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TOPIC HIGHLIGHT

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Single access laparoscopic surgery: Complementary or alternative to NOTES?

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Abstract

In recent years, single access laparoscopic surgery (SALS) and natural orifice translumenal endoscopic surgery (NOTES) have gained interest from both clinical and industrial point of view, with the increased development of different laparoscopic instruments, production of various access ports, and improvement of operative endoscopes. The main advantages stimulating these two approaches are the cosmetic result, the rapid recovery of the patient, and the reduced need for pain killers. SALS and NOTES are in part complementary and in part alternative techniques. Currently, SALS is much simpler and technically easier than NOTES.

Key words: Single port; Single incision; Single access; Laparoscopy; Transumbilical; Natural orifice translumenal endoscopic surgery

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INTRODUCTION

Single access laparoscopic surgery (SALS) consists of performing laparoscopic procedures through a unique access, usually the umbilicus, because it represents a natural scar and constitutes a well-healing site of access to the peritoneal cavity. This approach was reported for the first time in 1996 by Kala *et al*[1] during laparoscopic appendectomy, and in 1997 by Navarra *et al*[2] during laparoscopic cholecystectomy. With the advent of natural orifice translumenal endoscopic surgery (NOTES), the umbilicus has gained more importance, being recognized as an "embryonic natural orifice".

NOTES is a term first coined by a joint group of surgeons and gastroenterologists organized by the Society for American Gastrointestinal Endoscopic Surgeons (SAGES) and the American Society of Gastroenterologists (ASGE). It describes the fusion of minimally invasive surgery and interventional endoscopy, in order to perform flexible endoscopic procedures by the transgastric, transvaginal, transentric, transvesical or transrectal approach. The first NOTES report was made in experimental animals in 2004 by Kalloo *et al*[3], and in human during a transgastric appendectomy by Rao and Reddy[4].

In the recent years, SALS and NOTES have received both clinical and industrial investment, with an increased development of different instruments, production of various ports for SALS, and research into operative endoscopes for NOTES. The main advantages stimulating these two approaches are the cosmetic results, and probably the decreased abdominal trauma, the improved recovery of the patient, and the reduced need for pain killers.

COMPLEMENTARY

SALS and NOTES currently share similar technical limitations: lack of triangulation between instruments, poor working ergonomics, restricted visual axis and reduced operative field.

The difficulty with working through a small single access, *via* an organ during NOTES, or the umbilicus during most SALS procedures, can be summarized by the limited triangulation obtained with the classic straight instruments, the restricted degrees of freedom of their movements, and the contact/proximity between the instruments during the operation.

These issues have been fully resolved in SALS, by the introduction of articulating instruments, where the straight shaft is supported by flexible tips and rotable handles.

Unfortunately using articulating instruments, surgeons have to cross their hands or the instruments' tip in order to reach a working triangulation, because the specific direction of the handles corresponds to fixed movements of the tools' tips. This enables surgeons to use the ergonomy of classic laparoscopy. Moreover, all articulating instruments are currently only available as disposables, and this has the consequence of increasing costs compared to standard laparoscopic procedures.

Because of this, we participated in the development of curved instruments for SALS, where the classic shafts have different curves in order to reach a working triangulation inside the abdomen and at the same time maintain an ergonomic position of the surgeon's hands outside the access. The curved instruments are mostly available as reusables, maintaining the costs at a similar level to classic laparoscopy.

The instruments were also modified for NOTES, giving consideration to the target to be reached from the natural orifice, and the difficulty of working in parallel positions. Long and flexible tools were developed for new operative endoscopes. These operative endoscopes are again mostly under research and not widely available. They are based on the concept of permitting the gastroenterologist and the surgeon to work together in an ergonomic position without conflict between the four hands, whilst allowing them to reach a triangulation at the target area.

In SALS, the limited visual axis can be resolved by the use of new optic-camera systems, which are equipped with optics allowing 360° rotation or a flexible camera. Hence the conflict between the optic and the instruments' tips inside the abdomen, as well as the conflict between the surgeon's hands outside the cavity can be avoided. During NOTES, the visual axis is much improved thanks to the use of new endoscopes, which are provided with articulation of the working channels. These new endoscopes continue to be supported by the optical washing system and by some channels for operative field exposure. Contrary to SALS, in NOTES procedures problems still remain concerning spatial orientation, which is quite difficult with flexible endoscopes.

