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*Original article*

# Experimental laparoscopic pyloromyotomy in pigs

**P. Holak, H. Matyjasik, M. Jalyński, Z. Adamiak, P. Przyborowska**

Department of Surgery and Roentgenology, Faculty of Veterinary Medicine,  
University of Warmia and Mazury in Olsztyn, Oczapowskiego 14, 10-719 Olsztyn, Poland

## Abstract

The objective of this study was to evaluate and compare laparoscopic pyloromyotomy methods involving the laparoscopic scalpel and the harmonic scalpel in pigs. The experiment was conducted on 4 subgroups of 12 animals subjected to laparoscopic-assisted pyloromyotomy with a surgical scalpel and the harmonic scalpel, as well as laparoscopic pyloromyotomy with Berci's laparoscopic scalpel and the harmonic scalpel. No postsurgical complications were observed. Four weeks after the surgery, the animals were sacrificed and autopsy was performed. In one animal peritoneal adhesions between the intestines and the mini-laparotomy incision were found. Laparoscopic pyloromyotomy and laparoscopic-assisted pyloromyotomy performed in pigs enabled the selection of laparoscopic entry sites, instruments for pyloromyotomy and evaluation of the applied surgical procedures in animals. The results of this study indicate that the methods applied can be safely used in clinical practice in dogs and cats due to minimal post-operative complications and fast healing of laparoscopic incisions in comparison with classical surgical wounds, and that the harmonic scalpel is a safe surgical instrument.

**Key words:** harmonic scalpel, pylorus, endoscopy, pig

## Introduction

Minimally invasive veterinary surgery is gradually entering daily clinical practice. Laparoscopy is increasingly often the method of choice for diagnosing and treating abdominal disorders, in particular in dogs, cats and horses (Fischer 1991, Csiszar and Brath 1997, Bouchard et al. 1999, Webb and Trott 2008, Freeman 2009, Matyjasik et al. 2011, Holak et al. 2013). In many clinics, tissue biopsy samples for histopathological analyses are obtained by laparoscopy. Laparoscopic biopsies are performed on the liver,

kidneys, pancreas, intestines, spleen, lymph nodes, prostate and adrenal glands (Rawlings et al. 2002, Webb 2008, Webb and Trott 2008, Rothuizen and Twedt 2009, Holak et al. 2010, Nowicki et al. 2010, Chyczewski et al. 2011). The most common laparoscopic procedures in veterinary medicine are gastropexy (Rawlings 2002, Mayhew and Brown 2009), cryptorchidectomy (Hanrath and Rodgers 2002, Vannozzi et al. 2002), ovariohysterectomy (Mayhew and Brown 2007, Matyjasik et al. 2011), cholecystectomy (Mayhew et al. 2008) and splenectomy (Collard 2010). Natural Orifice Transluminal Endoscopic

Surgery (NOTES) represents the next stage in the evolution of minimally invasive surgical techniques in veterinary medicine (Matyjasik et al. 2011).

Laparoscopic surgical treatment is becoming increasingly popular on account of its minimal invasiveness. There is a general lack of published studies into the use of laparoscopic pyloromyotomy in veterinary medicine. In view of the above, the objective of this study was to propose new surgical entry sites and procedures for pyloromyotomy in animals.

The process of mastering surgical procedures that require complex manipulation skills and adapting them to veterinary medicine requires experimental animals. Animal experiments provide surgeons with the necessary experience for the treatment of pyloric stenosis in dogs and cats. Pyloric stenosis (narrowing) leads to the obstruction of the pyloric lumen and problems with stomach emptying. The exact cause of the disorder is unknown, but research in human medicine suggests that excessive production of extracellular matrix proteins by muscle cells can contribute to hypertrophic pyloric stenosis (Guarino et al. 2000). Other studies demonstrated an absence or a deficiency of nerve fibers responsible for the relaxation of the pyloric sphincter (Ohshiro and Puri 1998). Some authors reported an absence of interstitial cells of Cajal, which modulate neurotransmission, generate discharge of electrical activity and inhibit the activity of smooth muscles of the gastrointestinal tract, in patients diagnosed with pyloric stenosis (Vanderwinden et al. 1996). Increased expression of insulin-like growth factor 1 and transforming growth factor beta was observed in selected patients. Pyloric stenosis causes persistent vomiting in young brachycephalic dogs and Siamese cats, but it can affect all dogs and cats. Most animals vomit directly after feeding, and projectile vomiting is reported in some cases. Persistent vomiting may lead to hypochloremia, hypokalemia and metabolic alkalosis (Ohshiro and Puri 1998). Pyloromyotomy is a method of choice in the treatment of pyloric stenosis. This study was designed to assess and compare two laparoscopic methods of pyloromyotomy performed with the use of laparoscopic scalpel and harmonic scalpel.

