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Large Animal VETERINARY Rounds®

FEBRUARY 2008
Volume 8, Issue 2

AS PRESENTED IN THE ROUNDS OF THE DEPARTMENT OF LARGE ANIMAL CLINICAL SCIENCES OF THE WESTERN COLLEGE OF VETERINARY MEDICINE, UNIVERSITY OF SASKATCHEWAN

Minimally Invasive Surgery in the Horse

By David G. Wilson, DVM, Diplomate ACVS

The development of minimally invasive surgical techniques in the horse began with arthroscopic approaches. Initial forays into laparoscopic surgery involved direct visual observation of genital structures in mares.[1] With the popularization of laparoscopic cholecystectomy in humans, rapid development of laparoscopic instrumentation ensued, allowing the development of laparoscopic surgical techniques in the horse. This issue of *Large Animal Veterinary Rounds* details the development of laparoscopic surgery in the horse, including laparoscopic approaches to cryptorchidectomy, ovariectomy, inguinal herniorrhaphy, colopexy, and renosplenic space ablation.

Unlike arthroscopic surgery, where a single individual can view and perform intra-articular manipulation, extending laparoscopy beyond intra-abdominal observation requires the aid of at least one assistant who can simultaneously view the operative field. The introduction of video-chip cameras in the 1980s and the increasing availability of laparoscopic instrumentation allowed the development of operative laparoscopic approaches to surgical conditions in the horse. Today, the advantages of minimally invasive approaches that include reduced morbidity and early return to function are available for the management of a wide range of surgical conditions.

Laparoscopic equipment and instrumentation

Standard equipment that is needed to accomplish operative laparoscopy includes: a laparoscope, a light source, a camera and video monitor, an insufflator, and an assortment of laparoscopic instruments. The workhorse of equine laparoscopy is a 33-cm long, 10-mm diameter laparoscope. Surgical manipulation can be accomplished with a 0° viewing scope; however, a 30° viewing scope offers more versatility by facilitating direct observation of instrument cannula insertion. Availability of a ≥ 50 cm laparoscope allows observation of both inguinal areas in the standing horse from one paralumbar fossa.

The abdomen of the horse is a large cavity and illumination requires considerable light source power. In general, brighter light is better and most systems used for laparoscopic surgery in the horse have 300-watt Xenon light sources. Three-chip video cameras have replaced single-chip units and the newest entries include integrated camera and laparoscope units. A wide assortment of quality equipment is available on the secondary market. Automated light intensity is available on matched light source/camera systems and some newer cameras have the capacity to adjust light levels independent of the light source; however, manual control of light intensity does not present a significant problem with older unmatched systems.

Video monitors designed for this purpose offer the best image. Flexibility of positioning of the video tower complex is enhanced if a longer than standard light guide is available. The largest diameter light cord available should be used, since the increased number of fibres will transmit more light into the abdomen. The author uses a 3-m light guide in his practice. At times, it can be difficult for everyone involved in the procedure to be strategically placed for viewing the video monitor. The use of multiple monitors and the fairly recent introduction of affordable head-mounted virtual reality video goggles greatly improve the operative environment.

Abdominal insufflation is essential to allow visual exposure within the abdomen. Adequate insufflation of the adult abdomen can require 30-40 L of carbon dioxide (CO_2). Insufflators capable of delivering flows in a range of 10-20 L/minute or more facilitate rapid initial distension of the abdomen and maintenance of distension during the procedure.

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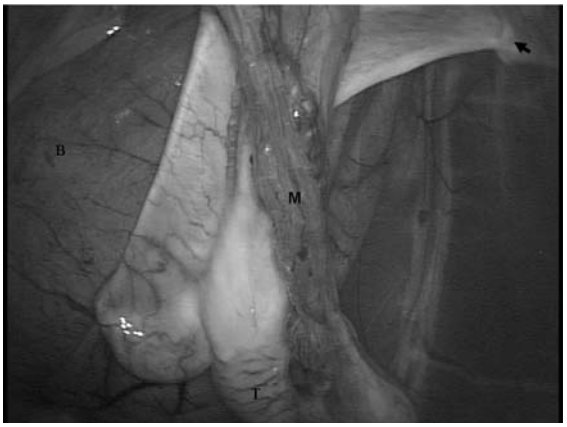
Figure 1: Endolaparoscopic instruments. Babcock – top; Right-angle dissecting forceps – middle; acute claw grasper – bottom.

