Key Points

- Minimally Invasive Surgery (MIS) offers many benefits to the surgeon including being less invasive, and by allowing better visualization of many abdominal structures.
- MIS can be technically challenging to perform, and intracorporeal suturing is difficult.
- Various techniques have been developed to reduce the difficulty of performing intra-abdominal ligation.

Various surgical approaches and methods of hemostasis have been reported for intra-abdominal ligation and hemostasis in equine MIS. In recent years laparoscopic approaches have become popular in light of the fact that they are minimally invasive, provide superior visualization, allow tension free hemostasis, and eliminate the need for general anesthesia. Laparoscopic techniques described for ligation and hemostasis include sharp dissection and ligature placement, laser dissection and staple or clip placement, sequential electrocoagulation and sharp transection, use of a vessel sealing device and sharp transection and use of an ultrasonic cutting and coagulating device. While all of these methods have proven efficacious certain advantages and disadvantages relating to surgeon preference, equipment costs, speed, reliability, and technical difficulty exist. The purpose of this presentation is to identify the techniques that have been used and the benefits and challenges that each approach provides.

Ligating Loops

Ligating loops are the least expensive method of hemostasis during laparoscopic surgery. This is especially true when self-tied ligating loops are used. The challenge of using ligating loops is that it is more technically demanding than using some of the other methods of hemostasis. The first reports on using ligating loops in horses for castration was in 1996 where Wilson et.al. pulled normally descended testes back into the abdomen and ligated them. Boure et.al. used commercially available ligating loops to ligate and provide hemostasis during ovariectomy in mares. In this study, they did not do any dissection of the ovarian pedicle until after placement of two ligatures. When they sharply transected the pedicle, it was between the ligatures. There were no complications noted with bleeding in these cases. One of the early concerns with commercially available ligating loops was the fixed diameter of the loop, the small size of the available suture, and the short knot pusher that was attached to the ligating loop. Several self-tied knots have been developed to allow the surgeon to make their own ligating loops patient side. Two studies on the use of larger sutures for horses confirmed the ability to self-tie ligating loops in order to provide equal or better knot security when compared to commercially available ligating loops. In some cases, especially when using the 4-S Modified Roeder knot with Size 1 Maxon, the knot security approaches that of a four-throw square knot. However, ligating loops can slip after application. This can be due to not getting them tight enough for the knot to lock when placing the loop, having too much tissue in the loop, cutting the tissue too close to the loop during transection, or by placing the loop on a wedge shaped piece of tissue. Rodgerson reported ligating loop slippage after an ovariectomy, and the author has had a
ligating loop slip during cryptorchid castration. It appears important to relax the tissue when finally tightening the loop to minimize tension on the loop for secure knot locking.

In summary, ligating loops have been consistently shown to be adequate for ligation and hemostasis in equine laparoscopy, especially in the areas of ovariectomy and cryptorchidectomy. The author prefers monofilament suture material both due to the increased knot security over braided material, but as well the propensity of the loop to hold its shape during placement.

**Polyamid Tie-Rap**

One of the main challenges of ligating loops is getting the loop around the desired structure. A study on the use of a commercially available polyamide tie-rap showed that the tie-raps can be successfully used to ligate and provide hemostasis in equine ovariectomies. In the study, 10 horses were ovariectomized using the tie-raps. Repeat laparoscopy was performed in 8 of 10 mares, 2,3,4, and 12 weeks post ligation. The transected stump was completely encapsulated by 3-4 weeks. In two mares, and adhesion between the left stump and the mesentery of the descending colon was observed. There were no remarks as to the consequences of the adhesions. The author has had to re-operate one mare that had clinically significant adhesions between the stump and the mesocolon.

In summary, the tie-raps can be used in ovariectomy, but the occurrence of adhesions is troubling, and bring the technique into question.

**Monopolar and Bipolar Electrosurgical Devices**

Monopolar and bipolar electrosurgery provide opportunities for hemostasis in the abdominal cavity for removal of cryptorchid testes, descended testes, ovariectomy, as well as adhesiolysis. Monopolar electrosurgery can be delivered via many configurations of laparoscopic instruments, while bipolar electrosurgery is delivered via an instrument that clamps the desired tissue between two jaws. Monopolar energy travels from the generator, through the instrument, through the desired tissue, and eventually to a ground plate. Bipolar travels only between the two jaws of the tissue. Consequently, bipolar is thought to be safer than monopolar with regards to stray energy affecting other tissues. Early reports of monopolar electrosurgical hemostasis in horses was combined with ligating loops. More recent reports have shown that bipolar electrosurgery can be successfully used in both ovariectomy and cryptorchidectomy. In most cases, sequential application of the electrosurgical device, and sharp dissection have been used. Some bipolar instruments incorporate both the electrosurgical paddles as well as a cutting blade, reducing the need to exchange instruments during the procedure.

