# TRANSVAGINAL VERSUS TRANSGASTRIC ENDOSCOPIC PERITONEAL APPROACH – A COMPARATIVE EXPERIMENTAL STUDY

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**TRANSVAGINAL VERSUS TRANSGASTRIC ENDOSCOPIC PERITONEAL APPROACH – A COMPARATIVE ANIMAL STUDY (*ABSTRACT*):** *Background:* During the last 30 years the advent of laparoscopy and interventional endoscopy induced the emergence of a new approach - Natural Orifice Translumenal Endoscopic Surgery (N.O.T.E.S.) in which the peritoneal cavity is accessed through stomach, vagina or other natural orifice, as a even lesser minimally invasive surgery. *Method:* A total of 8 female pigs (20-35 kg), were assigned to either transgastric or transvaginal endoscopic procedures. General anesthesia with orotracheal intubation was applied following a pre-established protocol in both groups. Transgastric peritoneoscopy, tubal excision and oophorectomy were performed in the first group, and transvaginal liver biopsy and colecistectomy in the second one, with a 14 days follow-up and necropsy at the end of the experiment. *Results:* All the procedures were successful, with no major intraoperative incidents. Postoperative evolution was uneventful. Necropsy showed mild to moderate peritoneal adhesions in both groups, with small perigastric abscesses in one animal (transgastric-NOTES). No other complications were noted. *Conclusions:* Both transgastric and transvaginal NOTES procedures are feasible and safe, but should have different indications and limitations. More research and sustained technical development are imperative before clinical implementation.

KEYWORDS: TRANSGASTRIC SURGERY, TRANSVAGINAL SURGERY, NOTES.

**ABBREVIATIONS:** OTSC clip ~ over the scope clip, SpO2 ~ oxygen saturation, TG-NOTES ~ transgastric NOTES, TV-NOTES ~ transvaginal NOTES.

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Up to the late twentieth century, laparotomy was considered the optimal solution for an adequate access to the peritoneal cavity. The advent of laparoscopy and interventional endoscopy shattered our classical view of surgical approach and changed into that of minimal invasive surgery. Natural orifice translumenal endoscopic surgery (N.O.T.E.S.) is a more recent concept consisting in a revolutionary idea of accessing closed cavities of the body (peritoneal or thoracic) through the natural orifices thus avoiding any skin incision.

The field of NOTES grew rapidly in just a few years, from simple peritoneoscopy [1-4] to more complex operations like splenectomy, sigmoidectomy etc. [5-8], mostly in experimental animal models.

* received date: 21.08.2011
accepted date: 12.10.2011

NOSCAR (Natural Orifice Surgery Consortium for Assessment and Research) group – a research consortium stated in 2005 the challenges that need to be overcome in order to introduce NOTES in clinical practice [9]. An effective closure, maintaining spatial orientation, multitasking platforms and adequate training are some of them. One of the most important problem is peritoneal access. Several approaches have been tempted – transgastric, transvaginal, transvesical or transcolonic but comparative data are not sufficient to draw a definite conclusion [10-12].

Considering all those aspects, we aimed to compare two types of endoscopic translumenal access in an animal acute experiment in terms of feasibility, incidents, accidents and complications of certain minimal surgical procedures.

## MATERIAL AND METHODS

*Subjects:*

The animal study was conducted in accordance to the European and national legislation for animal use (directive 86/609/EEC) and the protocol had the approval of Craiova Medical University Ethics Committee. Eight female pigs (Sus scrofus domesticus) with a body weight of 20 to 35 kg were used in this experiment separated in two subgroups, transgastric and transvaginal, each consisting of 4 animals.

*Preoperative care:*

Five days before the planned procedure the animals were placed in quarantine in special rooms, with adequate space and controlled temperature and light cycles, in our University's new Animal Facility. The pigs were removed from woodchip bedding 3 days later in order to avoid gastric fitobezoars, and placed into separate cages, with access to a liquid diet. 24 hours before surgery animals were fasted with a 6 hours restriction from water.