Figure 2: Left abdominal cryptorchid in a standing horse. B = bladder; M = mesorchium; T = testis; Arrow indicates vaginal ring



A majority of surgeons use laparoscopic cannula systems to maintain distension during the procedure. Disposable single-use cannula systems work well, but for economic reasons most surgeons utilize reusable systems. Standard-length cannulas (10 cm) are effective in the recumbent horse, but longer systems (20 cm) are needed in the standing horse. Three cannulas are required at a minimum; however, additional cannulas may be used when performing bilateral standing procedures and complex procedures in the recumbent horse. The author prefers cannulas with manual valves that allow the valve to be held open during withdrawal of instrumentation. Standard-diameter cannulas range from 10 mm to 12 mm. Reducer systems should be available to allow the use of both 5-mm and 10-mm diameter instruments. The author prefers a cannula with a guarded trocar for the first insertion in the recumbent horse (source: Dr. Fritz, LLC Louisville, KY).

Laparoscopic instrumentation is available both as single-use disposables and reuseable equipment. The primary limitation of co-opting instrumentation from the human field is length, but that concern has largely been resolved with the development of equipment specifically designed for use in the horse. Minimum operative instrumentation needed to perform routine procedures in the horse include: a Babcock forceps, a right-angle dissecting forceps, some type of ligating device such as ligating loops, scissors, and 2 acute-claw graspers (Figure 1). Additional equipment that falls in the "nice to have" category includes: bipolar cautery capability with a standard bipolar cautery forceps (CONMED Linvatec 11311 Concept Blvd., Largo, FL), a tripolar cautery forceps (ACMI, 136 Turnpike Road, Southborough, MA), or a capacitance monitored bipolar cautery device (LigaSure™ Tyco Healthcare Group LP, Boulder, CO). Endolaparoscopic staplers have been used as ligation devices and endolaparoscopic ligaclips can be useful in dealing with unanticipated small bleeders.

Laparoscopic cryptorchidectomy

Laparoscopic cryptorchidectomy is a minimally invasive approach to castration of the abdominal cryptorchid. Unlike more traditional inguinal approaches that are performed without the benefit of actually viewing the testis, laparoscopy offers the surgeon the advantage of visually locating the testis in the abdomen. The approach is ideally suited to the management of a horse exhibiting stallion-like behaviour in the absence of a reliable history of castration. In addition, unlike the case with inguinal approaches, there is no disruption of inguinal security or risk of herniation. Horses can return to performance as early as 10 days after surgery.

Laparoscopic cryptorchidectomy can be performed in either the standing[2] or recumbent[3] horse. Factors determining the choice of an approach include: the temperament of the horse, operator experience, and operator preference. The abdominal testis is easier to locate in the standing patient, but surgical manipulation is more difficult owing to the physical limitations of the paralumbar fossa that results in instrumentation crowding of the laparoscope.

Standing laparoscopic cryptorchidectomy

Laparoscopic cryptorchidectomy can be readily performed in the standing horse. The horse should be fasted for a minimum of 24 hours, and stocks are used for restraint. In the unilateral abdominal cryptorchid, the ipsilateral paralumbar fossa is clipped and prepared for aseptic surgery. The author routinely performs a xylazine epidural to augment analgesia during manipulation of the testis. The horse is sedated with a combination of xylazine and butorphanol, or detomidine and butorphanol, and an inverted "L" block is used to achieve anesthesia of the paralumbar fossa.

The laparoscope is inserted at the level of the dorsal margin of the internal abdominal oblique muscle and the abdomen is insufflated to a pressure of 10 to 15 mm Hg. The laparoscope is directed caudally and the internal inguinal area is visually inspected. If an intra-abdominal testis is found (Figure 2), a pair of instrument cannulas are inserted either ventral to the laparoscope or immediately cranioventral and caudoventral to the laparoscope. An endoscopic ligating loop is introduced into the abdomen through one cannula and a Babcock grasping forceps is placed through the second cannula. The author uses commercially available polydioxanone loops, but ligating loops can be constructed from suture materials using a double S Roeder knot.[4] A grasping forceps is placed

through the ligating loop and the testis is seized and manipulated into the ligature. The ligating loop is placed as far proximal on the vascular pedicle as possible and tightened. The free end of the ligature is cut and laparoscopic scissors are used to transect the vascular pedicle. The vascular stump is inspected for hemorrhage before the testis is transferred to an acute claw grasper; the instrument cannula incision is enlarged and the testis is removed from the abdomen.