## Materials and Methods

The study was carried out in the Department and Clinic of Surgery and Rentgenology, Faculty of Veterinary Medicine of the University of Warmia and Mazury in Olsztyn, Poland, upon the approval of the Local Ethics Committee for Experiments on Animals (decision No. 01/2009 of 14 January 2009). The study was performed during 2009-2011.

The experiment was performed on 12 Polish Large White pigs of both sexes, aged approximately 3 months, with body weight of 20-30 kg. The animals were divided into 2 groups of 6 pigs each. Pyloromyotomy was performed in 3 animals from the every subgroup.

### Group 1 – Laparoscopic-assisted pyloromyotomy

Group 1a – Laparoscopic-assisted pyloromyotomy with the use of a surgical scalpel.

Group 1b – Laparoscopic-assisted pyloromyotomy with the use of the harmonic scalpel.

### Group 2 – Laparoscopic pyloromyotomy

Group 2a – Laparoscopic pyloromyotomy with the use of Berci's ball point type scalpel.

Group 2b – Laparoscopic pyloromyotomy with the use of the harmonic scalpel.

The procedures were performed with the involvement of a laparoscopic column, laparoscopic instruments and the harmonic scalpel.

All the animals were fasted for 12 hours before the laparoscopic surgery and subjected to general anesthesia in accordance with species-specific requirements. The surgical field was prepared in line with general standards. Pneumoperitoneum was achieved through insufflation with carbon dioxide. When pressure inside the peritoneal cavity was stabilized, an optical port (port No. 1) was inserted in the umbilical region in both groups.

In group 1, a working port (port No. 2) was inserted along the axillary line on the right side of the abdomen, approximately 4 cm from the ribcage. Babcock forceps were introduced into the abdominal cavity through a port No. 2. The pylorus was grabbed with the forceps and pulled in the direction of the working port. All surgical manipulations were monitored on the video screen. The incision in the abdominal integument, through which the working port was inserted, was extended to approximately 3 cm in length. The pylorus was pulled up to the incision, grabbed with the left hand, and Ramstedt's pyloromyotomy was performed with the right hand. Pyloromyotomy was carried out with the use of a surgical scalpel in group 1a and the harmonic scalpel in group 1b. The serous membrane and part of the muscular layer of the pylorus were incised, but only partially to avoid accidental perforation of the pyloric mucosa. The incision was made between the proximal duodenum, along the long axis of the pylorus in the direction of the stomach, in the region where the

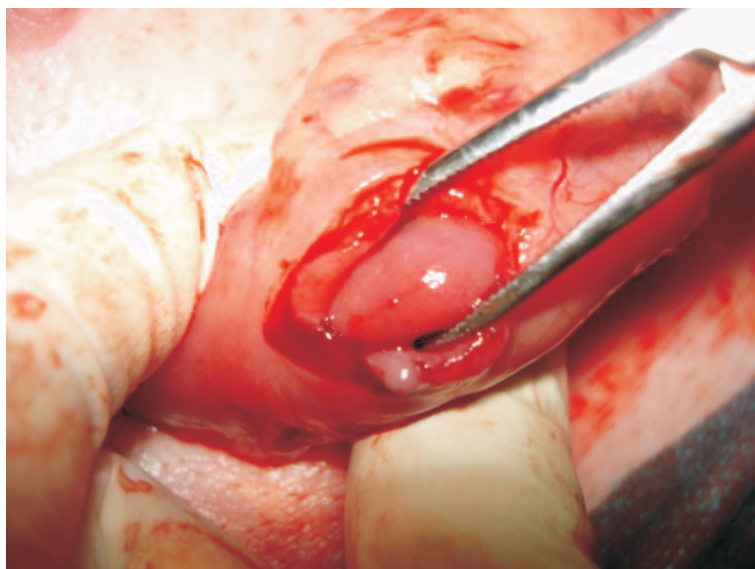


Fig. 1. Protruding mucosa after laparoscopic-assisted pyloromyotomy (group 1a).