For the transvaginal group food and water was provided ad libitum, the only precaution taken was total alimentary restriction 12 hours before the surgical intervention. For an adequate decontamination of the access site, repeated vaginal irrigation with diluted 10% Polyiodine® solution (Hexi Pharma Co., Bucuresti, Romania) was performed preoperatively.

Every animal was monitored daily for signs of distress by qualified personnel. The surgical interventions were performed by a mix group of surgeons, endoscopists, veterinary technicians and anesthetists.

*Anesthesia:*

All surgical procedures were performed under general anesthesia with endo-tracheal intubation. Preoperative antibioprophilaxy with Ceftriaxone (Cefort®, Antibiotice SA, Iasi, Romania) was provided in both subgroups.

After premedication (i.m. injection of Ketamine 20mg/kgc, Xylazyne 2mg/kgc and A- tropine 0.015mg/kgc), anaesthesia induction was managed with Propofol 3-5mg/kgc, after placing a peripheral venous catheter 18G or 20G (WellcathPlus™, Wellmed, Noida, India) at the marginal vein of the ear. Endotracheal intubation was achieved with a 7mm endotracheal tube with simple lumen (MedicalExpand, La Talaudiere, France), the animal placed in dorsal decubitus for intervention.

Anaesthesia maintenance was achieved by Propofol 0,5mg/kgc/h in continuous perfusion, Fentanyl 3 μg/kgc bolus every 45 minutes, Pavulone® (Pancuronium Br, Schering-Plough) 0,1 mg/kgc in a normal saline solution 5 ml/kgc/h, with controlled pressure anesthesia with 12/minut frequency, 50% FiO2 and tidal volume.

After endotracheal intubation the swine were kept on a semi-open circuit, inhalation of 1-3% Isoflurane under ECG monitoring and SpO2, the sensor being placed at the level of the ear.

*Equipment:*

The following endoscopic equipment was used for this study: single channel colonoscope (Olympus Evis Exera™ INNOFLEX CF-Q160AL), chemically sterilized with PeraSafe™ solution (Rely+On™, DuPont, Suffolk, UK) following producer's specifications, endoscopy tower (Olympus mobile workstation WM-30, Olympus Corp., Tokyo, Japan), 0.035inch guidewire (THSF-35-400 Wire Guide, Wilson-Cook Medical Inc., Limerick, Ireland), snare (SnareMaster™ SD-221U-25, Olympus EndoTherapy, Tokyo, Japan), endoscopic OTSC™ clips( OVESCO Endoscopy GmbH, Tuebingen, Germany).

In case of the transvaginal hibrid group, we used laparoscopy instruments as 5mm and 12mm single-use trocars (Versaport Bladeless / V2, Autosuture™, Covidien, MA, U.S.), laparoscopic forceps (EndoGrasp, Autosuture™, Covidien) and multi-loads clip appliers (EndoClip II ML, Autosuture™, Covidien). The surgical procedures were recorded on a DVD-recorder (Panasonic Diga™ DVD-recorder DMR-EH68, Panasonic Corp., Osaka, Japan).

***Technique for transgastric access:***

The transgastric NOTES procedure (TG-NOTES) started with a normal eso-gastroscopy to evaluate the integrity of the stomach and to find an adequate puncture site. The translumenal access consisted in puncturing the anterior gastric wall with the needle knife, after local gastric lavage with sterile saline solution. The guidewire was inserted and the endoscopic balloon was inflated in order to obtain an orifice large enough to allow the passage of the endoscope into the peritoneal cavity. The peritoneoscopy evaluated both supra and submezocolic floor, the exposure being granted by the endoscopic forceps and by placing the operating table at different angles, in Trendelenburg / anti-Trendelenburg position with a left-right tilt.

*TG-NOTES surgical procedure*

The actual intervention in the transgastric group was unilateral or bilateral adnexectomy with oophorectomy, achieved with the help of a polipectomy snare. Local haemostasis was ensured by endoscopic monopolar diathermy. The specimen was extracted translumenally, after which the gastric access site was closed with an OTSC™ clip.

***Technique for transvaginal access:***

In the transvaginal NOTES group (TV-NOTES) the animal was placed in a 30 º Trendelenburg position and a 1.5 cm long posterior colpotomy was created. The endoscope was advanced through the transvaginal incision into the peritoneal cavity and a thorough examination of the intraabdominal organs was performed in the same manner as in the transgastric group.