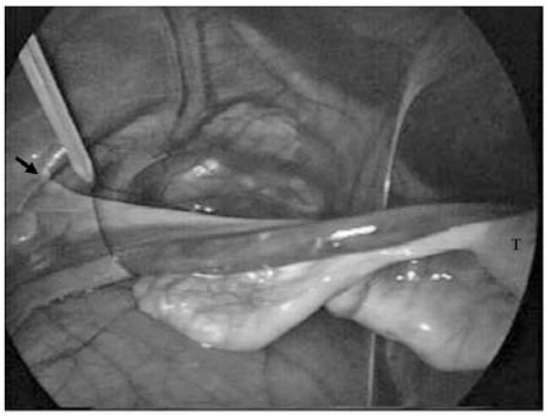
If the horse is a bilateral abdominal cryptorchid, both paralumbar fossae should be clipped and prepared for aseptic surgery. The author begins on the left side and, with the aid of a long laparoscope, the right inguinal area can be viewed by passing the laparoscope under the small colon. In most horses, a retained right testis can be removed from the left side. In this case, the right testis is freed from attachments as described above, but to avoid loss of insufflation that is inevitable with the enlargement of an incision, removal is delayed until the left testis has been freed. Closure of the enlarged incision is performed in 3 layers (external abdominal oblique muscle, subcutaneous tissue, and skin). The other incisions are closed with interrupted skin sutures. Phenylbutazone is given for 3 days after surgery and horses can return to performance in 10 days. Complications encountered during standing laparoscopic cryptorchidectomy include lack of patient compliance, inadvertent insufflation of the retroperitoneal space, and dropping the testis during removal.

Recumbent laparoscopic cryptorchidectomy

Patient compliance is ensured when laparoscopic cryptorchidectomy is performed with the horse under general anesthesia. Instrument manipulations are easier than in the standing animal because placements are widely spaced, although location of the abdominal testis is more challenging. Feed is withheld for a minimum of 24 hours, the author prefers 48 hours because this enables an emptier abdomen allowing easier manipulation during the procedure. The horse is positioned in dorsal recumbency and, because elevation of the hindquarters is required, positive pressure ventilation must be employed.

A 1-cm skin incision is made at the umbilicus and a number 15 blade is used to make a stab incision through the linea alba. A standard teat cannula is introduced through the stab incision using a thrusting motion and the abdomen is distended with CO_2 to a pressure of 15 mm Hg. The teat cannula is removed and the laparoscopic cannula is inserted (the author uses a cannula with a safety trocar). The laparoscope is inserted and, when intra-abdominal positioning has been visually confirmed, the hindquarters are elevated into a Trendelenburg position to facilitate cranial displacement of the viscera and allow visual observation of the internal inguinal area. If an abdominal testis is observed, an instrument cannula is inserted 10-15 cm lateral to the ventral midline at a level midway between the umbilicus and the external inguinal ring on either side of the midline. In most cases, the ligament to the tail of the epididymis is visible because it attaches to the vaginal process at the vaginal ring, but often the bowel obscures the testis. The ligament is grasped with an atraumatic grasping forcep and a second instrument used in a hand-over-hand motion allows the testis to be drawn into view. A ligating loop is placed

Figure 3: Left side cryptorchidectomy in a recumbent horse showing ligation. T = testis; Arrow indicates vaginal ring



proximal on the vascular pedicle (Figure 3) and scissors are used to free the testis from its attachments. In the unilateral cryptorchid, a single instrument cannula incision is enlarged to allow removal of the testis. In the bilateral abdominal cryptorchid, the first testis is temporarily stored on the lateral ligament of the bladder while the second testis is located, ligated, and freed from its attachments, before each testis is individually removed through a single enlarged instrument cannula incision.

The enlarged instrument cannula incision is again closed in 3 layers (external rectus fascia, subcutaneous tissue, and skin). The other incisions are closed in 2 layers (linea alba or external rectus fascia, and skin). Phenylbutazone is given for 3 days after surgery and horses can return to normal activities in 10 days.

Complications of recumbent laparoscopic cryptorchidectomy are rare, but include inadvertent insufflation of an abdominal viscus and abdominal wall vessel injury from cannula insertion. Irrespective of the castration history, if there are no palpable scrotal testes, both internal inguinal areas should be visually assessed. The author has removed 2 abdominal testes from several horses that reportedly already had 1 testis removed.