Fig. 2. The use of Berci's scalpel during laparoscopic pyloromyotomy (group 2a).

pyloric sphincter is located. The incision was deepened carefully by introducing Pean forceps into the wound and opening them vertically across the incision. The forceps were expanded until the mucosa protruded into the wound (Fig. 1). Port wounds were closed with two layers of sutures made of absorbent material with a nominal diameter of 3-0. Sutures were removed ten days after the surgery.

In group 2 animals, three working ports were placed in the abdominal wall after an optical port had been inserted, similarly to group 1. They were used to insert Babcock forceps (ports No. 2 and 3) and Berci's scalpel (port No. 4). Port No. 2 was placed along the right axillary line, approximately 4 cm behind the last

rib. Port No. 3 was located along the left axillary line, approximately 6 cm behind the last rib, and port No. 4 – along the paramedian line, between the optical port and port No. 3. Ports No. 2 and 3 were used to insert Babcock forceps, and port No. 4 – to introduce Berci's scalpel in subgroup 2a pigs or the harmonic scalpel in subgroup 2b animals. The blade of Berci's scalpel was hidden inside the sheath during insertion, and it was extended only when the incision was made in the pylorus. Similarly to group 1, the pylorus was grabbed and immobilized with Babcock forceps, and the pyloric serosa and muscular layer were incised with Berci's scalpel in subgroup 2a (Fig. 2) and with the harmonic scalpel in subgroup 2b

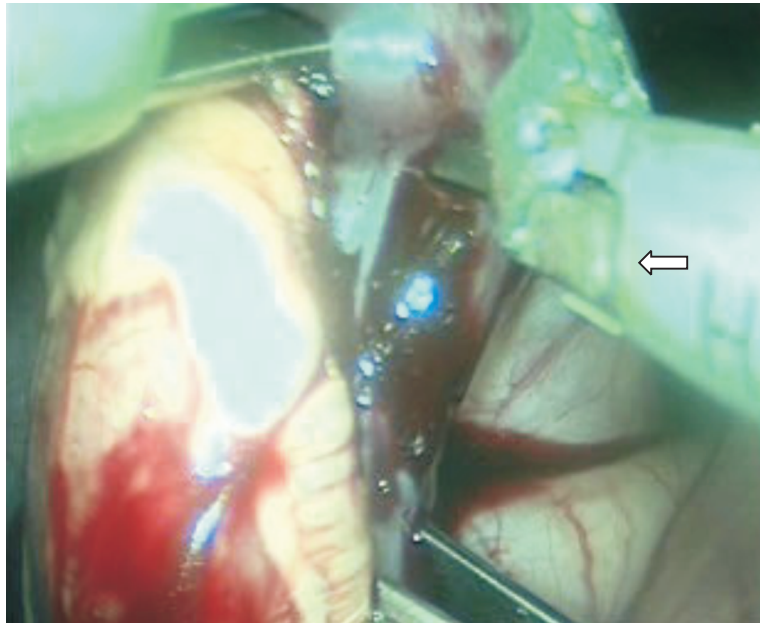


Fig. 3. The use of the harmonic scalpel during pyloromyotomy (white arrow) in group 2b.

