Laparoscopy – A New and Rapidly Advancing Field in Veterinary Science

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ABSTRACT

Laparoscopy is a minimally invasive technique for exploration and manipulation of the internal structures and wall of the peritoneal cavity. The minimally invasive nature of the procedure, diagnostic accuracy, reduction in surgical stress, reduced patient morbidity and post-operative pain contribute to making this procedure a definite alternative to open surgical approaches in small animals. This narrative review will cover the equipment, technique, diagnostic and surgical applications, advantages, disadvantages and complications of small animal laparoscopy. Laparoscopy represents a major advancement in veterinary science and demonstrates a forward thinking approach to patient care. [Beierer LH & Burgess DM (2009) Aust Vet Practit 39:10]

INTRODUCTION

Minimally invasive surgical techniques are becoming increasingly prevalent in veterinary surgery as technology and client expectations continue to broaden. Laparoscopy is a minimally invasive technique for exploration and manipulation of the internal structures and wall of the peritoneal cavity. The procedure involves insufflation of the abdominal cavity and placement of a rigid endoscope (laparoscope) through a portal positioned percutaneously in the abdominal wall. Once abdominal distension and visual access is attained, adjacent portals can be inserted and used for placement of a wide variety of instruments for both diagnostic and surgical procedures.

Laparoscopy is a growing discipline in veterinary science which promises significant advantages over traditional open surgical procedures. The minimally invasive nature of the procedure, diagnostic accuracy, reduction in surgical stress, reduced patient morbidity and post-operative pain contribute to making this procedure a definite alternative to open surgical approaches in small animals. This narrative review aims to critically evaluate published literature in the field of small animal laparoscopy.

EQUIPMENT


Light Source
Light is transmitted from a remote light source via a fibre-optic cable to the laparoscope (Fig 1). Commonly available light sources are 150W or 300W halogen or xenon powered and must provide sufficient illumination to satisfactorily view the abdominal contents in true colour. This can best be achieved with a xenon powered fibre optic light source, as it is brighter and provides the truest colours when compared to its halogen counterpart (Monnet & Twedt 2003).

Camera
Video assisted laparoscopy (Fig 2) is now considered to be routine practice (Monnet & Twedt 2003) as it enables the entire surgical team to view the image simultaneously, reduces operator fatigue, aids teaching and
enables recording of the procedure (Richter 2001). Currently available cameras come as a one or three chip model, the latter providing superior resolution necessary for quality photo documentation but also are more expensive.

Laparoscope

Laparoscopes (Fig 3) are rigid endoscopes which vary in length, diameter and viewing angle. The conventional rigid endoscope optical system incorporates a series of convex lenses separated by large air spaces, but the recently developed Hopkins rod lens system utilises comparatively longer rods of glass and smaller air spaces. The advantages of the rod lens system are better image resolution, greater light transmission, a wider field of view and image magnification. They vary from 2.7mm to 10mm outside diameter and can be forward viewing (0 degrees) or angled (10, 25, 30, 45, 70, 90, 120 degrees). A 0 degree scope provides a direct forward viewing area and is commonly accepted as being more intuitively obvious as the object of interest is directly in front of the scope. However oblique angled scopes enable viewing in relatively inaccessible areas such as the dorso-cranial aspect of the liver (Richter 2001).

Veress needle

A Veress needle is used for initial gas insufflation of the abdominal cavity and consists of an outer cutting sheath which punctures through the abdominal wall and an inner spring loaded obturator that retracts into the cutting needle while penetrating the abdominal wall and extends beyond the sheath once through the peritoneum to provide a blunt protective barrier against perforation of abdominal organs.

