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POINT OF VIEW

Natural orifice transluminal endoscopic surgery (NOTES)

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ABSTRACT

A current review and update of an exceedingly novel and appealing topic, namely natural orifice transluminal endoscopic surgery (NOTES), is discussed, as well as the authors' viewpoint thereon. Most reviewed studies were performed in laboratory animals, but reports on transvaginal cholecystectomy and the emergence of editorials and review articles on this topic pose a number of as yet unanswered questions on this type of surgery, which represents a potential advance towards "endoscopic surgery with no scars, no infection, minimal anesthesia requirements, and immediate recovery".

Key words: NOTES. Natural orifice transluminal endoscopic surgery. Laparoscopic surgery.

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INTRODUCTION

Conventional surgery using laparotomy has been greatly replaced by laparoscopic surgery; classical incisions have been substituted for by "small incisions or orifices" through which trocars and laparoscopes are introduced, which has revolutionized abdominal and digestive surgery. Laparoscopic cholecystectomy has already become a classic approach, and is even performed under sonographic guidance (USLap).

Based on minimally invasive surgery, a novel approach to endoluminal endoscopic surgery is currently emerging that takes advantage of natural orifices (NOTES), aimed at eliminating scars and scar-related complications (pain, herniation, infection) in the abdomen (a more esthetic surgery), and promoted by the NOSCAR team (1) (Table I).

Table I. Conditions to be met in NOTES (1,14)

1.	Effective peritoneal access
2.	Safe gastric or intestinal closure
3.	Infection prevention
4.	Development of sutures and anastomoses
5.	Maintenance of spatial orientation
6.	Development of a multidisciplinary platform
7.	Bleeding control
8.	Management of iatrogeny and other complications (pneumodissection, pneumoperitoneum, pneumothorax, etc.)
9.	Learning
10.	Specific, precise indications

MINIMALLY INVASIVE SURGERY

Three radically novel concepts were applied to surgery 20 years ago – that incision size "does matter", as it influences postoperative course and outcome (paralytic ileus); that surgery must be a multidisciplinary activity; and that technology is essential for surgeons in the development of laparoscopic surgery versus minilaparotomy. These three concepts apply to NOTES.

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ENDOSCOPIC DIGESTIVE SURGERY

ERCP-mediated sphincterotomy, pancreatic pseudocyst drainage (2-10), mucosectomy (11) or endoscopic mucosal resection (EMR), endoscopic submucosal dissection (ESD), endoscopic muscular dissection (EMD), tumorectomy (12), and transanal endoscopic microsurgery (TEM) have been carried out via an endoscope introduced into the body through the mouth or anus, also aided by or under the guidance of endoscopic ultrasounds (EUS) (Table II).

Table II. Indications

Group I:
- Pancreatic pseudocyst drainage (4)
- Necrosectomy (5)
- Esophageal fistula closure, ostomies, sutures (6)
- Bilioduodenal anastomosis
- Hepaticojejunostomy
- Gastrojejunostomy (7)
- Gastroplasty for obesity (8)
- Gastropexy or endotherapy for GERD (9)
- Lymphadenectomy (10)
- Mucosectomy (11) and tumorectomy (12)

Group II:
- Peritoneoscopy and liver biopsy (13)
- Hepatectomy
- Lymphadenectomy (10)
- Splenectomy (16)
- Appendectomy
- Intestinal perforation (18,19)
- Vaginal (20) or intestinal cholecystectomy

Group III:
- *Future indications:*
- Transgastric surgery in ICU (26)
- Diagnosis of mesenteric ischemia (26) and pancreatic conditions
- Percutaneous endoscopic gastrostotomy (27) in human
- Distal pancreatectomy
- Sigmoidectomy
- Other (in obese subjects, bridles or adhesions, etc.).

Group IV:
- Transesophageal intracardiac procedures (28), including biopsies

Group V:
- Nephrectomy and adrenalectomy
- Appendectomy, hysterectomy, myomectomy, ovariectomy, and transvaginal tubal ligation.

TRANSLUMINAL ENDOSCOPIC SURGERY (NOTES)

Transluminal access may be gained via the transesophageal, transgastric, transesophago-gastro-duodenal (transoral), transcolonic, transvaginal, and transvesical routes using multichannel endoscopes and prototypes – Karl Storz, dual-channel Olympus-R, curved, four-channel Transport & Cobra, Pentax, Wolf.

Flexible peritoneoscopy and liver biopsy are mainly performed via the transgastric route (13), but the term "transluminal" implies a direct entry of the endoscope into the peritoneal cavity through natural internal orifices in the stomach, colon or vagina (14).

