Objective: To evaluate surgical techniques, perioperative complications and outcome of laparoscopic surgery for unilateral and bilateral ovariectomy in mares. 

Study Design: Retrospective multicenter case series.

Animals: Mares (n = 157).

Methods: Indications for surgery were neutering, fertility problems, elimination of hormone-related abnormal behavior, ovarian tumors as well as nonregressive ovarian hematomas or cysts. Ovariectomy (n = 206) were performed by a standard laparoscopic procedure in 157 standing sedated mares. Dissection and hemostasis were achieved by using either (1) a linear stapling device, (2) bipolar electrosurgical instruments, with or without a modified Roeder knot, (3) a vessel-sealing system, or (4) a diode-laser with ligation. For some larger ovarian masses (> 20 cm diameter), a 2-step surgical procedure was used with standing flank laparoscopic ovariectomy followed by ovarian retrieval through a median celiotomy. Surgical techniques, outcome, and perioperative complications of each method were recorded and analyzed.

Results: Laparoscopic dissection of the ovary was accomplished in all mares. Because of the size of the ovarian tumor (n = 7) or in 1 mare with behavioral problems (n = 1), the dissected ovary was removed through a median celiotomy under general anesthesia. Seventeen mares (10.8%) developed postoperative complications (eg, incisional drainage, incisional infection, seroma formation, dehiscence, transient fever and mild abdominal discomfort). All mares with flank incisional problems had ovarian size >12 cm and in 15 (88%) of these mares electrosurgical instruments were used for mesovarial dissection.

Conclusions: Laparoscopic ovariectomy in standing sedated mares provides good surgical access and is associated with low morbidity.

INTRODUCTION

Different conventional surgical procedures and minimally invasive techniques have been reported for unilateral and bilateral ovariectomy in mares. Ovariectomy seems to be associated with a higher frequency of perioperative complications than other elective surgical procedures. Ovariectomy by laparotomy or colpotomy is associated with serious perioperative complications, including hemorrhage, myopathy and neuropathy, wound infection and dehiscence, eventration, peritonitis, adhesions, postoperative colic and ileus. Minimal invasive surgery is considered to result in fewer complications and has become more popular in the last few years. In comparison to colpotomy and laparotomy, laparoscopic procedures offer the advantages of good intraoperative visibility, secure hemostasis, less invasiveness, reduced surgical morbidity, and shortened hospitalization. According to individual surgeon preference, laparoscopic intervention can be in the standing sedated horse or in dorsal recumbency. Most authors favor surgery in standing sedated mares because of the normal anatomic orientation, increased operative visibility, and avoidance of the risks and complications associated with general anesthesia.

We report findings from a retrospective multicenter clinical study to evaluate the surgical techniques, intra- and perioperative complications, and outcome of laparoscopic surgery for unilateral and bilateral ovariectomy in mares.
MATERIALS AND METHODS

Horses

Medical records (1996–2009) of 157 mares that had either unilateral or bilateral ovariectomy at the Veterinary Clinic Starnberg, Germany, the Department of Equine Surgery, School of Veterinary Medicine, Justus-Liebig University, Giessen, Germany, and the Faculty of Veterinary Medicine, Department of Equine Sciences, Utrecht University, Netherlands, were selected. Clinical indications were neutering, fertility problems, elimination of hormone-related abnormal behavior, ovarian tumors as well as non-regressive ovarian hematomas or cysts.

A complete physical examination, a hematologic and serum biochemical profile and a gynecologic examination, including abdominal palpation per rectum with ultrasonographic evaluation of the reproductive tract were performed in all mares presented for ovariectomy, regardless of the reason.

Depending on the clinical indication, the behavior of the mare, the size of the ovary, and the surgeon’s preference, ovariectomy was performed as a standing laparoscopic surgical procedure or a 2-step surgical procedure. For the 2-step procedure, in the 1st step, transection of the ovarian pedicle was carried out laparoscopically in the standing sedated mare and in the 2nd step, the dissected ovarian tumor was extracted through a median celiotomy in dorsal recumbency under general anesthesia.