Insufflator

Gaseous insufflation of the abdomen provides exposure of the abdominal organs. Insufflation is performed via an automatic insufflator (Fig 4) which delivers gas at a prescribed rate to obtain a constant intra-abdominal pressure (IAP). A variety of different gases have been trialled for use in intra-peritoneal insufflation including carbon dioxide (CO₂), nitrogen (N₂), nitrous oxide (N₂O), and helium (He). Studies of He (Wolfgang et al 1994) and N₂ (Gilroy & Anson 1987) have found them to be highly insoluble in blood and to pose a high risk for fatal gas embolism, a potential complication of laparoscopy. Carbon dioxide is considered the gas of choice to prevent air embolism due to its high diffusability and rate of bodily excretion (Magne & Tams 1999, Richter 2001). Conjecture exists regarding the use of both CO₂ and N₂O in peritoneal insufflation as both have been touted as the "gas of choice" (El-Minawi et al 1981, Fitzgerald et al 1992, Gross et al 1993, Ishizaki et al 1993a, Ishizaki et al 1993b, Kotzampani et al 1993, Katircioğlu et al 1998, Aksoy et al 2001). Carbon dioxide is associated with significant hypercarbia and respiratory acidosis (El-Minawi et al 1981, Gross et al 1993, Kotzampani et al 1993) while N₂O is disadvantageous as it places limitations on the surgeon as electrocautery techniques, that support combustion, cannot be used (Duke et al 1996). But, it is associated with insignificant changes in arterial carbon dioxide tension and arterial pH while CO₂ is associated with a significant rise in arterial carbon dioxide tension and a significant decrease in arterial pH (El-Minawi et al 1981).

Older or debilitated patients with pre-existing pulmonary disease are at risk of CO₂ retention and He may be a reasonable alternative as it is associated with significantly less hypercarbic or acidic changes than is CO₂ (Bongard et al 1991, Fitzgerald et al 1992, Kotzampani et al 1993). It is an inert and non-inflammatory gas and while posing a risk of air embolism, this can be reduced through an open (manual dissection to the peritoneum) technique of insufflation. Insufflation pressures below 20mmHg have been recommended for laparoscopy (Motew et al 1973, Jones et al 1985, Gross et al 1993, Duke et al 1996).

In a controlled experimental study, assessing systemic haemodynamics through step wise increases in IAP (8, 12, 16mmHg), the changes of decreased cardiac output, increased systemic vascular resistance and decreased hepatic blood flow were not evident at 8-12mmHg, but were significant at 16mmHg (Ishizaki et al 1993b). In a randomised controlled study, of eight dogs with varying IAP of 10-20-30mmHg, all induced cardiorespiratory changes resolved rapidly (< 5 mins) when pressures did not exceed 20mmHg (Gross et al 1993). Pressures greater than or equal to 15mmHg are currently recommended to minimise the effects of maintaining a pneumoperitoneum (Jones et al 1985, Gross et al 1993, Monnet & Tweedt 2003).

Ports

The trochar-cannula unit comprises of a sharp tipped trochar which is contained within a cannula. The cannula is used as an instrument or laparoscope portal and the inside trochar portion is used to traverse the abdominal wall. Once into the abdomen, the sharp tipped trochar is removed and the laparoscope or instrument is inserted into the cannula. An air tight seal and locking adapter is built into each trochar-cannula for continued insufflation of gas. A recent modification is the EndoTIP(tm) which works to displace muscle and IAP without puncturing or cutting and potentially removes the possibility of organ injury by uncontrolled penetration.

PATIENT PREPARATION

All patients should be fasted for a minimum of 12hrs before the procedure, and their urinary bladder should be evacuated (Richter 2001, Monnet & Tweedt 2003). Evaluating pre-surgical coagulation status for animals undergoing laparoscopic intervention has been recommended (Jones 1990), but it is controversial (Richter 2001). Further studies need to be performed to quantify the association between in-vitro coagulation tests and real bleeding time following biopsy, especially of the liver, before their significance in the pre-laparoscopic examination can be determined.

Laparoscopy is performed under general anaesthesia in most cases; however, select procedures can reportedly be performed under heavy sedation and local anaesthesia at portal entry sites (Monnet & Tweedt 2003). For the extremely debilitated patient laparoscopy may be

1 EndoTIP, Karl Storz
accomplished with just local anaesthesia with minimal or no sedation (Jones 1990).

TECHNIQUE
The approach is chosen based on the procedure to be performed and portal site placement is selected before the animal is prepared. General and procedural specific portal placement sites and approaches are described in the literature (Richter 2001, Monnet & Twedt 2003). The abdomen is clipped extensively to facilitate conversion to an open approach, if required, and routine aseptic patient skin preparation and draping is performed.

A 1mm skin incision is made with a scalpel blade and a Veress needle is placed into the abdomen. A gas line is then attached from the insufflator to the Veress needle.

FIGURE 1: A xenon light source.

FIGURE 2: A camera and camera control unit.

FIGURE 3: A selection of telescopes commonly used for laparoscopy (top to bottom), a 10mm diameter telescope with a 30 degree viewing angle, a 10mm telescope with a 0 degree viewing angle, a 5mm diameter telescope with a 30 degree viewing angle and a 5mm diameter telescope with a 0 degree viewing angle.