Laparoscopic ovariectomy

Laparoscopic ovariectomy can be performed in either a standing[5] or recumbent[6] horse. Indications for ovariectomy include behaviour modification and removal of ovarian tumours. Factors for choosing an approach include: the temperament of the horse, size of the ovary, operator experience, and operator preference. The ovary is easier to locate in the standing patient and, other than interference between instruments within the limited space of the paralumbar fossa, manipulation of the ovary is generally easier in the standing horse. Bilateral approaches are required to remove both ovaries.

Bilateral standing ovariectomy

Feed is withheld for a minimum of 24-hours. The author performs a xylazine epidural in an attempt to provide analgesia during ovarian manipulation (sufficient in approximately 50% of mares). The mare is sedated with detomidine and butorphanol; sedation is maintained using a continuous-rate infusion.

Figure 4: Left ovary (O) showing Babcock forceps grasping the suspensory ligament.
Solid arrow indicates suspensory ligament of the ovary; white arrow indicates the mesosalpinx

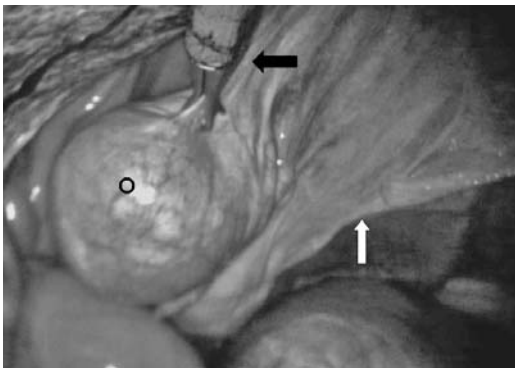
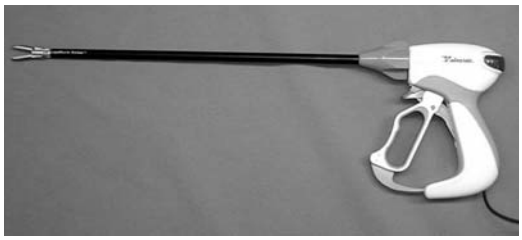


Figure 5: LigaSure™ instrument with coagulation forceps and deployable cutting blade.



An inverted "L" block is used to provide anesthesia of the paralumbar fossae. The left ovary is approached first. The laparoscope is inserted at the dorsal margin of the internal abdominal oblique muscle and a pair of instrument cannulas are placed cranioventral and caudoventral to the laparoscope or in a vertical line ventral to the laparoscope.

Early in the development of laparoscopic ovariectomy, hemostasis was achieved with ligating loops. That procedure required some dissection of the ovarian pedicle to reduce the mass of tissue included in the ligature. Today, most surgeons have abandoned ligation techniques in favour of electrocoagulation techniques.

The ovary is grasped with Babcock forceps (Figure 4). If the horse resists manipulation, mepivacaine is infused into the ovarian pedicle. Division of the ovarian pedicle involves separation of the suspensory ligament of the ovary, mesovarium, the mesosalpinx, oviduct, and the uterovarian ligament. The ovarian vessels are located in the more substantial part of the pedicle, specifically, the mesovarium. The first reports using electocoagulation involved the application of a standard bipolar cautery instrument. The LigaSure™ is a capacitance-monitored, bipolar electrocautery device that allows surgical efficiency because a single instrument is used to coagulate tissue before a built-in cutting blade is deployed (Figure 5). Beginning at the cranial aspect of the ovary, the suspensory ligament is coagulated and divided with scissors. As the dissection continues caudally, the ovarian bursa is entered, allowing differentiation of the mesovarium, medially, and the relatively avascular mesosalpinx, laterally. The mesosalpinx, oviduct, and uterovarian ligament are divided with scissors; if any small bleeders are encountered, they are electrocoagulated, as needed. The mesovarium is progressively electrocoagulated and divided in a caudal direction, and the dissection is continued across the proper ligament to free the ovary of its attachments. The pedicle is observed for hemorrhage and the ovary is transferred from the Babcock forceps to an acute claw grasper and left within the abdomen while the laparoscope is placed through the right paralumbar fossa and the right ovary is freed of its attachments. At this point, the right ovary is grasped with an acute claw grasper before the laparoscope is returned to the left side. While viewing from the left, the right ovary is passed under the small colon to the left side of the abdomen to allow both ovaries to be removed through a single enlarged instrument cannula incision.[7] Some surgeons remove each ovary by enlarging an instrument cannula incision on each side;[8] however, the author rarely finds that necessary. Closure of the incisions is routine. Flunixin meglumine is administered for 3 days after surgery, and horses can usually return to normal exercise in 10 days.

