The aim of the study was to evaluate the possibility to use live anesthetized pigs as a model for laparoscopic liver resection. During two days laparoscopy course two trainees were operating on two live animals performing exposure of the liver, Pringle manoeuver, division of liver ligaments, dissecting of the structures inside the hepatoduodenal ligament, dissection of the hepatic veins and left lateral liver sectionectomy. Exposure of the liver and Pringle manoeuver were performed correctly within 50 and 35 minutes. Left lateral sectionectomy has been performed correctly within 2 hours. The full dissection of the hepatoduodenal ligament and exposure of the hepatic veins were judged as insufficient by experienced laparoscopic tutors. There was one injury to the suprahepatic vena cava that was managed laparoscopically. The porcine model can be used as an advanced training for laparoscopic liver surgery.

Key words: laparoscopic liver resection, porcine model, laparoscopic training

The rise of minimally invasive procedures has increased the interest of many surgeons in laparo- and endoscopy training models that use live animal. As a result, pigs have been frequently used as a model for colorectal laparoscopic surgery (1), sheep as a gynecologic and transvaginal NOTES model (2) and rabbit as a pediatric thoracoscopy model (3). Indeed, the introduction of a new technique based on animal experiment can lead to steeper learning curve (1) and finally to less complications in humans after clinical application of the technique (4).

Training in laparoscopic liver surgery using animal models is not very popular although several groups have tried to use it as a model with relatively good results (5, 6).

The aim of the present study was to evaluate the applicability of the porcine model for laparoscopic training in liver surgery.

MATERIAL

We have used two live anesthetized pigs as a model for liver laparoscopy training during laparoscopy training course (1st Spanish-Polish Days of Laparoscopic Oncology, April 2014, JUMISC, Caceres, Spain) that lasted for two days. Two trainees with different level of laparoscopic experience but with no previous liver laparoscopy experience were included in this study. Before the start of the operation an experienced veterinarian laparoscopic tutor ex-
plained to the trainees swine anatomy and physiology with special attention to the liver function and anatomy. The pigs were placed in a supine position and anesthetized. After obtaining 12 mm Hg pneumoperitoneum, four standard trocars (10 mm for optics, 5 mm, 5 mm and 12 mm working trocars) were introduced. The operative team consisted of two trainees. After performing simple (cholecystectomy) and more complex (sigmoidectomy, nephrectomy, hysterectomy) laparoscopic procedures the trainees were asked to perform the following manoeuvres as part of their liver surgery training:

- exposure of the hepatoduodenal ligament and liver hilum,
- preparing Pringle manoeuver,
- division of liver ligaments (falciform and triangular),
- dissecting the structures inside the hepatoduodenal ligament,
- left lateral liver sectionectomy,
- dissecting of the hepatic veins.

The parenchymal transection was performed with staplers. There was no time limit to perform each task, however all liver manoeuvres could not last for more than 2 hours because of operating room availability limited by the fact that liver manoeuvres were performed as the last task of an operating day. All intraoperative complications had to be controlled by the trainees. Assistance was available only in form of oral consultation with expert veterinarian with important experience in porcine laparoscopy.

RESULTS

The Pringle manoeuver and division of the liver ligaments were performed correctly in both pigs (fig. 1) although in the first one the time needed to complete both tasks was significantly longer (50 min vs 35 min). Clear exposure of the hilar structures and hepatoduodenal ligament was obtained (fig. 2) but the identification of the structures within hepatoduodenal ligament was not satisfactory as judged by an experienced veterinarian laparoscopy tutor. Left lateral sectionectomy was completed in both animals. However, in the second animal during parenchymal transection suprahepatic inferior vena cava has been torn. The hemorrhage was controlled laparoscopically, the inferior vena cava sutured and left lateral sectionectomy was completed. In neither of the experimental animal the trainees were able to fully dissect the hepatic veins.

DISCUSSION

There exist several differences between human and porcine liver anatomy (fig. 3). For the beginner in the field of swine laparoscopy these differences can be cumbersome at first but with the appropriate theoretical preparation the surgeon can obtain a very interesting simulation of a human laparoscopic liver surgery during an operation with a pig as a laparoscopic model.

