

Natural Orifice Transluminal Endoscopic Surgery

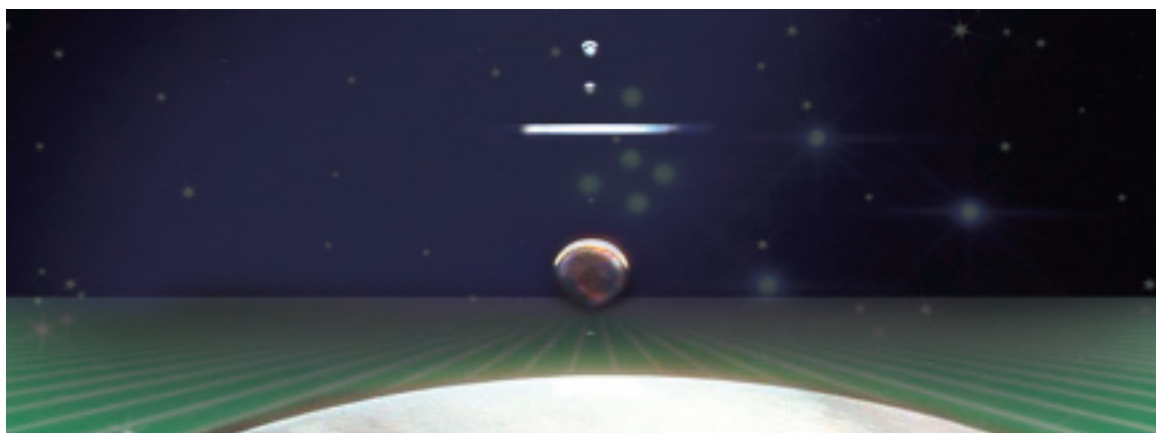
A Clinical Review

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“The limits of the possible can only be defined by going beyond them into the impossible.”
Arthur C. Clarke (author and inventor, b.1917)

It is amazing to think that only a decade ago, an intestinal perforation resulting from an endoscopic intervention was considered a major violation of medical care. However, the concept of breaching the gastrointestinal tract to gain access to the peritoneal and even the thoracic cavity is rapidly gaining acceptance. This review discusses the current status of natural orifice transluminal endoscopic surgery (NOTES).

Rationale for NOTES

Throughout the history of medicine, physicians have sought less invasive approaches to the diagnosis and therapy of diseases. Perhaps its relative lack of invasiveness is the greatest attraction of NOTES to the medical and general public, particularly with regard to cosmetic effects. A frequently touted advantage of laparoscopic surgery over open surgery is a better cosmetic outcome. With NOTES, perfect cosmetic results are possible even when peritoneal intervention is required.¹

Since the advent of interventional endoscopic therapy, the fields of gastrointestinal surgery and interventional endoscopy have been on converging paths.² Therapeutic endoscopists are becoming increasingly invasive, performing interventions such as transgastric pseudocyst drainage and pancreatic necrosectomy and treating endoscope-related perforations that would have had to be managed surgically