Complications of standing laparoscopic ovariectomy include lack of patient compliance, difficulty in achieving ovarian anesthesia, postoperative colic, and failure to remove the ovary from the abdomen (dropped and lost). In the event that an ovary is misplaced, traditional wisdom suggested converting to an open-flank celiotomy to retrieve the lost ovary. Shoemaker and coworkers have confirmed effective ovariectomy without removal of the ovary from the abdomen;[9] thus, in the rare case where a normal ovary is lost, it seems reasonable to allow the structure to undergo avascular necrosis.

Recumbent ovariectomy

Largely, the decision to perform either a unilateral or bilateral ovariectomy with a mare in dorsal recumbency is based solely on operator preference. Exposure is greatly facilitated if feed is withheld for 48 hours. Positive-pressure ventilation is essential to allow placement in a Trendelenburg position. The abdomen is insufflated and the laparoscope introduced at the umbilicus. Some surgeons place a pair of instrument cannulas on either side of the midline.[6] The author usually accomplishes the procedure with just 2 instrument cannulas, although there are instances where a third instrument cannula allows easier directed access to facilitate division of the ovarian pedicle.

Unlike in the standing mare, where the ovary is essentially hanging in plain view, locating the normal ovary in the recumbent horse requires progressive manipulation to bring the ovary into view. This process generally involves locating a part of the uterus and using 2 atraumatic grasping forceps in a hand-over-hand fashion to elevate the ovary from beneath the viscera. At this point, the suspensory ligament of the ovary is grasped and the pedicle is electrocoagulated in a cranial-to-caudal direction using a standard bipolar cautery device, followed by scissor

dissection or a LigaSure™. Specific identification of the individual components of the ovarian pedicle is more difficult in the recumbent animal; as a result, most surgeons electrocoagulate the entire pedicle. When the ovary is free of its attachments, the pedicle is inspected for hemorrhage and the procedure is repeated on the contralateral side. When both ovaries are free, they are removed individually through a single enlarged instrument cannula.

Incisional closures are routine. Flunixin meglumine is given for 3 days and the mare can return to normal exercise 10 days after surgery. Complications are rare, but include hemorrhage due to abdominal vessel damage during instrument cannula insertion, hemorrhage from the ovarian pedicle, and postoperative colic.

Laparoscopic inguinal herniorrhaphy

Inguinal herniation occurs congenitally in colts and as an acquired condition in mature stallions. Traditional surgical approaches involve open inguinal dissections, most often accompanied by removal of the testis from the affected side. In foals, laparoscopic herniorrhaphy allows bilateral treatment without the additional morbidity associated with bilateral inguinal approaches.[10] Testes-sparing options have been developed and can be applied in both foals and mature stallions.[11-13] An additional advantage of laparoscopic herniorrhaphy includes the ability to visually evaluate the viability of a herniated bowel without the attendant risks of open celiotomy.

Foals with castration

Inguinal herniorrhaphy is indicated for congenital hernias in foals not responding to conservative management. Given that there may be a heritable component, most surgeons recommend castration. The foal is placed under general anesthesia and positioned in dorsal recumbency. The approach is similar to that used for laparoscopic cryptorchidectomy. In most cases, the herniated intestine returns to the abdomen spontaneously when the foal is placed in dorsal recumbency. If the bowel is still herniated when the laparoscope is introduced, atraumatic forceps are used to apply gentle traction to the intestine drawing it back into the abdomen. The viability of the affected bowel is visually assessed; however, the intestine is rarely compromised.

The vaginal ring of the foal readily dilates and a normally descended testis can easily be returned to the abdomen by applying traction to the testicular vessels. The ligament to the tail of the epididymis is electrocoagulated and divided, essentially creating an abdominal cryptorchid. Inguinal security is accomplished by apposing the edges of the vaginal ring with 4 to 6 endolaparoscopic staples. The procedure is repeated on the contralateral side, before each testis is freed from its vascular attachments and removed from the abdomen.

Postoperatively, foals undergoing laparoscopic inguinal herniorrhaphy are, typically, much more comfortable than those undergoing open approaches. Some swelling is expected at the incision sites; however, the scrotum is neither inflamed nor sensitive. Nonsteroidal anti-inflammatory drugs are administered for 3 days. The author also uses ranitidine for its prophylactic antiulcer properties.

