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UTILISATION OF LAPAROSCOPIC SURGICAL TECHNOLOGY AND EXPERIENCE TO PERFORM NATURAL ORIFICE TRANSLUMINAL ENDOSCOPIC SURGERY (NOTES), A NEW ERA IN MINIMALLY INVASIVE SURGERY

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Summary
The field of minimally invasive surgery has seen tremendous development and refinement since the first laparoscopic cholecystectomy was performed in 1987. Laparoscopic surgery has several advantages over traditional surgery. The next logical step in the evolution of minimally invasive surgery may be to eliminate all abdominal incisions. The terms being used in the literature include "incisionless", "endoluminal", "transluminal", and "**N**atural **O**rifice **T**ransluminal **E**ndoscopic **S**urgery" (**NOTES)**. This article aims to summarize the background and current status of NOTES.

Introduction
While laparoscopic procedures are beneficial to most patients, complications related to wound infection, hernias, and pain do occur. In addition several incisions are often required to be used as working ports. Recently, several groups have begun evaluating the feasibility of performing abdominal surgeries without external incisions. Access to the abdominal cavity was achieved through various natural orifices such as the mouth, anus, urethra, and vagina.

The Evolution of Endoscopy
Bozzini is credited as the person introduced the first endoscope, the Lichtleiter, in 1806[1]. The rigid, candle-powered endoscope was initially used to perform cystoscopy. Nearly 60 years later Kussmaul modified the Lichleiter to make it suitable to perform gastroscopy in sword swallowers in 1868. Von Mikulicz later added electric light to the endoscope in 1880[2,3]. Although the principles of fiber optics were demonstrated in the late 1800s, Hirschowitz introduced the first fiber optic, fully flexible fiberscope in 1957, which became commercially available 3 years later[4]. In 1963, an external light source and biopsy channels were added to the flexible gastroscope. By 1980s, video cameras replaced fiber optics, and the contemporary endoscope was born[3].

As technological improvements continued the field of surgical endoscopy performed more invasive endoscopy and lesser invasive surgery. Endoscopic ultrasound and biopsy, first reliably performed by Strohm in 1980[5], which later enabled skilled endoscopists to perform splenic, adrenal, hepatic, and pancreatic biopsies. More advancement in this field included transgastric pancreatic pseudocyst drainage[6], and endoscopic mucosal resection for mucosal lesions of the oesophagus, stomach, and colon[7]. The percutaneous endoscopic gastrostomy (PEG) tube,

first described by Ponsky in 1980[8], represents the first report of breaching the lumen of the hollow abdominal viscera. After the first reported success of endoscopic transgastric peritoneoscopy in 2000[9], this issue has been explored and investigated by researchers with great interest.

The Beginning of "Notes"

At the Digestive Diseases Week in 2000, Kalloo with the Johns Hopkins group and the Apollo group reported their work using a per-orally introduced flexible endoscope via a sterile overtube into the abdominal cavity in a porcine model. It was refereed to as flexible transgastric peritoneoscopy (FTP) and the final results were published in 2004[10]. Using sterile technique and irrigation of the stomach with an antibiotic solution, the anterior gastric wall was punctured near the greater curvature with a needle-knife. The gastric puncture was extended using either a pull-type sphincterotome or an 8.0 mm dilating balloon. A standard upper gastrointestinal endoscope that had subjected to high-level disinfection and gas sterilisation was advanced into the peritoneal cavity through a sterile overtube. After full examination of the peritoneal cavity and performance of liver biopsy, the perforated gastric wall was closed with jumbo Endoclips (Olympus, Tokyo, Japan). After an overnight fast, the pigs were fed without major complications. Micro-abscesses were found in the first two animals on necropsy because of the absence of intragastric irrigation in these animals. There were no signs of peritonitis or localised infection in the other animals. This was the first study to show that per-oral transgastric endoscopic access to the peritoneal cavity may be feasible and safe. Several studies have since been published that describe the technical feasibility of this approach to the peritoneal cavity.

In 2003, Zvnyl et al used the porcine model to determine the feasibility and safety of transgastric retroperitoneal surgery[11]. Six pigs survived well with excellent healing of the gastrostomy. One died as a result of over distension and one died because of failure in closure of the gastrostomy. Other researchers demonstrated the accuracy to systematically identify abdomino-pelvic organs using transgastric abdominal exploration technique in seven pigs[12]. The stomach, liver, small bowel, colon, urinary bladder, uterus, fallopian tubes and ovaries were easily identified in all cases. The parietal peritoneum could also be thoroughly examined in all animals. The small bowel could be followed and easily manipulated by grasping with two forceps placed via a dual-channel endoscope. The entire length of the uterine horns could be similarly traced to the uterine body medially and the ovaries laterally. The spleen tip could be seen in all animals. However, the entire spleen could not be evaluated. The identification of the gall bladder and retroperitoneal structures is challenged with the current endoscopic equipment. Only four out of seven animals' gall bladders were visualized. The duodenum, appendix, pancreas and kidneys were not identified.