Mares were provided free choice of water but fed only mash and pellets for 36–48 hours before surgery or had food withheld for 48 hours. Cefquinom sulfate (1.0 mg/kg intramuscularly [IM]), procaine penicillin G (22,000 U/kg, IM) or sodium benzylpenicillin (30,000 U/kg, IM) in combination with gentamicin (6.6 mg/kg intravenously [IV]), and flunixin meglumine (1.1 mg/kg, IV) or meloxicam (0.6 mg/kg, IV) were administered preoperatively. In 119 mares, butylscopolamine (0.2 mg/kg, IV) was administered preoperatively to achieve spasmoanalgesia.

Surgical Technique

Sedation and analgesia was achieved with detomidine (0.01 mg/kg, IV) and butorphanol (0.01 mg/kg, IV). Throughout the surgical procedure, sedation was adjusted as needed by administration of detomidine and butorphanol (each in a dosage of 0.005–0.01 mg/kg, IV).

According to the diagnosis, one or both paralumbar fossae were shaved and aseptically prepared. Local analgesia was achieved by a paravertebral anesthesia and or an infiltration anesthesia subcutaneously, intramuscularly and subperitoneally with 20 mL 2% lidocaine (with or without 2% adrenalin) each at the surgical sites: the paralumbar fossa and the 17th intercostal space at the level of the tuber coxae.

Laparoscopic ovariectomy was achieved through 2 ipsilateral instrument portals in the flank and 1 optic portal in the 17th intercostal space or just caudal to the last rib. After exposure of the ovary, infiltration anesthesia of the ovarian pedicle was performed using 10–20 mL 2% lidocaine (with or without 2% adrenalin). Before transection, the size of the ovary was reduced by suction of fluid, when possible. Dissection and secure hemostasis of the mesovarium was achieved using either (1) a linear stapling device (35 mm or 45 mm, Endo-GIA, Covidien, Service Center S.A., Elancourt, France); (2) bipolar electrosurgical instruments, with or without ligation; (3) a vessel-sealing system (LigaSure® Force Triad™, Tyco Healthcare Deutschland GmbH, Soltau, Germany); or (4) a diode-laser (Dornier MediLas D®, Dornier Medizinlaser GmbH, Wessling, Germany) with ligation. In 13 mares, the ovarian tumor was contained within in an intraabdominal sterile plastic bag, cut into pieces and then retrieved within the bag. In the mares, the ovaries were removed intact, when necessary by enlarging 1 of the instrument portals or by connecting the 2 instrument portals up to a length of 15 cm using a modified grid technique. After removal of the ovary, portals and flank incisions were sutured. In bilateral interventions, the same procedure was performed through the opposite paralumbar fossa to remove the contralateral ovary. In 1 mare, the dissected left ovary was moved from the left to the right side, and both ovaries were exteriorized through the same right-sided incision at the end of the procedure.

For ovarian tumors with a diameter >20 cm or if the mare displayed aggressive behavior, ovariectomy was accomplished in a 2-step procedure.

Surgical techniques for dissection and hemostasis, the diameter of the tumor (measured with a ruler after removal) and intra- and perioperative complications (bleeding of the mesovarium, wound healing problems, fever and abdominal discomfort) were evaluated. In 30 mares, surgical time was measured to evaluate the influence of the dissection technique (linear stapling, bipolar electrosurgery and vessel-sealing); these procedures were performed by 1 surgeon in horses with an ovarian tumor <12 cm diameter.