A porcine liver is very rich in interlobular connective tissue which gives this organ distinctive appearance. The interlobular fissures are deep and very well marked. With respect to the bile ducts, there are three hepatic ducts: left, from the left lobe, right from the right
lateral and caudate lobes and the middle hepatic duct which drains the right medial and quadrate lobes. The hepatic ducts join at the hepatic porta to form the common hepatic duct that soon unites with the long cystic duct, from the gallbladder, to form the bile duct. The bile duct runs in the lesser omentum and reaches the duodenum, where, after a short intramural passage, it opens on the major duodenal papilla located 1.5-2.5 cm distal to the pylorus. The gallbladder occupies a fossa, excavated between the right medial and quadrate lobes. The cystic duct is relatively long which makes this animal a very good model for cholecystectomy (7). The hepatic vein and inferior vena cava (IVC) confluence is intraparenchymal in pigs, which makes dissection of these veins much more challenging than in humans. Also, the left hepatic vein is very friable, short, and prone to damage. The IVC and intraparenchymal hepatic veins had extremely thin walls, and the neighboring diaphragm is easily damaged (5). Porcine hepatic artery can be highly variable but the most common is to encounter two constant branches to left lateral and left median lobes and one branch to right medial lobe (8). When it comes to segmental anatomy, although the external morphology of the porcine liver differs from that of the human, the segmental anatomy is remarkably similar in term of its vascularity and biliary tree (9).

The lesser omentum is short and strong and in its right portion includes the structures of the hepatic pedicle (hepatoduodenal ligament with hepatic artery, portal vein and bile duct) (7). In general, the porcine peritoneum is relatively lax.

The need for an experimental model for laparoscopy training is well recognized (10). Among many training options the laparoscopy simulators, including homemade ones are a very good starting option (11). More advanced students go for more sophisticated simulators with the help of laparoscopy instructors, however the need for constant instructor feedback has been recently put in doubt (12). Cadaveric and live animal models are probably the models that let the trainee get as close to the real laparoscopy experience as possible (2, 13). There have been multiple approaches to use pigs as an experimental animal for surgical procedures.

In a recent study Martin Cancho et al. showed that exposing inexperienced anesthetist to liver transplant procedure in pigs is a training technique that can yield very promising results. The groups of trainees in this study were asked to manage pigs during the whole process of liver transplant. Such an exposure allowed for quicker skills development than traditional training (14). Also in a recent study by our group we have shown that concentrating on evitable errors during colorectal laparoscopy training in pigs can yield better results than traditional training which focus on technical aspects of laparoscopy. With our approach we were able to obtain interesting results even with low number of repetition, which translates into fewer experimental animals that need to be operated in order to train one trainee (1).

Based on these experiences we have opted for the swine model for the liver laparoscopy training.

The trainees in our group were novices in the field of laparoscopic liver surgery. This is probably the reason why the time the trainees needed to perform simple tasks like Pringle manoeuver or liver ligaments division was quite long compared with total time of left lateral sectionectomy in porcine model in experienced hands. In the study by Consten et al. the mean time of left lateral sectionectomy was 64±11 min (15). This has been completed in 2 hours in our case. However, the 2 hours time did not include obtaining pneumoperitoneum nor trocar introduction as these steps had been done in the experimental animal during earlier procedures. Then again the goal of this training was not to acquire technical skills and be able to operate faster but rather to understand pos-
sible dangers in order to avoid them. This approach is similar to the FMEA (Failure Mode and Effect Analysis) training method described by our team recently (1). In short, it consist on evaluating each step of a surgical process, identifying and then eliminating the parts of the process that pose the greatest risk for the patient. If applied in animal laparoscopy training, this approach allows the trainee to acquire a safe approach toward a trained procedure faster (e.g. liver resection).

CONCLUSIONS

The value of our study is limited by a low number of experimental animals. However, we were able to show that the porcine model can be used in laparoscopy liver surgery training. With the correct preparation and approach we believe that even with few experimental animals a trainee is able to obtain higher level of expertise in liver laparoscopy without jeopardizing the lives of our patients.

REFERENCES