FIGURE 4: An automatic insufflator.

FIGURE 5: Hepatic biopsy using a laparoscopic cup biopsy forceps. (* = Cup biopsy forceps; L = Liver.)

FIGURE 6: An ultrasonic current generator.

FIGURE 7: A laparoscopic renal biopsy being performed using a Tru-Cut biopsy needle. (* = Tru-Cut biopsy needle; K = Right kidney.)
and set to a constant intra-abdominal pressure. Once a pneumoperitoneum is established another skin incision is made, no larger than the diameter of the cannula, to allow for placement of the trochar-cannula unit. The trochar-cannula is placed into the abdomen via a twist and thrust motion. Once into the abdomen the trochar is removed to prevent organ damage and then the cannula is immediately advanced further. The laparoscope is placed through this portal into the abdomen. The gas line is then transferred to the cannula stop-cock and the Veress needle is removed under direct visualisation. Additional instrument portals can then be inserted under direct vision through the laparoscope, in combination with external palpation, to prevent organ damage.

On completion of the procedure a final examination is made of the abdomen for unsuspected trauma or abnormal bleeding from biopsy or therapeutic intervention sites. Suction can be used to eliminate any remaining free fluid. Once the abdomen has been satisfactorily evaluated and no complications are present, all instruments and the laparoscope can be removed from the abdomen and the valves on all cannulas are opened. Gentle pressure is placed onto the abdomen to force out any remaining gas and then all cannulas are removed. At entry sites, the rectus fascia, subcutaneous tissue and skin are then closed using standard techniques.

APPLICATIONS

Liver Biopsy

Numerous methods of obtaining liver biopsies have been described (Dalton & Hill 1972, Lettow 1972, Bunch et al 1985, Jones et al 1985, Van Den Ingh et al 1988, Richter 2001, Barnes et al 2006, Vasanjee et al 2006). Obtaining liver specimens is an invasive technique, but one that can achieve an aetiological diagnosis and help plan appropriate treatment regimes (Jones et al 1985). Biopsies may be collected using percutaneous, keyhole, laparoscopic (Fig 5) and conventional open surgical techniques (Jones et al 1985). Specimens are obtained by using biopsy punches, biopsy needles, the ligature method, laparoscopic biopsy forceps and the ultrasonically activated scalpel (Fig 6) (Vasanjee et al 2006).

Laparoscopic biopsy offers a minimally invasive alternative to open surgical biopsy (Richter 2001), visual control, visual assessment of coagulation post-biopsy, the ability to select samples from multiple sites in the liver (Rawlings & Howerth 2004, Richter 2001) and the ability to simultaneously survey other abdominal structures (Jones et al 1985). Laparoscopy is often the preferred biopsy technique in animals with either coagulation or wound healing deficiencies (Rawlings & Howerth 2004). However, laparoscopy is inferior in detecting intra-hepatic lesions and ultrasonography may be preferred in this instance (Rawlings & Howerth 2004). A blinded prospective case series of 124 dogs and cats undergoing 18 gauge needle biopsy (simulating ultrasound-guided biopsy) and simultaneous surgical wedge biopsy (similar in size to laparoscopic biopsy, defined in the paper as the definitive histopathologic diagnosis) found a poor correlation, 48% (59 of 124), between morphologic diagnosis on needle biopsy to the definitive finding (Cole et al 2002). In that study, the histopathologists were blinded from the clinical data associated with tissue samples and the disparity between interpretations was likely associated with obtaining smaller tissue samples during needle biopsy and indicates the superiority of laparoscopic biopsy when compared with ultrasound guided needle biopsy.

Vasanjee et al (2006) compared five different hepatic biopsy techniques in a study of 12 dogs; biopsy punch (4mm Bakers Biopsy2), biopsy needle (16g” Tru-cut2), ligature method, clamshell laparoscopic biopsy forceps and ultrasonically activated scalpel; all but the biopsy needle yielded adequate samples for histopathology. The study, however, failed to define “adequate for histological evaluation” and did not adequately blind the pathologists. Only 19% of the biopsy punch samples contained less than six portal triads; this is of concern when hepatic pathology involves the portal-triads, as human studies have shown greater than six-to-eight portal triads are required for diagnosis of human liver disease (Bravo et al 2001). The number of portal triads required for diagnosis of canine liver disease has not been quantified but it is likely to be similar to this human figure.