NATURAL EXTERNAL AND INTERNAL ORIFICES

An endoscope may be introduced through a natural external orifice such as the mouth, anus, vagina, and urethra to visualize various cavities and to use incisions and sutures (6) to create internal orifices for entry into the free peritoneal cavity and access to different viscera (Table III), including the gallbladder (15), spleen (16), liver, and female genitalia (17), for surgery. Intestinal and gastric perforations could also be closed (18,19).

Table III. Procedure (modified from 38)

Anesthesia *versus* sedation
Selection of an entry port for a sterile, high-resolution, therapeutic, multichannel, curved and flexible endoscope (transoral *versus* transanal)
Desinfection of external orifices (Betadine [povidone-iodine]) and of cavities (neomycin and polymyxin B for the stomach; cefazoline for the colon) (13,33)
Broad-spectrum antibiotic prophylaxis (amoxycillin-clavulanate)? (34)
Incisions with a scalpel-sphincterotome; balloon dilator; gastrostomies; sutures with endoclips, plicator, or other suturing tools (TAS, Eagle claw, G-prox Ethicon, clips) (6,17); coagulation systems (mono-bipolar, hemoclips) (equipment not fully developed as of today)
Abdominal cavity insufflation (CO_2) and exploration
Endoscopic therapy (triangulation, fixation, attachment, organ dissection, etc.), still not fully developed. All this will improve with the use of computers and robots. The EndoVia robotic system is currently available
Complication management (infection, intraperitoneal abscess, bleeding, pneumo, perforation, splenic injury, immune disorders, and others)
Organ extraction

These procedures are most often performed via the transgastric, transcolonic, and transvaginal routes, and the first transvaginal cholecystectomy in humans (Operation ANUBIS) (20) has already been carried out. Also, the first transgastric appendectomies in humans (unpublished) were performed by Rao and Reddy in India in 2004.

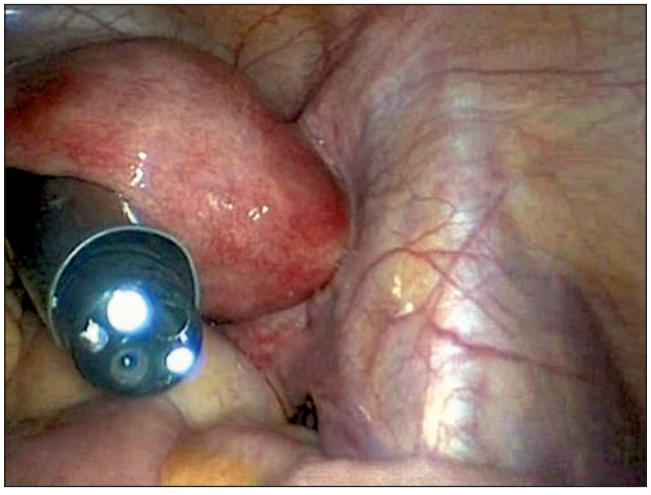

Fig. 1. A videoendoscope entering the peritoneal cavity through a trocar in the posterior vaginal fornix – courtesy from Dolz et al. (43,44). *Videoendoscopio entrando en cavidad peritoneal a través del trocar colocado en el fondo de saco posterior de la vagina – cortesía de Dolz y cols. (43,44).*

A transvesical route has been recently implemented (21), and experimental work is now being conducted regarding a combined transgastric-transvesical route (22), or a hybrid transgastric-laparoscopic approach for cholecystectomy.

MATERIALS USED IN NOTES

Pneumoperitoneum will be performed using a Veres needle at the bottom of the navel, with trocars, laparoscopes or minilaparoscopes (3-mm trocars) for hybrid techniques.

However, true NOTES will use special 120 mm-long, high-resolution flexible videoendoscopes with multiple channels to reach the abdominal cavity. As discussed above, a number of different manufacturers exist. Overtubes will be used. The Shape Lock technology, a shared platform and support for videoendoscopes, is now available. A robotic EndoVia device is also available that may help in therapeutic endoscopy.

Opening equipment will include scalpels, papillotomes, laser, polyethylene balloon dilators, etc., as well as resection and closure (suture) materials (Eagle Claw) (Plicator) (Esophyx-Palex), anastomosis materials, etc.

Suture and anastomosis materials for the stomach and colon are very important in view of perforation and peritonitis risks.

Dissection and vascular coagulation materials will also be used (monopolar, bipolar, bipolar/multipolar electrocoagulation; clips, etc.), as well as 20- or 30-mm Endoloop, and a plastic bag for resected organs (Unimax) with mouse-tooth forceps (43).

All this equipment is not fully developed as of today. NOTES-specific materials will be available in the future.