The problem of having reduced operative field in SALS, as in NOTES, is mainly due to the exposure of the operative field. This can be improved by the placement of stitches or by the use of some grasping anchors. These anchors are applied for one extremity to the viscera, and for the other one to the peritoneal sheet, increasing the operative field. Furthermore, the grasping anchors can also be maneuvered by external magnets in both SALS[5] and NOTES[6] approaches.

ALTERNATIVE

SALS and NOTES are alternatives if we consider their current and probable future application in humans.

SALS, given its similar character to standard laparoscopy, is overall technically easier than NOTES, because the learning curve is much less. The transvaginal approach obviously cannot be offered to male patients, hence the restriction for male patients of the remaining transgastric, transentric, transvesical or transrectal procedures. Moreover, in females, a problem persists for pregnant patients, where the NOTES procedure can be attempted, in contrast to SALS.

In patients with a BMI > 35 kg/m^2, SALS may be quite difficult although still easier than NOTES, because the fatty tissue does not compromise the route of the scope and instruments through the single access[7], and ports are added as necessary as during NOTES[8].

In comparison to SALS, NOTES has advantages because of the possibility to perform not only translumenal, but also endolumenal procedures. For the esophagus, classic endoscopic mucosectomy can be safely performed with endolumenal suturing. Furthermore the performance of endolumenal fundoplication, already reported as feasible and reliable[9], offers patients with symptomatic gastroesophageal reflux or small hiatal hernia, the option of being treated by scarless surgery.

Another application area favouring NOTES is the endolumenal approach for bariatric revisional surgery. Thanks to the new operative endoscopes, already developed[10-12] or under development[13], surgeons can offer patients these endolumenal techniques, thus avoiding new transabdominal surgeries. Patients with gastric pouch dilation, gastrojejunal anastomosis enlargement, or early complications such as bleeds and leaks, can be submitted to this new transoral intragastric surgery with obvious benefits.

Similarly, the old strategy of treating rectal lesions by transanal endoscopic microsurgery, is nowadays incorporated in NOTES procedures. This not only to avoids extended and incapacitating resection of the rectum, but also has the option of suturing and closure of potential rectal defects, thanks to the improvement of these dedicated instruments[14]. Thanks to NOTES and to the development of the new operative colonoscopes, some urgent cases such as colic perforation during diagnostic colonoscopy, will be treated through this access with no more open or laparoscopic surgery.

In future, thanks to the introduction of the new operative endoscopes, NOTES will be useful to transorally correct some congenital agenesis of the gastrointestinal tract, e.g. esophageal and duodenal (Jeffrey Ponsky, commu-

nication at SAGES 2009). The new operative endoscopes should permit both opening the visceral lumen, and suturing of the new gastrointestinal continuity endoluminally.

At present, NOTES retains some limitations when compared to SALS. First, is the intrinsic risk for abdominal spillage of gastric, vaginal, enteric, vesical or colonic contents during the NOTES procedures. The second issue is the difficult task of viscerotomy closure with increased risk for leakage during the post-procedure course.

Finally, the application of standard laparoscopy or open surgery remains available for patients with previous open surgeries, as both translumenal and single access may difficult to achieve in these conditions. In addition, the resection of huge benign and malign tumors or solid organs, cannot be performed by either SALS or NOTES approaches, and the use of standard laparoscopy or open surgery is indicated.

COMMON FUTURE

The classic operative endoscopes have undergone a revolution, and are currently under continue research in terms of long instrument stability, overtube diameter, port-access safety, spatial orientation, and working handle changes. These endoscopes will be supported by free rotation of the tools' tips, simplified instrument change through the working channel, more controlled flexibility of the instrument shaft, and external handle modifications similar to standard laparoscopy. In the near future they will be available for NOTES, and if they are modified in length and in some other parts, like port access, these endoscopes will also be applicable for SALS procedures. Obviously a learning process will be required for laparoscopic surgeons performing SALS with new operative flexible endoscopes. Once research and development is completed, the ideal platform for NOTES and SALS will probably be similar in terms of principles and instruments' action.

CONCLUSION

NOTES and SALS have stimulated innovative efforts invested in surgery in recent years. With the advent of NOTES, SALS has been reconsidered because the umbilicus is considered as the embryological natural access. At present, SALS is actually more applicable than NOTES, because of the lack of new operative endoscopes, absence of visceral access and closure of openings. In the future, the ideal platform will not be very different between the two approaches in terms of principles and instruments' action.

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