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TECHNIQUES

Natural Orifice Transluminal Endoscopic Surgery: Transgastric Cholecystectomy in a survival porcine model

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Beyond doubt, laparoscopic cholecystectomy has changed the focus of surgery and the mind-set of nearly all surgeons. For this reason, the initial natural orifices translumenal endoscopic surgery (NOTES) project focused on cholecystectomy, which seemed to be the most logical and appealing clinical application.

The first reports on cholecystectomy confirmed the feasibility of NOTES but identified substantial technical limits because of exposure, endoscope stability issues, and limitations in the control of dissection tools [1, 2]. These limitations led to experimentation with other natural orifice accesses: the colon, the urinary bladder, and combined routes [3, 4].

Although transcolonic cholecystectomy has been reported in survival studies, to date, the feasibility of transgastric cholecystectomy has been described only in nonsurvival animal models [1, 2, 5]. We report the successful performance of transgastric cholecystectomy with survival in a porcine model.

Materials and methods

Animals

Six female pigs weighing 25 to 30 kg were used in this study. All the animals were managed according to the French laws for animal use and care as well as the directives of the European Community Council (number 86/609/EEC).

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Preoperative preparation

The pigs were deprived of food for 48 h before surgery. Premedication consisted of intramuscularly injected ketamine 7 ml and 3 ml of a solution containing with azaperone, methylene parahydroxybenzoate and propyle parahydroxybenzoate (Stresnil; Janssen-Cilag, Berchem, Belgium). General anesthesia was induced with intravenous (IV) propofol 10 ml/30 kg and pancuronium 2 ml. After endotracheal intubation, anesthesia was maintained with isofluorane 2%.

All the animals received antibiotic prophylaxis with an IV injection of cephalexin 1 g. After intubation, an orogastric tube was placed, and a gastric lavage was performed with 1,500 ml of sterile saline solution 0.9%. Once the stomach was adequately cleaned, an antibiotic suspension (cephalexin 1 g + 250 ml of saline solution 0.9%) was instilled through the orogastric tube and left in place for 10 min.

Procedure

The animals were placed in supine position. A sterile double-channel video gastroscope (Karl Storz Endoscopy, Tuttlingen, Germany) was inserted orally into the stomach. The gastrotomy site was carefully chosen by observation of the indentation on the gastric wall produced by palpation of the anterior abdominal wall (percutaneous endoscopic gastrostomy [PEG] technique). A needleknife (Microknife,

Boston Scientific, Natick, MA, USA) with monopolar energy was used to make a 1.5-cm-long incision on the anterior gastric body. The metallic tip of the needleknife then was retracted, and the catheter was pushed through the gastrotomy as a guide for advancing the video gastroscope into the peritoneal cavity. Once the endoscope was in the abdomen, the needleknife was retrieved and an abdominal exploration was performed to rule out any damage that may have occurred during performance of the gastrotomy.

After a peritoneoscopy, the gallbladder was visualized using a particular position of the endoscope in retroflexion that allowed for normal orientation of the operative image (Fig. 1). A Veress needle was inserted into the right subcostal region through a 1.5-mm skin incision to insufflate carbon dioxide and then to monitor the pneumoperitoneum. The needle was used to retract the fundus of the gallbladder and help in the exposure of Calot's triangle.

All the surgical principles of cholecystectomy were strictly respected. The elements of Calot's triangle were clearly identified, with excellent visualization of the cystic duct and artery, which were secured with endoclips (Ez-clip; Olympus, Tokyo, Japan) and divided (Fig. 2). The gallbladder was dissected away from the intrahepatic fossa with an endoscopic grasper and a unipolar round-tip electrode (Karl Storz Endoscopy, Tuttlingen, Germany). The dissection then was performed toward the gallbladder fundus.

Once resected, the gallbladder was caught with a snare and retrieved from the abdominal cavity through the gastrotomy in one piece. The gallbladder fossa was washed and inspected to rule out bleeding, liver bed laceration, or bile leak. Adjacent organs also were examined carefully for evidence of inadvertent injury.

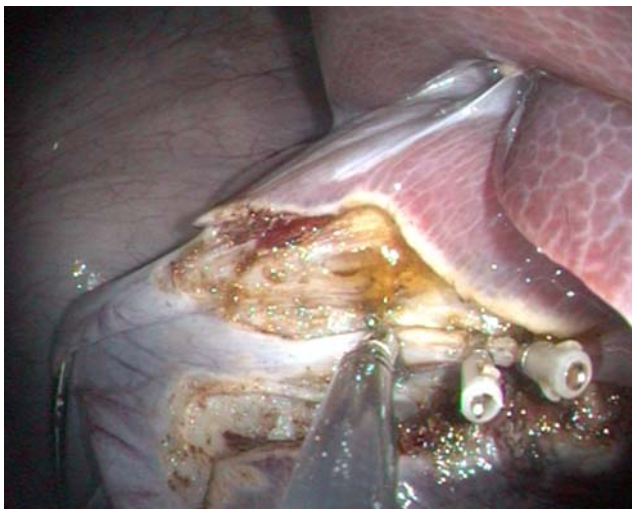

Fig. 2 Endoscopic view of the cystic pedicle with endoclips in place

The pneumoperitoneum was evacuated through the Veress needle with suction from the endoscope. The endoscope was retracted into the stomach, and the gastrotomy was closed using a 27- to 30-mm polyethylene terephthalate cardiac septal occluder (Occlutech; Jena, Germany) according to a previously described method [6] (Fig. 3).