In summary, these modalities are easy to apply to the horse. Both mono and bipolar electrosurgery can be performed in the standing sedated horse. While successful, it should be noted that these modalities are recommended for 3 mm diameter vessels or smaller. Care should be taken in cases where the vessels are larger than 3 mm. It is also important to note that hemostasis is accomplished by forming a coagulum in the vessel lumen that can be dislodged with movement or increased blood pressure.

**Vessel Sealing Devices**

The reduced vessel size capabilities of mono and bipolar electrosurgery have lead to the development of other, more sophisticated, electrosurgical devices. These devices are generally known as vessel sealing devices, and use radio-frequency energy in a bipolar fashion to create sealed vessels as compared to a coagulum in other electrosurgical techniques. The most
commonly used device in horses is the LigaSure from Valley Lab. It is designed to seal vessels up to 7 mm in diameter and withstand blood pressures up to 3 times normal. The shears generally incorporate a cutting blade so the instrument can be used to coagulate and cut sequentially. The use of vessel sealing devices have been reported in horses for the removal of normal ovaries as well as removal of granulosa cell tumors. In most instances, the hemostasis is complete with no bleeding at any point in the procedure. There have been no reported complications. There does appear to be a significant increase in total protein in the abdominal fluid at 24 hours post surgery when comparing the vessel-sealing device to the use of ligating loops for ovariectomy. The total protein returns to a similar level to the ligating loop by 72 hours. The clinical significance is not known.

In summary, the vessel-sealing devices are generally accepted to be the most secure, easy to use device for removal of ovaries and testes in the horse. The ability to seal a 7 mm vessel is quite valuable in the hemostasis and amputation of large ovaries. The only downside is the cost of the generator and the shears which are meant to be disposable.

_Ultrasonic Cutting and Coagulating Devices_

Another, sophisticated device used for hemostasis is the ultrasonic cutting and coagulating device. The device cycles at 55,000 Hz, and the friction and heat created by the ultrasonic movement denature the protein in the vessel wall, creating hemostasis. These devices can be used as a blade, or as a shears. When using the shears, one of the blades is static and holds the tissue so the cycling blade can coagulate and cut the tissue. These devices coagulate and cut at the same time. The amount of pressure exerted, along with the energy setting determine the speed of cutting, and the completeness of the coagulation. There are two studies on the use of ultrasonic energy for ovariecetomy in mares. In one study involving 8 mares, all 16 ovaries were removed without any bleeding. In the other study involving 10 mares, 40% of the ovarian pedicles required additional hemostasis in the form of ligating clips. The general consensus is that in the second setting the energy setting was too high, favoring rapid transection without complete hemostasis.

In summary, the ultrasonic devices are designed to coagulate vessels up to 3 mm in diameter. The equine ovarian pedicle can sometimes contain vessels that are larger. Methods of additional hemostasis should be available when using these devices.

_Stapling Devices_

Surgical stapling devices have been developed to allow easy and safe hemostasis and amputation of abdominal structures. In one study involving 10 horses undergoing laparoscopic ovariecetomy, the endoscopic stapling device was found to work very well. The surgical time was thought to be less than that with ligating loops, required minimal ovarian manipulation, and there were no intra or post-operative complications. Surgical staplers require larger diameter cannulas than are typically used in equine laparoscopy, and the surgeon should be prepared for this before attempting the use of surgical staplers.

In summary, surgical staplers are technically easy to use and very effective in providing hemostasis for equine ovariecetomy. The biggest problem is the cost of the stapling devices, and the need for a larger cannula.
Surgical Lasers

Surgical lasers have been used to provide hemostasis in both open and laparoscopic surgery. There is one report of the use of lasers and endoscopic stapling devices in unilateral ovariectomy in normal mares. There were no surgical complications, and the mares resumed normal activity 2 weeks after surgery. There is some concern with the use of lasers in large ovaries with larger diameter vessels. Lasers are generally considered to be capable of providing hemostasis in vessels that are 3 mm diameter or less.

References