*TV-NOTES surgical procedure*

The gallbladder was identified and the Calot's triangle exposed with the help of a laparoscopic forceps introduced through a laparoscopy trocar inserted in the right upper quadrant. After endoscopic dissection, the cystic artery and duct were clipped using a laparoscopic multiple clip applier and then cut. The gallbladder was separated from the liver bed using the needle-knife and extracted transvaginally using the polipectomy snare.

At the end of the intervention the colpotomy was closed with interrupted 3-0 monofilament polydioxanone (Marisorb® violett, Catgut GmbH, Germany).

In both groups pneumoperitoneum was induced and maintained by the insufflation mechanism of the colonoscope. At the end of each procedure gas was endoscopically evacuated.

For hybrid NOTES procedures, the skin incision was sutured in a standard fashion using 3-0 PDS monofil.

After 14 days of postoperative follow-up the animals were sacrificed by a single dose of sodium pentobarbital (200mg/kg i.v.) and necropsy was performed.

**RESULTS**

Both transgastric and transvaginal access routes proved successful in all animals. In case of TG-NOTES, despite thorough gastric lavage with an 18Fr/Ch oro-gastric tube, consistent residues were observed in one animal. For the other subjects, as a result of the strict hygiene measures taken a significantly lower quantity of food particles was noted.


**Fig. 1** *Gastric access using the needle-knife*

The incision site was chosen on the anterior gastric wall, at the level of the antrum (Fig. 1). The pneumogastrum and the endoscopic transilumination proved to be of great help in correctly identifying the exact spot for incision. During this initial step, the pneumogastrum was also considered a potential danger during the last part of the translumenal access due to the close contact with the abdominal wall and nearby structures (liver, gallbladder, bowel) and the risk of damaging these structures. Consequently, after marking the access spot with the needle-knife, the air was partially evacuated and the procedure could continue as planned. We took this precaution measure after having accidentally punctured the peritoneum of the anterior gastric wall (Fig. 2).

The average time to perform the gastrotomy was 18.36 min (04.46-33.24 min).

Following the gastrotomy creation the visualization of the submesocolic organs proved easy, as it showed to be in the direct axis of the endoscope. For this reason tubal excision was considered as the most appropriate intervention for this type of translumenal access.


**Fig. 2** *Accidental lesion of the ventral abdominal wall during transgastric access*

Inspection of the upper quadrants of the abdomen and the access site required the endoscopic "U" turn, with the subsequent retroverted image of the operative field (Fig. 3).

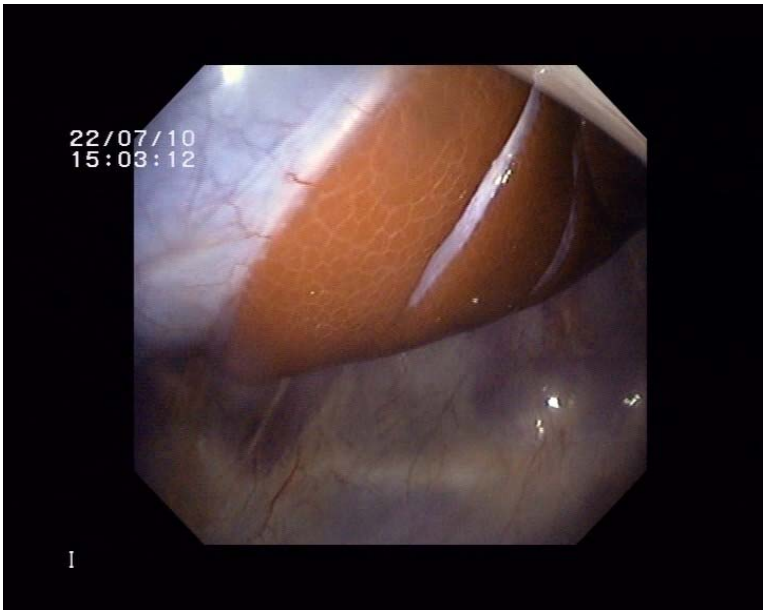


**Fig. 3.** *Retroverted image of the liver and gallbladder. Transgastric endoscopic view.*

In case of the transvaginal approach, the colpotomy creation and endoscopic access time averaged between 7 min – 10.30 min (mean 8.37 min), with no incidents occurring in this period, thus proving quicker and easier than for the transgastric access. Supramesocolic structures were identified with ease. Following the same logic as in the transgastric group, colecistectomy was chosen as an adequate procedure to perform (fig 4).