Postoperative care

After surgery, all the pigs received an IV injection of of flunixine (meglumine) 2 ml/50 kg as analgesic antiinflammatory agent. They were extubated, recovered, and kept in stalling in individual cages. Oral antibiotics (300 mg of oral cephalexin) were administered daily for 5 days.

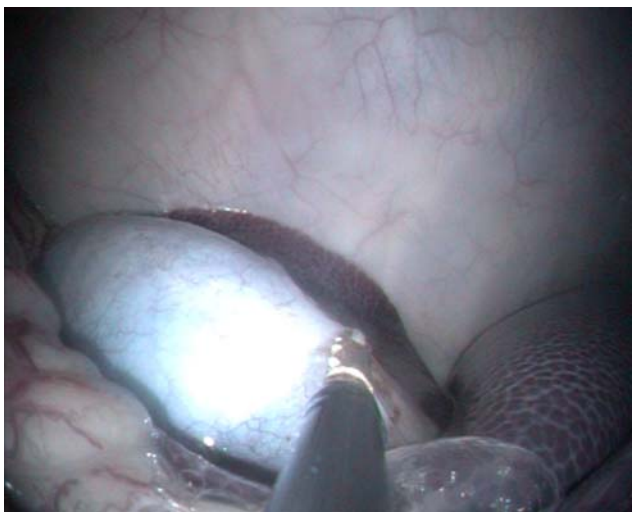

Fig. 1 Endoscopic view of the gallbladder

Fig. 3 Gastric closure with the occluder

A regular diet was resumed within 24 h after the procedure. All the animals were monitored daily for signs of distress or changes in their feeding habits.

Follow-up evaluation

Postoperative follow-up assessment included gastroscopy 1 and 2 weeks after the initial procedure and laparoscopy on postoperative day 12. Gastroscopy was performed to check the gastrotomy site. Laparoscopy allowed for examination of the peritoneal cavity to find evidence of infection, abscess, bile, or digestive leak and adhesions.

Results

Transgastric cholecystectomies were successfully performed in all cases with no intraoperative or postoperative complications. In all cases, it was possible to reproduce the position of the endoscope to obtain a "normal" anatomic orientation of the operative field. Four of the six pigs experienced perforation of the gallbladder during dissection. Three injuries were due to cautery, and one was caused by the grasper.

The mean operative time was 60 min (range, 40–120 min), which dramatically decreased with experience. All the animals thrived in the postoperative period, with appropriate weight gain. Follow-up endoscopy at 1 and 2 weeks showed a successful and secure closure of the gastrotomy. Laparoscopic exploration of the peritoneal cavity demonstrated minimal thin adhesions in the right hypochondrium of all the animals. The gallbladder fossa was clean (Fig. 4). There were no signs of bile leak or infection.

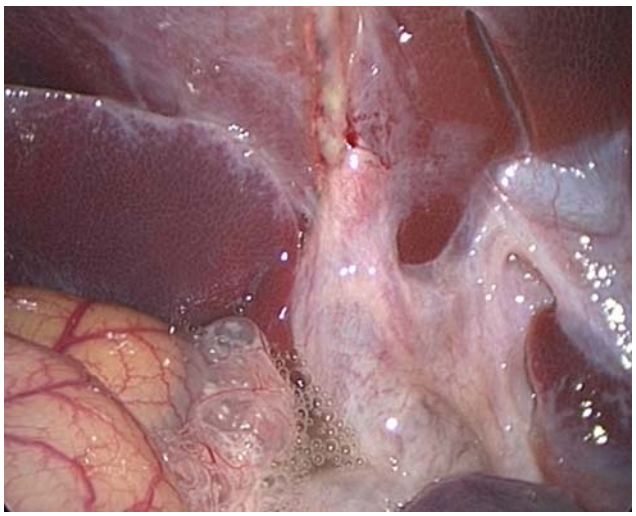

Fig. 4 Laparoscopic view of the gallbladder fossa on postoperative day 12

Loose and thin adhesions were found between the serosal side of the gastrotomy site and the omentum.