Table 1. Summary of Published NOTES Experiments

Author and Year of Publication	Type of Surgery	Type of Access	Intervention
Kaloo et al (2004) ¹³	Survival and nonsurvival	Transgastric	Peritoneoscopy and liver biopsy
Jagannath et al (2005) ¹⁴	Survival	Transgastric	Tubal ligation
Wagh et al (2005) ¹⁸	Survival	Transgastric	Partial hysterectomy and oophorectomy
Park et al (2005) ¹⁶	Nonsurvival	Transgastric	Cholecystectomy, cholecystogastric anastomosis
Kantsevov et al (2005) ¹⁵	Survival	Transgastric	Gastrojejunostomy
Lima et al (2006) ²¹	Survival and nonsurvival	Transvesical	Liver biopsy
Merrifield et al (2006) ¹⁷	Survival	Transgastric	Partial hysterectomy
Kantsevov et al (2006) ²²	Nonsurvival	Transgastric	Splenectomy
Bergstrom et al (2006) ¹⁹	Survival and nonsurvival	Transgastric	Gastrocholecystic anastomosis
Fritscher-Ravens et al (2004) ²⁰	Survival	Transgastric	Lymphadenectomy
Wagh et al (2006) ³⁰	Survival	Ex vivo study	Oophorectomy and tubectomy
Sclabas et al (2006) ³²	Ex vivo study	Transgastric	Closure methods
Pai et al (2006) ²³	Survival	Transgastric	Cholecystectomy
Sumiya et al (2006) ²⁴	Nonsurvival	Transcolonic	Simulating appendicitis and appendectomy
Ryou et al (2007) ²⁸	Ex vivo study	Transgastric	Closure methods
Fong et al (2007) ²⁷	Survival	Transcolonic	Abdominal exploration
Onders et al (2007) ²⁶	Nonsurvival	Transgastric	Diaphragmatic pacing
Rolanda et al (2007) ²⁵	Survival	Transgastric/transvesical	Cholecystectomy
Kantsevov et al (2007) ²⁹	Survival	Transgastric	Peritoneal access
Onders et al (2007) ²⁶	Nonsurvival	Transgastric	Peritoneal exploration
Meirless et al (2007) ³¹	Nonsurvival	Transgastric	Intraperitoneal pressure measurement

2 decades ago.³ In contrast, surgical interventions in the peritoneal cavity have become less invasive, particularly with the advent of laparoscopic surgery, culminating in the formation of minimally invasive surgical centers of excellence. Therefore, from the standpoint of invasiveness, it appears that NOTES may be the natural convergence of laparoscopic surgery and therapeutic endoscopy (Figure). Certainly laparoscopic surgery has taught us that smaller incisions are associated with faster recovery from surgery, earlier return to work, and less suppression of the immune response with fewer adhesions.⁴⁻¹² It is reasonable to think that NOTES may further improve on the benefits of laparoscopy, but clinical trials are needed to confirm this supposition.

NOTES offers exciting possibilities in the surgical management of the morbidly obese patient. Morbid obesity affects close to 5% of the US population. The wound infection rate has been significantly reduced by using the laparoscopic approach, so hypothetically, any incisionless approach to an intra-abdominal intervention could be greatly beneficial. Of course, NOTES will increase this possibility and may serve as a platform for bariatric procedures.

Laboratory Experiments: Evaluating Feasibility

CAN WE DO IT SAFELY?

Following our initial description of NOTES in the animal model, several laboratory experiments were conducted that attested to the technical feasibility of NOTES.¹³⁻³² These experiments are summarized in Table 1. In addition to evaluating the technical feasibility of NOTES, the experiments helped to alleviate fears concerning the adverse consequences of breaching the gastrointestinal wall, including infection, peritonitis, and iatrogenic complications. The research also sparked the development of innovative techniques to surmount barriers identified by the experiments.

The most important question was: “Can a perforation of the gastrointestinal tract accompanied by passage of an endoscope into the peritoneal cavity be safely performed?” This question was answered by the results of numerous experiments from multiple centers revealing that this is indeed possible. The question of whether NOTES can be safely applied to humans remains to be answered.

IS SURGERY POSSIBLE THROUGH A FLEXIBLE ENDOSCOPE?

The initial laboratory experiments also demonstrated the feasibility of performing traditional surgical techniques through a natural orifice. The creation of anastomoses and removal of organs are basic but essential techniques in surgery. We demonstrated that transgastric gastrojejunostomy with long-term survival is possible in a porcine model.¹⁵ This was an important step in convincing the medical community