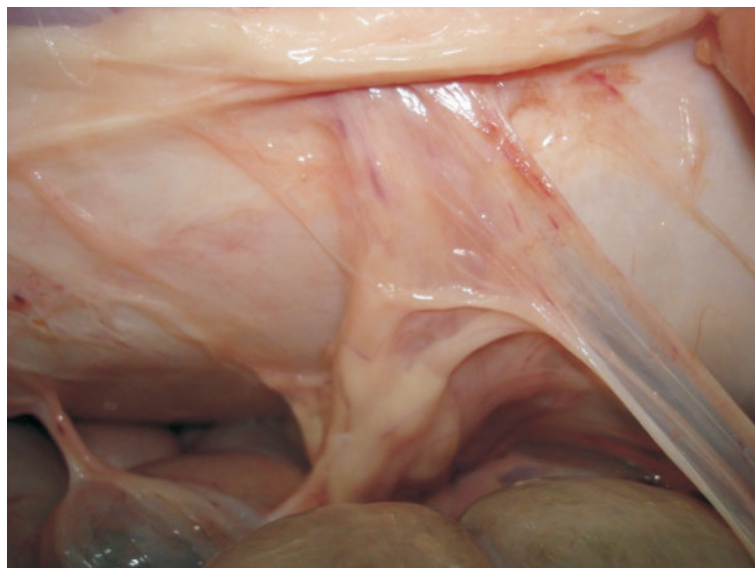


Fig. 4. Peritoneal adhesions between the intestines and the mini-laparotomy incision.

(Fig. 3). All surgical manipulations were monitored on the video screen. Port wounds were sutured using the same technique as in the first group.

Post-operative antibiotic treatment was continued for 5 days, body temperature was monitored daily for 7 days, then weekly for 4 weeks until euthanasia.

## Results

No anesthetic or surgical complications were reported in any of the 12 animals subjected to pyloromyotomy. Twenty-four hours after the procedure,

all experimental group animals were fed in the amount identical to that administered before the treatment. The experimental animals were observed for 4 weeks after the surgery, and no complications associated with laparoscopic procedures were reported. Body temperature was monitored daily in the first week after the surgery, and it was within the norm. After the first week, temperature was controlled at weekly intervals, and it remained within a normal physiological range until the end of the experiment. Wounds created by mini-laparotomy procedures and laparoscopic ports healed without complications, with only minor swelling and reddening

of the surrounding area. The swelling around mini-laparotomy wounds was greater than that induced by port insertion. The operative time ranged from 40 to 70 minutes during laparoscopic-assisted pyloromyotomy, and from 60 to 80 minutes during laparoscopic pyloromyotomy. A post-mortem examination, carried out 4 weeks after the experiment, revealed peritoneal adhesions between the intestine and the mini-laparotomy incision in one pig from group 1a (Fig. 4).

## Discussion

The first stage of the study was conducted on pigs weighing 20-30 kg. Those animals were selected for the experiment due to similarities in body weight and size with dogs, the target species for the developed laparoscopic techniques and procedures. Twelve pigs was the minimum required number of individuals for developing operative methods, mastering the technique and acquiring the necessary experience for clinical practice.

Pyloromyotomy was performed based on the method described by Ramstedt (Alain et al. 1991). The serous membrane and part of the muscular layer of the pylorus were incised, and the edges of the wound were extended until the pyloric mucosa became visible. According to the authors, Ramstedt's technique is a safe method that minimizes the risk of mucosal damage and perforation. In human medicine, perforation of the pyloric mucosa is reported in 8% of cases in pyloromyotomy by laparotomy and in 2% of cases in laparoscopic pyloromyotomy (Yagmurlu et al. 2004). Patients undergoing laparoscopic pyloromyotomy generally recover faster than those who are subjected to the treatment via laparotomy (Hall et al. 2004, Haricharan et al. 2008, Hall et al. 2009).

A review of veterinary literature indicates that Ramstedt's pyloromyotomy by laparotomy through the linea alba has been performed in dogs and cats with pyloric stenosis. According to the authors' best knowledge, there are no documented reports of laparoscopic pyloromyotomy in veterinary practice.

Based on the authors' previous experience in laparoscopic surgery, novel laparoscopic entry sites and port sites have been proposed. Ports No. 1 and 2 in the right anterior quadrant of the abdomen in group 1 enabled the surgeon to grasp and pull up the pylorus to the line of incision in the abdominal integument. The incision, approximately 3 cm in length, was long enough to perform the pyloromyotomy.