The translumenal incision was successfully closed in the TG-NOTES using OTSC™ clips in 14.05 min ± 2.05 min as for the TV-NOTES it required an average of 4 min (3-5 min).

The total time of each operation varied from 80.28 min to 112.20 min in the transgastric group, and from 96 min to 191 min for the transvaginal interventions.


**Fig.4** *Endoscopic view of the gallbladder in transvaginal NOTES*

The hemodynamic and respiratory parameters in the two groups showed normal results in terms of blood pressure value, pulse and O2 saturation. In the first transgastric animal aspiration of pneumoperitoneum was requested by the anaesthetist at the beginning of the intervention.

We encountered two complications in the TG-NOTES, bleeding at the incision site in one case, which was successfully managed by monopolar coagulation, and a minor abdominal wall lesion with no influence upon the success of the intervention and no consequence in the postoperative evolution.

In the postoperative course no particular events were noted, with a single exception in case of the transgastric group with fever, lack of appetite and a tendency for isolation since the 3rd p.o. day. Consequently, antibiotics (Linco-Spectin™, Pfizer Animal Health div., Pfizer Inc., NY, U.S.) 7ml/day, were administered for five consecutive days, with favorable response. The necropsy revealed perigastric abscess and gastric ulcer confirmed by the histopathological examination, yet no leakage was uncovered.

The gross examination found good cicatrisation at the translumenal entry site in all animals, aspect confirmed in case of TG-NOTES by the gastric air bursting tests, and mild to moderate peritoneal adhesions.

**DISCUSSION**

The path for the translumenal endoscopic surgery is open and the numerous animal experiments performed to this date are the solid proof of the interest it elicited among surgeons and gastroenterologists. Many aspects need to be investigated before its safe and wide-spread introduction into clinical practice. The fact that this concept involves multiple access options means that one of the directions of research must be oriented towards the comparative analysis of different approaches. Our team focused on this aspect in a comparative study regarding the two most frequently used routes for peritoneal translumenal access: the transgastric and the transvaginal ones. In order to accomplish it, we considered that it is mandatory to have an overall analysis concerning the feasibility of each type of surgery, of the intraoperative and postoperative problems, follow-up, total and specific access and closure time.

A major but less mentioned problem in animal transgastric NOTES is the preoperative gastric preparation, which is more demanding, takes longer to perform and, in many cases, it shows to be suboptimal [13]. However, this is a problem that should be less encountered in humans view the different physiology of gastric empting, diet and compliance.

Transgastric peritoneal exploration is easier for the submesocolic organs that are in direct view. Still, tissue retraction and exposure was difficult due to the excessive flexibility of the colonoscope and the inadequate endoscopic accessories. The individual examination of each loop of the small bowel was accomplished by grasping with the endoscopic forceps and moving them with the articulated end of the endoscope, in certain cases proving quite difficult and time-consuming due to the small size of the endoscopic instruments and their poor haptic capabilities. As in laparoscopy, the visceral mass is displaceable using gravity by tilting the operating table at different angles.

Another aspect pledging for transvaginal approach is the cost of the procedure: the need for single-use equipment (needle-knife, endoscopic balloon, polipectomy snare, closure devices) and preoperative preparation means higher costs in case of transgastric surgery.

The specimen extraction was easy to perform in both groups mainly because both translumenal orifices have excellent elastic properties, being able to expand easily and regain its original shape. One possible drawback for TG-NOTES is the limited calibre and fragility of the oesophagus, with direct consequences over the maximum size of the retrievable specimen.