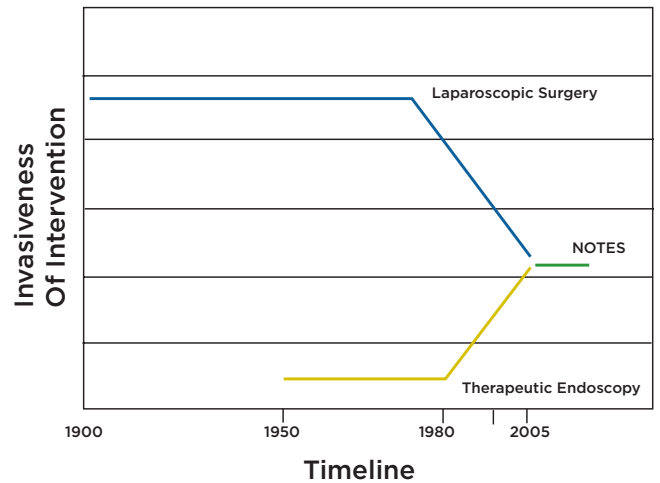


Figure. Natural orifice transluminal endoscopic surgery (NOTES) as the possible convergence of laparoscopic surgery and therapeutic endoscopy.



Photo courtesy of Dr. Kalloo.

Anthony N. Kalloo, MD (holding endoscope) and team at the Johns Hopkins School of Medicine performing natural orifice transluminal endoscopic surgery in a pig model.

Table 2. Potential Barriers to Clinical Practice

Access to peritoneal cavity
Gastric (intestinal) closure
Prevention of infection
Development of suturing device
Development of anastomotic (nonsuturing) device
Development of a multitasking platform to accomplish procedures
Control of intraperitoneal hemorrhage
Management of iatrogenic intraperitoneal complications
Physiologic untoward events
Compression syndromes
Training other providers

that NOTES is feasible. For NOTES to become part of standard surgical practice, the successful creation of anastomoses is critical.

Another common surgical procedure is organ removal. Splenectomy, oophorectomy, and cholecystectomy have all been successfully performed through natural orifices in the laboratory setting.^{16,17,22,23,25} Clearly, if large organs are to be removed, morcellation of the organs will be required before removal. This process has already been successfully accomplished with laparoscopic techniques.

Current Status of NOTES

In July 2005, leaders from the American Society of Gastrointestinal Endoscopy (ASGE) and the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) formed a working group called the Natural Orifice Surgery Consortium for Assessment and Research (NOSCAR). The primary responsibility of this group is to develop NOTES safely and responsibly for clinical practice. The group has identified challenges and hurdles that need to be addressed before NOTES can become widespread in clinical practice (Table 2).³³ The identification of such challenges was a critical step to the long-term success of NOTES because it gave investigators a framework for clinical research that would lead to the successful performance of natural orifice surgery. Additional information can be found at www.noscar.org.

Another important but overlooked development in the genesis of NOTES is the collaboration between surgeons and gastroenterologists. NOSCAR represents an equal partnership between 2 specialties that manage the same disease conditions. In “real life,” collegiality is important to provide optimal, multispecialty patient care, but rivalry is inevitable as surgeons become endoscopists and endoscopists perform procedures that were once surgical. NOTES may enhance multidisciplinary care and minimize rivalry as these practitioners potentially evolve into 1 specialty.

Human Experience

The initial human experience with NOTES was described by Drs. G.V. Rao and D.N. Reddy at the Asian Institute of Gastroenterology in Hyderabad, India. Although their study was not published, they described a series of patients in whom transgastric appendectomy and tubal ligations were successfully performed per os. Hybrid procedures that combine NOTES with a laparoscopic approach have been recently described. Marks et al. described the transgastric retrieval of a dislodged gastrostomy tube.³⁴ The most notable feature of this procedure was that it was performed at the bedside in an intensive care unit (ICU), not in an operating room. Most recently, there have been unpublished reports of 2 cases of transvaginal cholecystomy, one performed as a hybrid and the other as a “purely” NOTES procedure.

Next Steps and the Future of NOTES

NOSCAR has made a priority of bringing NOTES to safe clinical practice. How will NOSCAR accomplish this? First, it will produce white papers to both guide research and identify issues for future investigations. Second, by providing organization for research, enhancing collaboration and attracting funding, NOSCAR will foster laboratory and clinical research. To date, NOSCAR has received \$1.5 million from industry, which has been used to fund peer-reviewed projects. Additionally, NOSCAR can serve as a sounding board for requiring and maintaining a patient registry, which will enable researchers to learn early on from each other's experiences.