Other procedures, which were performed, successfully included endoscopic ligation of porcine fallopian tubes[13], endoscopic gastroenterostomy[14], splenectomy[12], and experimental cholecystectomy and biliary anastomosis[15].

The Benefits Of "Notes"

The potential benefits of NOTES are avoiding incision-related complications such as wound infections, incisional hernias, and adhesions. Wound infection may develop in 2% of the patients or much higher depending on the type of surgery and patient[3]. Hernia formation develops in 4% to 18% of open surgery, and in 0.02% to 3% of laparo-

scopic procedures[3]. Postoperative adhesions are very common, and although small bowel obstruction is not as common, however, there is an estimation of 1% lifetime risk of developing small bowel obstruction[3].

In addition to the potential benefits of limiting complications of traditional surgery, NOTES may expand the scope of surgical indications such as an inside-out approach in morbidly obese patients, or those patients with obstructive carcinomatosis requiring palliative by-pass, and a possible coupling of NOTES with endoscopic ultrasound technology.

Additional possible benefits of NOTES are minimization of anaesthesia and analgesia with their related complications. One particular group of patients that may be well served the children in whom incision related pain and complications could be avoided.

Challenges in Sterilisation

One major challenge to the transition of transgastric surgery to clinical trials is how to reliably overcome the problem of possible infectious complications. Laboratory studies have demonstrated that these complications may be overcome by intravenous antibiotics, disinfecting the oral cavity and gastric irrigations with antibiotics. Intragastric irrigation using Neomycin 40mg + polymyxin B sulfate in 1 L Saline solution[10], Entrofloxacin intravenous 5 mg/kg before surgery and Entrofloxacin 5 mg/kg orally q.i.d for 3 days after surgery, and intragastric irrigation solution of Cefazolin + Normal Saline over 10 minutes are among the regimes used to prevent infectious episodes. These researchers found no infectious complications in their studies[16].

Limitations of "Notes"

Current limitations involve both technical and social concerns, which are typical for any emerging technology[3,17].

Most of the current animal studies in transgastric surgery used conventional instruments. The endoscopes used are either single or double channel scope systems. All of them are, obviously inadequate to perform complex surgeries. These endoscopes and instruments have limitations in their current design that restrict their usefulness for such completely different approach and type of surgery. This includes the need for small diameter tools, lack of effective triangulation, exclusively coaxial force exertion, inability to work outside the scope axis and a 2-D operational field[17]. However, there are several attempts to develop a new generation therapeutic endoscope and novel endoluminal surgery system[17].

Societies and professional organizations will struggle with logistic concerns implementing new technology. One such group, the Natural Orifice Surgery Consortium for Assessment and Research (NOSCAR), is composed of leaders from the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) and American Society of Gastrointestinal Endoscopy (ASGE)[18]. This consortium has established taxonomy, delineated the current limitations to NOTES, and motivated a unified plan of research to move forward in applying NOTES into human practice (Table).

Transanal, cystoscopic, or transvaginal NOTES techniques may provide superior visualization of abdominal organs when compared to transgastric access, however, in the absence of studies comparing access techniques, no conclusive evidence establishes optimum technique[3].

Concluding Remarks

There are unpublished reports of successful transgastric appendectomy and tubal ligation in humans performed in India[19]. These reports support the feasibility and safety of transgastric

surgery in humans. NOTES is a developing field that is in its infancy. Endoscopists, surgeons and engineers need to work together to develop viable and practical new instruments with better interface technology[17]. More laboratory work is essential to understand the physiologiocal and pathophysiological events following transgastric surgery.

Technical aspects are not the only issues precluding NOTES from integration into human practice. Professional and logistic controversies of an infantile field also merit serious consideration and long-term planning by leaders in the surgical endoscopic community[3]. Determining indications, or more important, contraindications will be required, and evidence-based guidelines should be developed to help govern judicious use of an emerging and unproven technology[3]. Credentialing requirements will be an important topic. Both gastroenterologists and general surgeons are likely to lay claim to this field; however, the best training may reside in an integrated training in both gastroenterology and general surgery[3]. Until NOTES is routinely performed, NOSCAR recommends initial attempts to be performed by a multidisciplinary team as a procedure in a standard operating room under general anaesthesia[18].

Table: NOSCAR Potential barriers to Clinical Practice and recommended Initial Animal Laboratory Studies for NOTES

Potential barriers to clinical practice
Access to peritoneal cavity
Gastric (intestinal) closure
Prevention of infection
Development of suturing device
Development of anastomotic (nonsuturing) device
Spatial orientation
Development of a multitasking platform to accomplish procedures
Control of intraperitoneal hemorrhage
Management of iatrogenic intraperitoneal infections
Physiologic untoward events
Compression syndromes
Training other providers
Recommended initial animal laboratory studies
Bacteriologic assessment of gastric fluid after irrigation with antibiotics versus saline solution
Assessment of intraperitoneal pressures during various insufflations and surgical techniques
Assessment of security of various gastric closure devices
Evaluation of postoperative gastric motility and function after NOTES

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