Discussion

Cholecystectomy is a good model of human ingenuity and technological advance that can help patients by reducing the trauma and discomfort associated with surgery. Langenbuchs' open cholecystectomy remained the gold standard for more than a century [7]. The latest variations of the technique focused on decreasing the surgical trauma by reducing the size of the incisions while respecting careful dissection techniques. Because of socioeconomic constraints, postoperative pain, length of hospital stay, recovery period, and cosmetic results became inevitable surgical end points.

The advent of laparoscopic cholecystectomy confirmed this trend. Within 2 years, supported by patient demand and technological developments, the technique was established as the new gold standard by the most respected health system authorities [8]. The main justifications for NOTES confirm this general trend. The hypothesis is that a further attempt to reduce the surgical trauma will have an impact on the surgical end points [9]. The potentials and constraints of NOTES are still a matter of discussion.

Although transgastric access to the abdominal cavity seems the route that may dominate NOTES in the future, some challenging issues remain such as infection risk and the method of gastric closure, which will need to be addressed before this technique is introduced into clinical practice. Initial studies have favored the transgastric approach, but the gallbladder still seems to be a difficult target. The main limitations identified by the investigators are difficulty related to identification of the gallbladder, a disorienting retroflex position for working, and the need to operate and provide retraction with inadequate instruments.

To overcome the limitation of isolated transgastric access, other translumenal accesses alone or combined (transcolonic, transgastric, and transvesical) and the use of multiple scopes (Swain) or multichannel prototype instruments with stabilization technology (Shapelock, USGI, San Clemente, California) have been described [1–4]. Although the transcolonic approach to the gallbladder has been reported as successful by Pai et al. [14] in a survival model, to date, transgastric cholecystectomy has been reported only in nonsurvival studies [1, 2, 4, 5].

One definitive asset of the transcolonic approach is direct access to the biliary structures and ease of endoscope maneuvers, avoiding the paradoxical motion often associated with a retroflex position [5]. However, this route raises a number of questions about the increased risks of infection. The transvaginal approach, used for years for different

surgical procedures, mimics the advantages of the transcolonic approach and may be the ideal route, with its intrinsic limitations [10].

Other issues appear as prerequisites to any clinical application and route of NOTES cholecystectomy: safety of the incision to the chosen hollow organ, safety of the entrance to the peritoneal cavity, and monitoring of the pneumoperitoneum. If the first issue can be addressed using a PEG-like technique in the transgastric route, the latter is not yet integrated into the conventional flexible endoscopes [11, 12]. There is still a need for transparietal monitoring using a laparoscopic Veress needle. The needle port will be used to insufflate carbon dioxide, monitor the intraperitoneal pressure, and retract the fundus of the gallbladder. Until the availability of dedicated NOTES endoscopes, we believe the safest technique is one that incorporates needle-scope monitoring of the entrance in the peritoneal cavity as well as the pneumoperitoneum while providing exposure [13].

Our report is a tentative attempt at overcoming the major issues of transgastric cholecystectomy. The success rate was 100% using a standard double-channel video flexible gastroscope and standard endoscopic instruments. The quality of the operative view obtained with the endoscope was excellent. At no stage of the procedures was there a need to switch to a laparoscopic view or to introduce a laparoscopic instrument other than the Veress needle to provide exposure and monitoring of the intraperitoneal pressure. The particular position of the scope provided a normal anatomic orientation of the operative field. This visualization, similar to that achieved during laparoscopy, facilitated the critical steps during dissection, minimizing surgical error.

All the principles of cholecystectomy were strictly respected. No bleeding or laceration of the liver bed occurred during the procedure. The cystic duct and artery were properly dissected, secured with endoclips, and divided. The combination of grasping and cutting with the endoscopic instruments and the deflection movements of the endoscope tip were used to accomplish the dissection. Perforation of the gallbladder during dissection did not lead to any perioperative or postoperative complication. However, this risk will be another important issue to consider before patients with multiple gallstones are subjected to transgastric cholecystectomy.

The standard endoscopic dissecting and grasping tools used were partially if not totally responsible for the gallbladder perforations. The enormous dependence of surgeons on instrument manufacturers for progress in NOTES is apparent. There is an urgent need for more effective flexible endosurgical tools, which frankly are poor currently.

Follow-up endoscopy and laparoscopy demonstrated the effectiveness of the gastric closure with a modified cardiac septal occluder. Minimal adhesions, comparable with those observed after a laparoscopic cholecystectomy, were present in the right hypochondrium. The peritoneal cavity was intact, with no signs of infection, bile leak, or injury to adjacent organs.

Conclusions

This study demonstrated the technical feasibility and safety of transgastric cholecystectomy and provided the first report on a survival porcine model. Major issues related to the transgastric route, infection, gastric incision and closure, visualization, exposure, and dissection were surmounted by this technique using standard flexible endoscopic tools. The 100% success rate was obtained at the cost of a 1.5-mm abdominal puncture in the right hypochondrium. Transgastric cholecystectomy is not far from application to humans.

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