Laparoscopy can also be used in animals with ascites to obtain liver biopsies without the accompanying protein loss that is inherent with a traditional laparotomy (Rawlings & Howerth 2004). However paracentesis is often performed before laparoscopy to evacuate cloudy fluid which readily impedes visualisation and increases anaesthesia time (Richter 2001).

Renal Biopsy

Current renal biopsy techniques described for use in small animals include percutaneous and surgical approaches (Grauer et al 1983, Wise et al 1989, Rawlings et al 2003a, Rawlings & Howerth 2004, Vaden 2005). Percutaneous methods include blind/palpation, laparoscopic (Fig 7), keyhole and ultrasound guided techniques. Wedge and needle biopsies can be obtained via a laparotomy (Vaden 2005). A prospective experimental case series of 36 dogs comparing laparoscopy-guided biopsy and variations of the keyhole biopsy technique found no statistical difference between specimens obtained via either method (Wise et al 1989). This was despite the risk of artefact associated with considerable displacement of the kidney, as sometimes occurs with the keyhole technique (Vaden 2005). This study was unable to quantify the post-biopsy complication rate as all dogs were euthanised immediately after the final biopsy and the primary outcome measure was not dependant on diagnostic yield. Instead, suitable tissue was defined as core biopsies which contained greater than or equal to five intact glomeruli and adjacent tubules. Another prospective experimental study comparing 14 gauge and 18 gauge ultrasound guided percutaneous and laparoscopic needle kidney biopsy specimens concluded that 14 gauge biopsy specimens, obtained laparoscopically, had a significantly higher mean number of glomeruli than the mean number of glomeruli obtained using ultrasound-
guidance (Rawlings et al 2003a). However, the authors are unaware of any clinical studies in dogs that document the required number of glomeruli in biopsy specimens required for an accurate histological diagnosis. All laparoscopic biopsies had transient and easily monitored haemorrhage whereas one ultrasound-guided sample had a large amount of haemorrhage (Rawlings et al 2003a).

A retrospective case series of 197 needle biopsy specimens obtained via the keyhole technique (dogs) and blind percutaneous (cats) found a 96% correlation rate with necropsy diagnosis in 101 cases and all cases of incorrect diagnosis were attributed to a lack of focal lesions and lack of glomeruli in samples (Jeraj et al 1982). Visual direction of laparoscopic biopsy leads to a higher likelihood that diagnostic tissue will be obtained when focal lesions exist and provides direct observation of haemorrhage after biopsy (Grauer et al 1983, Vaden 2005). Visualisation of the kidney can detect renal tumours, infarcts, petechiation and irregular renal surfaces, all of which can be missed by digital palpation with the keyhole biopsy technique (Grauer et al 1983). Sedation and local anaesthesia requirements for laparoscopy are similar to those for the keyhole technique (Grauer et al 1983). Surgical biopsy may be the preferred method in small dogs (less than 5kg) and those undergoing a laparotomy for another reason (Vaden 2005).

Pancreatic Biopsy
Laparoscopic biopsy of the canine pancreas (Fig 8) was performed in 10 clinically normal dogs without incident. Biopsied tissue was deemed to be of satisfactory size and condition to allow for a histopathologic diagnosis by the attending pathologist (Harrington et al 1996). In a case series of 23 dogs that underwent laparoscopic biopsy of the pancreas, biopsies could not be obtained in four cases due to severe pancreatic atrophy or coalescence (Spillmann et al 2000). In an early study, laparoscopic pancreatic biopsy was performed successfully in two dogs and the authors believe the speed with which the procedure can be conducted under sedation and local or general anaesthesia avoids some of the risks surrounding a laparotomy (Dalton & Hill 1972). An experimental case report described laparoscopic pancreatic biopsies in four healthy laboratory beagles which were completed uneventfully, and without difficulty, providing satisfactory tissue for histopathologic examination. Two dogs were euthanised at seven and 21 days post-surgery and did not exhibit any permanent abnormalities in clinical health, haematology or biochemical parameters (Harmoenen et al 2002). Pancreatic biopsy is considered a relatively safe procedure for the diagnosis of pancreatic diseases with high diagnostic value (Spillmann et al 2000).