Aids in the form of endoscopic ultrasounds (EUS) and miniprobes (MPs) will be used on occasion, probably not often. Radial or sectorial Doppler echoendoscopes, currently 5 to 20-MHz electronic devices, will be used to facilitate the study of vessels, or even 12- or 15-MHz miniprobes, with balloons to provide good acoustic windows; thus, the risk for potential complications would be reduced (Table II).

DISCUSSION

From recent reviews (23-26,37-42) and studies, primarily in research animals, the following considerations ensue:

—*Transesophageal route*. This route will likely be used for transesophageal intracardiac procedures (group IV), including biopsies, aided by or under guidance of EUS (28). Radial and sectorial EUS with FNAP will be essential for transesophageal route procedures.

—*Transgastric route*. Group-I indications are already being carried out through the transgastric or transduodenal route under EUS. A clear instance is pseudocyst and abscess drainage, and EUS-guided pancreatic necrosectomies, which represent a "notable" advance for NOTES.

Indications in groups II and III represent the true targets for NOTES: lymphadenectomy, cholecystectomy, splenectomy, appendectomy, pancreatectomy, sigmoidectomy, and other procedures such as ventral hernia repair (29). Of these, only distal pancreatectomy will probably require EUS support along the stomach's greater curvature to locate an entry point for distal pancreatic resection. Miniprobes (MPs) may also likely help in selecting an entry point.

—*Transcolonic route*. Besides TEM (30-31) for uT0-uT1N0 tumors, submucosal tumors, and retrorectal cysts (32), this route will allow the closure of intestinal perforations and drainage of fluid collections, as well as cholecystectomies (33) and appendectomies via the trans-sigmoidal route (34), always under ERUS (endorectal ultrasounds) or EUS.

—*Transvaginal route*. Numerous procedures have already been performed through this route, some of them indicated in group V. Most novel among these is transvaginal cholecystectomy (20).

NOTES represents a new field that is drawing the attention of surgeons and endoscopists alike. Potential future applications cannot be established yet, nor can potential benefits regarding the development of new complications (opening of hollow viscera with peritonitis risk, failed sutures, etc.) be ascertained.

Research with animals must continue for visceral disinfection techniques, optimal entry points for each organ and procedure, potential need of EUS or MPs, optimal approach (scalpel, puncture, dilation), insufflation mode,

sustained sterility for endoscopes, need for one *versus* several access points, and closure of openings for organ access; most relevantly, new technology is needed to provide materials equivalent to those of laparoscopy but usable through flexible endoscopes 120 cm in length, and with several work channels 3.5-4.2 mm in diameter.

The precise usefulness and real indications of NOTES will be established once these questions are answered and material advances have taken place, when its complications *versus* benefits ratio is seen to be superior to that provided by other techniques such as laparoscopy.

Another debated topic is who should perform this technique and where. Surgeons reconverted to endoscopy? Surgeons assisted by endoscopists? Endoscopists supported by surgeons? In the operating room? In the endoscopy room? Should patients be sedated or anesthesized? Surely, some indications will be carried out by gastroenterologists-endoscopists with no surgical training but expertise in therapeutical endoscopy, whereas other indications involving visceral resection and risk of surgical conversion should be taken in charge by surgeons with endoscopic training. The booming of this novel technique may perhaps lead to changes in specialty/subspecialty fields and education, with the emergence of "endoscopist surgeons". Or maybe nothing will come of this, as was the case with biliary lithotripsy or more recently with anti-reflux management.

Both at present and in the future, cholecystectomy and probably appendectomy represent the primary surgical targets, and will be performed using the transgastric (36), transvaginal (20), or trans-sigmoidal route, maybe a combined (transgastric-transvaginal, transgastrica-transvesical) route, or even the transumbilical route, but many, highly appealing indications exist (44-51) that account for the interest in this approach, and awake optimism regarding the achievement of intended goals: "Surgery with no scars or infection, minimal anesthesia requirements, and immediate recovery".

¿What are the indications, benefits and drawbacks or laparoscopic or minilaparoscopic cholecystectomy, and of NOTES cholecystectomy?

¿Will NOTES cholecystectomy be cost-effective? (Table IV).

Table IV. NOTES advantages and disadvantages (42)

Advantages:
Cosmetic surgery with no scars
Free of local complications (pain, herniation, or infection)
Reduced anesthesia. Sedation?
May be taken to, and performed at the ICU
For cases with contraindicated laparoscopy (adhesions, obesity, etc.)
Disadvantages:
Infection, bleeding, perforation, and pneumoperitoneum
Effective sutures?
Instrumentation and equipment not fully developed
Reconversion percentage?
Cost-effective?

We do believe in multidisciplinary teams, that technological advances will provide materials specific for this type of surgery, and that the true indications of NOTES will eventually be established.

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