Closure of the posterior colpotomy is rapid and without difficulties; based on gynaecologic experience some even argue that incisions can be left open, leaving the secretions to spontaneously drain [14]. As for the gastric closure methods in NOTES, they have continuously evolved. Since the first translumenal endoscopic experiments in pigs more than seven years ago, using only endoscopic clips or no closure at all for the gastrotomy, new devices were created, such as T-tags (Ethicon, Cook Endoscopy), LSI Solutions prototype (LSI Solutions, N.Y., U.S.), TPD (NDO Surgical Inc., U.S.), Eagle Claw™ (Olympus America, Inc.), OTSC™ etc.

All those devices represent a step forward but they lack the reliability, safety and the ergonomics of laparoscopy or open surgery [15].

The main drawback for the transvaginal approach in natural orifice surgery is that this route, contrary to the transgastric access, is available only for half of the population. Several exclusion criteria lessen even more the applicability of this access route: active vaginal infection, local malignancies, pregnancy and, arguably, endometriosis. There are also some questions regarding postoperative pain and dispareunia [16], although most studies tend to disprove this idea [17-19]. The lower innervation of the posterior cul de sac is probably linked to the absence of this type of symptomatology [20].

One final aspect concerning translumenal endoscopic surgery, mandatory for all involved in this field, is safety. Even if the total number of subjects taken into account is too small for any statistical analysis and despite the hybrid nature of the TV-NOTES, we believe that in our study transvaginal approach was safer, considering the intra- and postoperative accidents and complications. Other authors describe sometimes important complications related to TG-NOTES such as perigastric abscesses, gastrocolic fistula, peritonitis etc sustaining this idea [21-23]. It appears that, more than everything, the safe introduction of transgastric endoscopic surgery depends on a reliable closing solution. Unlike transvaginal approach an inefficient gastric closure may in the end imperil patient's life.

## CONCLUSION

Both transgastric and transvaginal surgical procedures proved feasible. Considering the current stage of endoscopic development, transvaginal endoscopic surgery may offer some advantages over the transgastric access route, especially regarding the virtually inexistent risk of peritonitis. Regardless of the access route, advanced multitasking endoscopic platforms are required in order to successfully implement this method into clinical practice.

**Acknowledgments:**

The authors kindly thank the team of dedicated endoscopists led by Prof. A. Saftoiu for their continuous support during the transgastric experiments.

**Disclosures:**

Part of this study was supported by the research grant *"Survival and immunologic impact in transgastric oophorectomy compared to laparoscopic approach"* (PNII 41-023 / 2007 / RONOTES). The authors have no conflicts of interest or financial ties to disclose.

**REFERENCES:**

1. Kaloo AN, Singh VK, Jagannath SB, Niiyama H, Hill SL, Vaughn CA, Magee CA, Kantsevoy SV. Flexible transgastric peritoneoscopy: a novel approach to diagnostic and therapeutic interventions in the peritoneal cavity. *Gastrointest Endosc.* 2004; 60(1): 114-117.
2. Wagh MS, Merrifield BF, Thompson CC. Endoscopic transgastric abdominal exploration and organ resection: initial experience in a porcine model. *Clin Gastroenterol Hepatol.* 2005; 3(9): 892-896.
3. Jagannath SB, Kantsevoy SV, Vaughn CA, Chung SS, Cotton PB, Gostout CJ, et al. Peroral transgastric endoscopic ligation of fallopian tubes with long-term survival in a porcine model. *Gastrointest Endosc.* 2005; 61(3): 449-453.