Intestinal Biopsy
A technique of laparoscopic-assisted small intestinal biopsy has been described (Rawlings et al 2002a, Monnet & Twedt 2003). A portion of intestine is grasped and exteriorised through an extended trochar incision and a small full thickness biopsy (as per an open abdominal surgical biopsy) is obtained (Rawlings et al 2002a, Monnet & Twedt 2003). In an evaluation of endoscopic (EB) and full-thickness biopsies (FTP) (obtained by laparotomy or laparoscopy), laparoscopy was identified as an effective minimally invasive alternative to laparotomy for abdominal exploration. It was also useful for assisting in FTB of the stomach and intestine (Evans et al 2006). In seven cats FTP was obtained with laparoscopic assistance and a laparotomy was performed in 15 cats and no surgical complications occurred after any of these procedures (Evans et al 2006). However EB yielded incorrect or inconclusive results in as many as nine of 11 cats (Evans et al 2006).

General Biopsy
Barnes et al (2006) successfully obtained laparoscopic biopsy of the liver, spleen, adrenal gland, pancreas, stomach, jejunum and bladder using laparoscopic or laparoscopic-assisted methods in 12 dogs. This suggests that laparoscopy can be used to obtain biopsies from almost all abdominal organs.

Oncological Applications
Laparoscopy can be used to diagnose and stage abdominal tumours through direct visual inspection and allows directed biopsies (Richter 2001). Laparoscopy can facilitate oncological staging, where surgery is of no benefit or may be detrimental to compromised animals, by facilitating documentation of disease for further management (Johnson & Twedt 1977). They reported that laparoscopic evaluation to assess prognosis was valuable for detecting peritoneal and diaphragmatic metastases, following splenectomy in one patient while undergoing chemotherapy. A second dog that was receiving chemotherapy for a malignant mast cell tumour developed abnormal liver function. In this case, laparoscopy facilitated non-invasive biopsy which revealed a lack of hepatic malignant invasion and chemotherapy-induced hepatopathy was subsequently diagnosed. Masses on the peritoneal surface (less than 1mm) can be visualised during laparoscopy despite being very difficult to detect via traditional diagnostic methods (Richter 2001). While ultrasonography is used commonly for imaging of most intra-abdominal masses, laparoscopy does confer the advantage of direct visual examination of masses and for visually guided biopsies (Magne 1995).

Reproductive Evaluation
Laparoscopy has been used to assess reproductive function in the bitch including ovarian changes (Wildt et al 1977a, Wildt et al 1977b, Wildt et al 1978, Wildt et al 1979, Wildt et al 1981b), and is reportedly useful for the examination of ovaries, the uterus, the pelvic vagina and for the detection of pathological lesions (Seager 1990, Wildt et al 1978). Applications, which may be superior to alternate techniques such as ultrasonography, have been investigated (Seager 1990) and include internal visual reproductive tract examination, collection of reproductive tract fluids and secretions, aspiration of ovarian follicular fluids and cysts, insemination of sperm directly into the uterus, uterine horn or oviduct and collection of ova by follicular aspiration. Additionally, intra-uterine insemination in the bitch has been performed with successful results (Silva et al 1995, Silva & Verstegen 1995). Although useful for detecting morphological ovarian changes, it does not allow precise determination of the time of ovulation (Silva et al 1996). Laparoscopic methods of male and female sterilisation are described later.
Ultrasound Assisted Diagnostics

The advent of high frequency ultrasonographic probes designed to be introduced into the peritoneal cavity, enables operators to overcome the inability to assess the internal structure of organs during diagnostic and surgical laparoscopy (Penninck & Finn-Bodner 1998, Sanchez-Margallo et al 2003, Spinella et al 2006). Laparoscopic ultrasonography (LU), via a microconvex transducer located at the tip of a rigid probe, allows core biopsy or needle aspiration to be performed by guiding the needle into non-superficial lesions, where video endoscopic guidance alone is not sufficient (Spinella et al 2006). Six dogs underwent pre-surgical ultrasound examination followed by LU which aided in obtaining biopsies from three of the dogs with focal intraparenchymal anechoic areas in the liver. One dog had an inhomogenous hypoechogenic mass cranio-medial to the right kidney and two dogs had vascularised masses. In the two dogs, where post-biopsy haemoperitoneum was considered a high risk, LU allowed the needle to be guided into the neoplastic tissue avoiding the vascular lacunae (Spinella et al 2006). Additionally, LU permitted comparison between surface findings discovered by laparoscopy and the sonographic structural examination of the parenchyma (Spinella et al 2006). In a study evaluating changes in characteristics of the gastroduodenal junction, during pyloroplasty performed laparoscopically, the authors found LU effective for morphological evaluation of the pyloric sphincter. With the addition of colour Doppler, it was useful for differentiating the common bile duct from the right gastric artery in clinically normal dogs (Sanchez-Margallo et al 2003).