Postoperative Care and Follow-up

Cefquinom sulfate (1.0 mg/kg intramuscularly, IM), procaine penicillin G (22,000 U/kg, IM every 12 hours), or sodium benzylpenicillin (30,000 U/kg, IM) in combination with gentamicin (6.6 mg/kg, IV) and flunixin meglumine (1.1 mg/kg, IV) or meloxicam (0.6 mg/kg, IV) were administered according to the initial administration for 2–6 days. During hospitalization, a clinical examination and white blood cell count were performed the first 3 days postoperatively. Horses were discharged with a recommendation of stall rest for 10–14 days after laparoscopic intervention and for 6 weeks after a 2-step surgical procedure with handwalking twice daily before resuming normal use. Short-term results (6–8 weeks) were determined by telephone questionnaire of owners, trainers or referring veterinarians in 72 mares.
RESULTS

Ovariectomy (n = 206) was performed in 157 mares. Laparoscopic ovariectomy was bilateral in 49 mares and unilateral in 108 mares. Clinical indications for bilateral ovariectomy were neutering (24 mares), nymphomania, hormone-induced abnormal behavior as well as estrus-related reduced athletic performance (24 mares), and bilateral ovarian tumor (1 mare). Unilateral ovariectomy was performed for granulosa-theca-cell tumor (GCT) in 103 mares, an ovarian cyst in 1 mare, and nonregressive ovarian hematoma in 4 mares. The diameter of the GCT in 68 mares was <12 cm (66%), in 23, between 12 – 20 cm (22%) and in 12, > 20 cm (12%).

Complete laparoscopic ovariectomy was achieved in 149 standing sedated mares. In 7 mares, laparoscopic dissection was followed by removal of the ovary through median celiotomy in dorsal recumbency because the ovarian tissue was > 20 cm diameter. In only 1 mare was conversion to celiotomy necessary after laparoscopic dissection of the ovarian pedicle because of inability to control behavioral problems in the standing mare.

Hemostasis and dissection of the ovarian pedicle was performed using either a 35 mm or 45 mm linear stapling device (n = 66), by vessel-sealing system LigaSure® (n = 49) or by using bipolar electrosurgical instruments as a single technique (n = 49) or in combination with a circular ligature around the main vessels (n = 38), knotted extracorporeally using a modified Roeder knot. In 2 mares, hemostasis was initially performed with a diode-laser and in 2 mares with a single modified Roeder knot. In these 4 mares, hemostasis was incomplete and bipolar electrocoagulation was necessary to occlude the bleeding vessels.

Use of linear stapling devices (Endo-GIA) was technically easy and created very precise cut edges. Mean ± SD surgical time was 40.2 ± 10.2 minutes. Two cartridges were necessary to completely divide the mesovarium of a normal ovary, whereas 3–4 cartridge units were needed for ovarian tumors.

Using the 10-mm bipolar vessel-sealing system, LigaSure®, the ovarian pedicle was progressively coagulated and cut in a single-step process. The main vessels were sealed twice at a distance of 1 cm before cutting. The device allowed very efficient and safe sectioning of the mesovarium and created a smooth coagulated wound surface at the resection site. By using this system, smoke evacuation was minimal and hemostasis was secure. Mean surgical time was 46.2 ± 8.2 minutes.

Electrocoagulation was performed using a bipolar forceps with a mechanical cutting blade, which allowed tissue coagulation and division over a length of 5 mm. Because the cranial and caudal part of the mesovarium is less vascularized, a single coagulation was sufficient to achieve secure hemostasis. In the middle part, including the main vessels, multistage tissue coagulation was performed before dissection. At the resection site, a coagulated and carbonized wound surface was created. This technique turned out to be a time-consuming procedure before a secure hemostasis was achieved. Mean surgical time was 60 ± 15.4 minutes.

In 13 mares, the ovarian tumor was intraabdominally placed in a sterile plastic bag, cut into pieces with a scalpel blade (# 11 or 22) and then extracted in pieces. In the other mares, the ovaries were removed intact, when necessary by enlarging 1 instrument portal or by connecting 2 instrument portals.

No major intraoperative complications occurred. Seventeen mares (10.8%) developed postoperative complications, such as postoperative dehydration (n = 1), extensive subcutaneous emphysema (n = 1), wound swelling, and seroma formation followed by infection and dehiscence of the flank incision (n = 15). In 4 of these 15 mares, transient fever up to 39.2°C was observed over 3–5 days, starting on the 2nd postoperative day. Two of these mares had mild postoperative depression and colic signs on the 1st and 2nd postoperative day. In 1 of these mares, a fist-sized hematoma at the resection site was diagnosed by rectal palpation and ultrasonography. In the other mare, an adhesion between the resected ovarian pedicle and the base of the cecum was detected, which was easily released by transrectal manipulation. All postoperative complications occurred in mares with an ovarian tumor size >12 cm (in 15 of 27 mares where the tumor was removed by flank incision). No incisional problems occurred in the celiotomy wounds.