4. Wagh MS, Merrifield BF, Thompson CC. Survival studies after endoscopic transgastric oophorectomy and tubectomy in a porcine model. *Gastrointest Endosc.* 2006; 63(3): 473-478.
5. Perretta S, Dallemagne B, Coumaros D, Marescaux J. Natural orifice transluminal endoscopic surgery: transgastric cholecystectomy in a survival porcine model. *Surg Endosc.* 2008; 22(4): 1126–1130.
6. Kantsevoy SV, Hu B, Jagannath SB, Vaughn CA, Beitler DM, Chung SS, et al. Transgastric endoscopic splenectomy: is it possible? *Surg Endosc.* 2006; 20(3): 522–525.
7. Bergström M, Ikeda K, Swain P, Park PO. Transgastric anastomosis by using flexible endoscopy in a porcine model. *Gastrointest Endosc.* 2006; 63(2): 307–312.
8. Leroy J, Cahill RA, Perretta S, Forgione A, Dallemagne B, Marescaux J. Natural orifice translumenal endoscopic surgery applied totally to sigmoidectomy: an original technique with survival in a porcine model. *Surg Endosc.* 2009; 23(1): 24-30.
9. Rattner D, Kalloo A. ASGE/SAGES Working Group on Natural Orifice Translumenal Endoscopic Surgery. October 2005. *Surg Endosc.* 2006; 20(2): 329-333.
10. Gettman MT, Blute ML. Transvesical peritoneoscopy: initial clinical evaluation of the bladder as a portal for natural orifice translumenal endoscopic surgery. *Mayo Clin Proc.* 2007; 82: 843-845.
11. Fong FG, Pai RD, Thompson CC. Transcolonic endoscopic abdominal exploration: a NOTES survival study in a porcine model. *Gastrointest Endosc.* 2007; 65(2): 312-318.
12. Marescaux J, Dallemagne B, Perretta S, Wattiez A, Mutter D, Coumaros D. Surgery without scars: report of transluminal colecystectomy in a human being. *Arch Surg.* 2007; 142(9): 823-827
13. Simopoulos C, Kouklakis G, Zezos P, Ypsilantis P, Botaitis S, Tsalikidis C, et al. Peroral transgastric endoscopic procedures in pigs: feasibility, survival, questionings, and pitfalls. *Surg Endosc.* 2009; 23(2): 394-402.
14. Franchi M, Ghezzi F, Zanaboni F, Scarabelli C, Beretta P, Donadello N. Nonclosure of peritoneum at radical abdominal hysterectomy and pelvic node dissection: a randomized study. *Obstet Gynecol.* 1997; 90: 622–627.
15. Surlin V, Saftoiu A, Rimbas M, Vilmann P. NOTES - "state of the art" surgical gastroenterology: the beginning of the voyage. *Hepatogastroenterology.* 2010; 57(97): 54-61.
16. Thele F, Zygmunt M, Glitsch A, Heidecke CD, Schreiber A. How do gynecologists feel about transvaginal NOTES surgery? *Endoscopy.* 2008; 40: 576–580.
17. Zorinig C, Mofid H, Siemssen L, Wenck CH. NOTES uber den transvaginalen Zugang. Transvaginal access for NOTES. *Der Chirurg.* 2010; 81(5): 426-430.
18. Abdelmonem A, Wilson H, Pasic R. Observational comparison of abdominal, vaginal, and laparoscopic histerectomy as performed at a university teaching hospital. *J Reprod Med.* 2006; 51: 945-954.
19. Roussis NP, Waltrous L, Kerr A, Robertazzi R, Cabbad MF. Sexual response in the patient after histerectomy: total abdominal versus supracervical versus vaginal procedure. *Am J Obstet Gynecol.* 2004; 190: 1427-1428.
20. Federlein M, Borchert D, Muller V, Atas Y, Fritze F, Burghardt J, et al. Transvaginal video-assisted cholecystectomy in clinical practice. *Surg Endosc.* 2010; 24(10): 2444-2452.
21. Perretta S, Sereno S, Forgione A, Dallemagne B, Coumaros D, Boosfeld C, et al. A new method to close the gastrotomy by using a cardiac septal occluder: long-term survival study in a porcine model. *Gastrointest Endosc.* 2007; 66(4): 809-813.
22. McGee M, Marks JM, Jin J, Williams C, Chak A, Schomisch SJ, et al. Complete endoscopic closure of gastric defects using a full-thickness tissue plicating device. *J Gastrointest Surg.* 2008; 12: 38-45.
23. Pauli EM, Moyer MT, Haluck RS, Mathew A. Self-approximating transluminal access technique for natural orifice transluminal endoscopic surgery: a porcine survival study. *Gastrointest Endosc.* 2008; 67(4): 690-697.