for creating new training programs. However, it is unlikely that practicing surgeons will be solely able to bear the costs of training, including costs of travel, housing, simulation, observation, lectures, and access to instrumentation. Hospitals and other surgeon partners will also need to participate. Industry will have to play a substantial role as well, but that role will need to be defined and possibly limited.

Training and education

Training in LESS surgery will need to occur in all disciplines of surgery and at all levels. There will be a significant catch up for practicing surgeons, and surgeons-in-training will need to learn LESS surgery much like they learned basic open surgery, the principles and practices of surgery, and conventional laparoscopy. Simulation will increasingly be a key component of education, particularly because of patient expectations of performance, and issues with hospital partners and liability carriers. Current simulation models will need to be further developed, as even the most advanced high-fidelity simulators are designed for laparoscopy, not LESS surgery. Task training will be very important to ensure that surgeons attain the necessary competency in knot tying, suturing, and using new imaging devices and energy delivery devices. Low-fidelity simulators will be important in reinforcing the basics of procedures such as a conventional laparoscopy or conventional open colectomy. High-fidelity simulators will be more important for surgeons-in-training than for practicing surgeons who are likely already familiar with such operations. It is unknown who will be the driving force behind training and who will fund it. However, several factors will be key, including the issues of patient safety, avoidance of complications, avoidance of poor outcomes, and every surgeon's aspiration to be the best they can be. Funding will be contributed by various parties (e.g. institutions and industry). It is likely that altruism will be a factor, as no analysis could appropriately or accurately assign the return on an investment to all monies involved in training. Who pays and how much they pay may ultimately be determined by who stands to gain the most.

A major component in training practicing surgeons will be cognitive training on patient selection and patient preparation. Considerations of BMI, height, operative history, and diseases and disorders being treated will need to be recognized. Patients that are too heavy or too tall will limit the application and results with LESS surgery because of exposure and instrumentation. For example, an extremely tall man will pose technical difficulties when reducing a giant hiatal hernia from the umbilicus. Similarly, the scars and adhesions associated with multiple previous abdominal operations with will make laparoscopy difficult and pose specific problems with LESS surgery. Acute cholecystitis will be much more difficult to treat through LESS surgery techniques than through conventional laparoscopic techniques because of the underlying disease or disorder. Additionally, a very large hiatal hernia will be more difficult to treat through an isolated umbilical approach than through conventional laparoscopy, which traditionally involves numerous trocars in the upper abdomen.

From laparoscopy to LESS surgery

In facilitating the transference of laparoscopy and all that it entails to LESS surgery, there must be a focus on safety. With LESS surgery, there can be no increase in complications or changes in risk profile. For example, with cholecystectomy, there cannot be an increase in bile duct injuries nor can there be an increase in injuries to the colon, which might possibly more frequently accompany a singular umbilical approach. Colon injuries currently are not a factor in conventional laparoscopic cholecystectomy, and they cannot become a factor, nor is it expected they will be, with LESS surgery. Adding trocars to LESS surgery to convert to conventional laparoscopy should never be considered a failure, but rather good judgment. However, routine conversions to conventional laparoscopy would represent a "bait and switch" by

surgeons. There is no definition of a reasonable conversation rate. Conversion is dependent on many factors, including patient selection, underlying disorders and diseases treated, and operating equipment – not just surgical skill. Similarly, conventional laparoscopic operations cannot be converted routinely to open operations or the advantages of conventional laparoscopy are uniformly lost. While conversion to open operations for specific reasons and indications is accepted, there is usually an acceptable incidence for such conversions. Generally, it is believed that about 5% of laparoscopic cholecystectomies will be converted to open operations because of difficulties with acute cholecystitis, exposure, or bleeding (26,27).

To facilitate transference of laparoscopy to LESS surgery, awareness of LESS surgery must increase. Application of LESS surgery in training centers and by small numbers of surgeons will progressively promote LESS surgery as more surgeons begin to embrace and employ it. The media will play a significant role in publicizing LESS surgery and the practices of given surgeons as it promotes the story and benefits of LESS surgery. Similarly, industry will promote LESS surgery through advertising and training, and will encourage its application through promotion of competition among surgeons. Professional societies will play a huge role in promoting the application of LESS surgery by including presentations on it at their meetings, and giving their tacit of approval to the development of the discipline. Market forces will play a major role in the transference of laparoscopy to LESS surgery – and these forces through patients, referrals, and competition cannot be minimized.

Conclusion

In short, LESS surgery is all about "no scar." LESS surgery will be applied to the same operations undertaken with conventional laparoscopy, and the same outcomes will need to be seen. There can be no more risks with LESS surgery than there are with conventional laparoscopy, and LESS surgery cannot carry a different risk profile. Increased application of LESS surgery is necessary to increase its relevance, and increased application will be driven by a number of factors including market forces. Surgeons will see LESS surgery as a practice builder. Patients will seek it because of improved cosmesis and perceived benefits of pain and quicker return to functional activities. Referring physicians will embrace it with the perception that it improves the care that their patients receive. The media will want stories about LESS surgery and such stories will promote the ability of patients to make better choices in their medical care. Money will need to be spent on marketing and training.

LESS surgery is both here and now. Its relevance will increase as its application increases. Market forces and patient demand will drive the application of LESS – and patients will demand it because of the perceived improved cosmesis and reduced disability and confinement. Therefore, laparoscopic surgeons will need to be able to provide it.

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