Finally, NOTES presents a unique and overlooked opportunity to change the operating room environment. Because the gastrointestinal tract is a confined lumen, it has the potential to be a "sterile field," rendering complete extracorporeal sterility unnecessary. It is conceivable that peritoneal interventions could be performed at the bedside in the ICU, as described in the case report by Marks et al. In this case report, a NOTES procedure was used to successfully recover and replace a dislodged gastrostomy tube at the bedside in the ICU without general anesthesia.³⁴ With appropriate equipment, it is conceivable that NOTES could be performed at the site where abdominal trauma has been sustained, such as the scene of an automobile accident, to repair acute organ injuries.

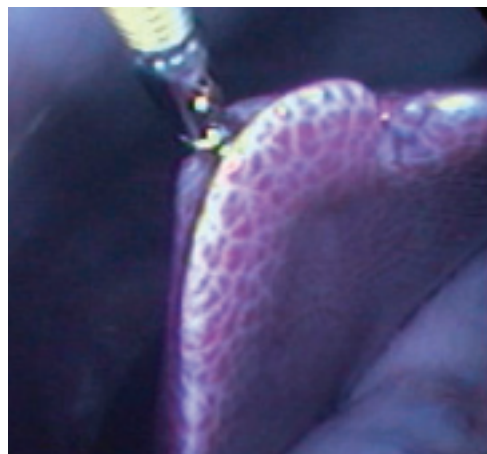
NOTES has sparked the imagination of surgeons and gastroenterologists and has forged new collaborations between these merging fields. However, enthusiasm must be balanced by the need for diligent laboratory research and careful clinical trials. Only by pushing the boundaries of the impossible will we discover what is possible and, we hope, improve the lives of our patients in the process.

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Closure of gastric incision after natural orifice transluminal endoscopic surgery (NOTES).



Liver biopsy being taken during transgastric procedure.



View of small intestine during transgastric procedure.

Photos courtesy of Dr. Kallou.

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Patient Guide to SURGICAL METHODS

Because of technical advances, surgery today does not necessarily have to involve large incisions. Depending on the type of surgery you are having, there are several surgery methods available.

Benefits of minimally invasive procedures may include:

- ❖ less pain after surgery because the incisions are much smaller
- ❖ reduced infection rate
- ❖ quicker recovery
- ❖ shorter hospital stay
- ❖ earlier return to regular activities
- ❖ smaller scars

Minimally invasive operations may last longer than open surgery, and may be more difficult for the surgeon. That is why it is very important to choose a surgeon who is well-trained and experienced in performing these operations.

Surgery

During **open surgery**, the surgeon cuts skin and tissues in order to have a full view of the structures or organs involved. Open surgery may be used to remove certain organs.

Minimally invasive surgery refers to any surgical technique that does not require a large incision. It is sometimes referred to as **laparoscopy**. Not all conditions are suitable for this type of surgery. Additionally, some patients who have had prior operations have an abundance of scar tissue in their body making minimally invasive surgery unsafe.

In minimally invasive surgery, small incisions of up to half an inch are made and plastic tubes called ports are placed through them. The surgeon then places a camera and the instruments through the ports. The camera transmits an image of the organs inside the abdomen onto a television monitor. Because the surgeon cannot see directly into the patient without a large incision, the surgeon uses the image from the video camera inside the patient's body to perform the procedure. The surgeon may use the instrument to take tissue samples for examination and testing.

Some procedures that were once routinely performed by open surgery now are often done with laparoscopic techniques. These include gallbladder removal (cholecystectomy), removal of the spleen and adrenal glands, and abdominal wall and inguinal hernia repair.

Endoscopy

Endoscopy is a procedure in which a small, flexible tube with a light and a camera lens at the end (endoscope) is used to examine the inside part of the digestive tract. The endoscope is inserted in the patient's mouth and gently edged down the esophagus until it reaches the stomach. Once in the stomach, the doctor will look closely for any problem areas. If anything suspicious is found, the doctor will take a sample for biopsy.

For more information:

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