Transection of the mesovarium was carried out with the bipolar electrosurgical forceps in 10 of 15 mares with incisional problems, in 2 mares with a combination of bipolar electrocoagulation and circular ligature, in 1 mare where a linear stapling device was used and in 2 mares where the vessel-sealing system was used. The hematoma as well as the intraabdominal adhesion occurred in mares in which hemostasis and dissection of the ovarian pedicle was carried out with the bipolar electrosurgical forceps.

All postoperative complications responded to conservative treatment and all 157 mares were discharged from the clinic. Mares that had laparoscopic surgery had an overall postoperative morbidity of 10.8% and mortality of 0%.

In the follow-up questionnaire, a slight depression of the musculature was reported for 8 mares at the site of the enlarged flank-incision. No further complications were reported.

DISCUSSION

We report laparoscopic ovariectomy in 157 mares (46 bilateral, 97 unilateral) for removal of normal (48 mares) and pathologic (109 mares) ovaries, using different techniques for mesovarial dissection and transection, with no mortality and 10.8% morbidity that is substantially lower than is reported for conventional surgical ovariectomy techniques (mortality, 4.5–7.7%m; morbidity, 24.4–26.6%m).

Incisional problems were the predominant complications (15 mares) and only occurred in mares with ovarian...
diameter > 12 cm. In 12 of these mares, mesovarial dissection was by electrosurgery (10 electrosurgery alone, 2 electrosurgery in combination with ligation). Others have reported incisional complications being statistically associated with ovarian tumor size\textsuperscript{30, 31}, particularly when ovarian diameter is > 18 cm. Six to 8 weeks after surgery, 8 mares in our study had a depression at the flank incision site. We did not suture the internal abdominal oblique and transverse abdominal muscles in the mares in this study. It is possible that closure of the muscle layers may have prevented this cosmetic defect; however, suturing these layers is technically difficult because of the small wound size. Nevertheless avoiding cosmetic defects is important in mares used for competition or those intended for sale.

Different techniques were used for removal of the transected ovaries. After mesovarial dissection, complete ovaries < 15 cm diameter were removed by enlarging the instrument portals exclusively, using forceps and wound retractors. Hand-assisted procedures\textsuperscript{32}, were not used. In 13 mares, we used an intraabdominal retrieval bag and fragmented the ovary to minimize the size of the mass being exteriorized. Other reported techniques include placing the mobilized ovary in a sterile plastic disposable surgical drape and, after intraabdominal transection into pieces with a scalpel or a morcellator\textsuperscript{33}, removal of the contained ovarian tissue through a smaller incision.\textsuperscript{32, 34, 35} This technique offers also the advantages of decreasing the risks of losing the ovary and avoiding wound contamination by the tumor during removal. In an effort to prevent incisional complications and to optimize cosmetic outcome in 7 mares with a tumor diameter > 15 cm, even after size-reduction by suction, we used a 2-step procedure with ovariectomy performed standing and ovarian exteriorization performed under general anesthesia through a median celiotomy.