The proposed distribution of ports in group 2 animals supported laparoscopic pyloromyotomy. The junction of the pylorus and the duodenum was grab-

bed with forceps inserted through port No. 2, and the pyloric cavity was grasped with forceps introduced through port No. 3 to safely manipulate the pylorus. According to the authors, the use of two tools to immobilize the pylorus provides better stabilization than when only one tool is applied. This is particularly important during pyloromyotomy because an incision of the pylorus requires great precision due to the small length and depth of the cut (Dozier and Kim 2007). Similar observations have been made by Hamada et al. 1995. In other studies, the pylorus was stabilized with the use of a single tool in laparoscopic pyloromyotomy (Alain et al. 1991, Muensterer et al. 2010), but according to the authors, four ports (group 2) is the optimal number of ports in laparoscopic pyloromyotomy.

In both experimental groups, pyloromyotomy was performed with the use of a surgical scalpel, Berci's scalpel and the harmonic scalpel. In groups where the harmonic scalpel was used, bleeding from the pyloric incision was less profuse than in patients who had undergone the procedure with the involvement of Berci's scalpel and a surgical scalpel. The harmonic scalpel causes 4-times less lateral damage to tissues than electrocoagulation or laser, therefore, it contributes to faster healing (Holub et al. 2002). The use of the harmonic scalpel enables coagulation of delicate anatomical structures such as the large intestine, blood vessels and bile ducts (Lee and Park 1999, Jitea et al. 2000). Adhesions in the liver area are also less frequently reported after cholecystectomies performed with the use of the harmonic scalpel (22%) than after electrosurgery (66%) or laser surgery (77%) (Lee and Park 1999).

The harmonic scalpel generates small amounts of vapor that is immediately absorbed by peritoneal surfaces. Unlike in electrocautery, where the produced smoke blocks the surgeon's field of view, the harmonic scalpel does not obstruct the surgical field. Smoke generated during tissue coagulation contains polycyclic hydrocarbons which are released when fat and proteins are subjected to high temperature, therefore, it is highly toxic and mutagenic. The harmonic scalpel produces less smoke and minimizes exposure to toxic and mutagenic chemical substances. Unlike electrosurgery, procedures performed with the harmonic scalpel are free from stray electrical currents that pass through the patient's body and damage tissues located at a distance from the operated area (Emam and Cuschieri 2003, Lee and Park 1999). The coagulation depth achieved by the harmonic scalpel after 10 seconds is 5 mm, whereas in electrocoagulation, the same effect is produced after 4 seconds. The above considerations make the harmonic scalpel a safer and more precise electrocoagulation instrument.

The authors' experience indicates that the harmonic scalpel contributes to the safety of pyloric incisions. According to the authors' best knowledge, the use of the harmonic scalpel in pyloromyotomy has never been documented in human or veterinary medicine. The results of this study suggest that the harmonic scalpel is the safest and the most effective instrument for laparoscopic-assisted pyloromyotomy and laparoscopic pyloromyotomy.

The operative time ranged from 40 to 70 minutes during laparoscopic-assisted pyloromyotomy and from 60 to 80 minutes during laparoscopic pyloromyotomy. The time of the surgery was gradually shortened as the relevant procedures were mastered by the authors. Laparoscopic techniques differ considerably from classical surgical techniques and require operator's skill and experience as well as mastery of surgical procedures. Laparoscopic equipment has to be carefully configured for the needs of a specific procedure. Laparoscopic-assisted pyloromyotomy requires fewer working ports and laparoscopic tools, and it is less manually challenging for the operator. However, the use of a full laparoscopic procedure minimizes the risk of peritoneal adhesions to mini-laparotomy wounds and intestinal exposure. The choice of method should be dictated by the operator's manual skills and the availability of laparoscopic instruments.

According to the authors, 12 pigs constituted a sufficiently large group for mastering the operative techniques required in laparoscopic pyloromyotomy. The planned layout of the operating room, the arrangement of surgical equipment and instruments, the position of the surgeon and the operator by the operating table significantly contributed to surgical effectiveness and reduced operative time. Laparoscopic repair of pyloric stenosis is a safe and less traumatic alternative to classical surgery, and the use of the harmonic scalpel further minimizes the risk associated with procedures of the type. The acquired experience and the proposed laparoscopic entry sites enabled the authors to introduce laparoscopic pyloromyotomy to clinical practice.

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