Mature stallions

Inguinal herniorrhaphy can be performed as a testis-sparing procedure in mature stallions. Fischer et al[11] initially described a mesh-augmented approach similar to that used in men. More recently, Marien[12] developed a laparoscopic technique that can be performed in the standing stallion. In this case, a cylinder of prosthetic mesh is placed through the vaginal ring and into the inguinal canal. The inflammatory response to the material results in fibrosis, reducing the size of the canal, while preserving the testis. Although effective, neither of these approaches can be employed in the stallion with abdominal distension.

Laparoscopic colopexy

Recurrence of large-colon volvulus and displacement occurs in a small percentage of horses affected with the conditions. For that reason, an open surgical approach to colopexy was developed.[14] Unfortunately, the colon is often compromised at the time of colic surgery precluding colopexy at that point. Prior to the development of a laparoscopic approach,[15] an additional celiotomy with the attendant risks of incisional herniation was required.

Laparoscopic colopexy is performed as an elective procedure 4 to 6 weeks after colic surgery. Feed is withheld for 48 hours to allow a reduction of fecal fill and to facilitate colonic manipulation. A 25-cm long skin incision is made 10 cm to the left of the ventral midline, beginning 20 cm cranial to the umbilicus and extending caudally. The abdomen is insufflated with CO_2 and the laparoscope is inserted on the midline at the umbilicus. An instrument cannula is placed 5 cm to the left of the ventral midline and 25 cm cranial to the umbilicus. A Babcock forceps is inserted and the lateral tenia of the left ventral colon is grasped. Two additional instrument cannulas are inserted caudal to the skin incision. A polypropylene suture (#2 armed with a modified 1/3 curved needle) is used to affix the colon to the abdominal wall. The suture needle is inserted into the abdomen at the cranial aspect of the left paramedian skin incision. An endolaparoscopic needle driver placed through a caudally-placed instrument cannula is used to grasp the needle and draw the suture through the abdominal wall. The Babcock forceps is used to partially elevate the colon and allow the suture to be placed through the lateral tenia before the needle is directed back through the abdominal wall. The colon is elevated to the abdominal wall using the Babcock forceps and the suture is tied outside the abdomen before the needle is reinserted into the abdomen. Approximately 15 cm of colon is brought into apposition with the abdominal wall with a continuous suture.

Postoperatively, horses are restricted to a stall for 30 days followed by 30 days of paddock rest. Clinical outcomes have been reasonably successful, although there is some risk of the colon tearing at the site of colopexy, which may cause the subsequent demise of the horse due to abdominal fecal contamination. Although the compli-

cation is rare, if it happens, the horse will die. Conservative surgeons may reserve colopexy for nonathletic horses, opting for colon resection in athletes.

Laparoscopic renosplenic space ablation

Left-dorsal displacement of the large colon involves entrapment of the colon in the renosplenic space. Resolution of this condition is easily accomplished via ventral midline celiotomy and, in selected cases, the entrapment can be resolved by rolling the horse or by the administration of phenylephrine. In each of these scenarios, the potential for reincarceration exists and, although the likelihood of re-entrapment is probably low, some horses seem predisposed to repeated left-dorsal displacements. In those horses, surgical ablation of the renosplenic space can be an effective prophylactic procedure.[16]

Laparoscopic ablation of the renosplenic space is performed in the standing horse. Feed is withheld for a minimum of 24 hours. The laparoscope is inserted as described earlier. One instrument cannula is inserted through the 17th intercostal space and a second instrument cannula is placed immediately cranioventral to the laparoscope. Assistance with intra-abdominal manipulation of the suture needle is normally achieved through the cannula placed in the intercostal space. The suture is introduced through the more caudally placed cannula, and a simple continuous suture (the author uses #1 polyglyconate) is used to attach the dorsal free margin of the spleen to the renosplenic ligament. Horses are restricted to a stall for 30 days before returning to normal activities. The prognosis is generally regarded as good; however, experience with this procedure is limited at present.

Summary

Minimally invasive approaches to surgical conditions in the horse offer viable alternatives to more traditional open techniques. Many of the same advantages that have made these techniques the practice standards in modern human medicine are also apparent in the horse, including reduced morbidity, low complication rates, and earlier return to function.

This issue of *Large Animal Veterinary Rounds* is guest edited by Katharina Lohmann, DVM, Diplomate ACVIM, PhD.

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8 – 11 March 2008
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4 – 7 June 2008
American College of Veterinary Internal Medicine Forum
San Antonio, Texas
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Dr. Wilson has stated that he has no disclosures to announce in association with the contents of this issue.

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This publication is made possible by an educational grant from

Schering-Plough Canada Inc.

117-069E