We used different primary methods to achieve hemostasis of the mesovarium before or during transection: linear stapling (66 ovaries), vessel sealing (49 ovaries), electrosurgical dissection (49 ovaries), electrosurgery in combination with ligation (38 ovaries); diode laser and ligation (2 ovaries) and ligation followed by electrocoagulation (2 ovaries). Measured in 30 mares with the same surgeon, time to accomplish mesovarial separation of an ovary (< 12 cm diameter), was comparable ( stapling, 40.2 ± 10.2 minutes: vessel sealing, 46.2 ± 8.2 minutes) although slightly longer with the electrosurgical method (60 ± 15.4 minutes). Other reported techniques include use of a modified Roeder knot\textsuperscript{32} or by diode-laser.\textsuperscript{20} Use of a modified Roeder knot or endoloop ligation are reportedly more economical\textsuperscript{36}; however, a disadvantage of these techniques is the potential for ligature slippage and bleeding during dissection especially with enlarged ovaries,\textsuperscript{30} and which we also experienced in 2 mares. A combination of bipolar electrosurgical dissection of the cranial and caudal part of the mesovarium with a circular ligature around the main vessels was reliable in our hands for removal of normal and enlarged ovaries. Surgical lasers (eg, diode- or Nd:YAG) should only be used in addition to one of the techniques already described.\textsuperscript{20} The coagulative abilities of these lasers are insufficient to achieve reliable hemostasis as the sole method. We had this experience in 2 mares and had to use electrocoagulation to achieve hemostasis. During laser-dissection, there is also risk of thermal damage to adjacent structures.\textsuperscript{37}

A safe, effective, but expensive, technique for laparoscopic ovariectomy is use of a vessel-sealing system (LigaSure®).\textsuperscript{35} We found this to be a quick, safe method for hemostasis of the mesovarial vasculature. Although vessel size may limit effective use of the LigaSure® especially in pathologic ovaries,\textsuperscript{38} we did not encounter any difficulty in its effective use. Perhaps this is because we sealed the main vessels twice before cutting. Compared with monopolar or bipolar electrosurgical instruments,\textsuperscript{39, 40} surgical time is less with the Ligasure and thermal damage is confined to the target tissue.\textsuperscript{41} The main disadvantage of electrosurgical instruments for ovariectomy in mares is the small-sized jaws (5 mm) of the bipolar forceps. Multistage tissue coagulation was needed in our mares to achieve reliable hemostasis causing a circumscribed thermal soft tissue necrosis with carbonization of the target tissue. As a consequence, in 1 mare a fist-sized hematoma occurred at the resection site and in another mare, an adhesion occurred between the resected ovarian pedicle and the base of the cecum. It seems that, the risk of postoperative adhesions might be higher when using electrosurgical instruments for coagulation of the ovarian vasculature.

Laparoscopic ovariectomy in the standing sedated mare has many advantages compared with conventional surgical ovariectomy through a median celiotomy. These include superior viewing, normal anatomic orientation, easier intraabdominal manipulation, and avoidance of the risks of general anesthesia.\textsuperscript{9, 42} In dorsal recumbency using conventional surgical technique, tension-free and secure ligation of the mesovarium under visual control cannot be guaranteed.\textsuperscript{14, 15, 29} Excessive traction on the ovarian pedicle can result in intraoperative hypotension, which is believed to contribute to myopathy and neuropathy.\textsuperscript{14, 15, 43} Using stapling devices for dissection of the mesovarium makes this surgical step technically easier. But even then, application of staples and ligatures tightened under tension may result in inadequate hemostasis.\textsuperscript{34, 45}

In our study, except for 8 mares, laparoscopic ovariectomy was completed in the standing position. Based on our favorable experiences with standing laparoscopic ovariectomy, recumbent ovariectomy should be limited to horses that exhibit behavioral problems during standing surgery. Laparoscopic ovariectomy in dorsal recumbency and 30° head down position has, from the technical point of view, no distinct advantages. Indeed, there is the potential disadvantage of cardiopulmonary derangement during laparoscopic surgery in the Trendelenburg position.\textsuperscript{9, 11, 25, 46}

Each surgical technique for ovariectomy in the mare has offered distinct advantages and disadvantages. Comparison of the different surgical techniques should be interpreted cautiously because treatments in this multicenter case series study were not conducted in a blind or random manner. Nevertheless, in our clinical experience laparoscopic ovariectomy in standing sedated mares has
been proven to be the preferred method for ovariectomy and avoids the risks of general anesthesia. It can be performed safely and reliably for removal of normal and enlarged ovaries and, compared with conventional surgical techniques, is less invasive and is associated with substantially lower perioperative morbidity and mortality.

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REFERENCES