Lymphangiography and Thoracoscopic Thoracic Duct Ligation

Mesenteric lymphangiography, via a laparoscopic approach, was successfully performed in two of five dogs (Brisson et al 2006) and could be combined with...
Numerous laparoscopic methods of female sterilisation have been described in the literature (Wildt, 1985, Minami et al, 1997, Dharmaceelan et al, 2000, Austin et al, 2003, Hamdane et al, 2003, Davidson et al, 2004, Devitt et al, 2005, Hancock et al, 2005) however they have not been widely adopted by veterinarians, due to the cost and complexity of laparoscopic equipment, the difficulty in mastering laparoscopic technique, the knowledge about the benefits. Laparoscopic ovariohysterectomy (OVH) can be performed as a complete laparoscopic procedure or via a laparoscopic-assisted approach. Laparoscopic-assisted OVH (LAOVH) techniques are able to maintain the minimally invasive attributes of laparoscopic technique while incorporating extracorporeal techniques to improve the efficiency of more complex procedures (Minami et al, 1997, Davidson et al, 2004, Devitt et al, 2005). Ovariectomy can also be completed laparoscopically (Dharmaceelan et al, 2000, Hamdane et al, 2003, Van Goethem et al, 2003, Van Nimwegen et al, 2005) and is being promoted as a relatively rapid, minimally invasive approach providing excellent observation of the genitalia and tract and other visceral areas (Van Goethem et al, 2003).

**Gastropexy**

Gastropexy is commonly indicated as a prophylactic procedure in large breed dogs that are susceptible to gastric dilation-volvulus (GDV). Laparoscopic techniques for gastropexy (Fig 10) are aimed at circumventing the drawbacks of a laparotomy. A variety of laparoscopic gastropexy techniques have been described in the literature (Thompson et al, 1992, Hardie et al, 1996, Wilson et al, 1996, Rawlings et al, 2001, Rawlings, 2002, Rawlings et al, 2002c). Additionally, two incidents of laparoscopic-assisted de-rotation of the stomach and incisional gastropexy have been reported (Rawlings et al, 2002c). Wilson et al (1996) compared laparoscopic and standard belt-loop gastropexy techniques in eight dogs, randomly divided into two groups of four, and found no statistical differences between biomechanical strength and surgical duration. In another study in which 14 dogs underwent laparoscopic stapled gastropexy (LG) and six dogs underwent incisional gastropexy (IG), the IG adhesions were found to be significantly stronger than the LG adhesions at seven days but at 30 days after surgery, the strength of the LG and IG adhesions were statistically equal (Hardie et al, 1996). The maximum tensile strength required for a permanent gastropexy is unknown (Levine & Caywood, 1983, Fox et al, 1985). Multiple breaking strengths of different gastropexy techniques have been documented (Table 1). These in vitro strengths demonstrate the adhesions produced by laparoscopic techniques are of similar strength to open gastropexy techniques.

Although laparoscopic correction of GDV in clinically affected dogs has been reported, the authors stipulated careful selection criteria. These included the ability to pass a stomach tube to ensure gastric deflation, lack of intra-gastric haemorrhage, as determined by the gastric contents, and haemodynamic stability after fluid resuscitation (Rawlings et al, 2002c). Prophylactic laparoscopic-assisted gastropexy can feasibly be combined with laparoscopic ovariohysterectomy (Rawlings et al, 2002c).

**Cryptorchid surgery**

Multiple techniques for laparoscopic detection and removal of cryptorchid testicles (Fig 11) have been described (Gallagher et al, 1992, Spinella et al, 2003, Miller et al, 2004, Catone et al, 2005, Lew et al, 2005). Laparoscopy has also been used in the removal of a seminoma in a cryptorchid dog (Pena et al, 1998).

<table>
<thead>
<tr>
<th><strong>Gastropexy technique</strong></th>
<th><strong>Open or laparoscopic</strong></th>
<th><strong>Assessment (days after surgery)</strong></th>
<th><strong>Breaking strength – mean ±SD (Newtons)</strong></th>
<th><strong>Investigator</strong></th>
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<tbody>
<tr>
<td>Incisional</td>
<td>Open</td>
<td>21</td>
<td>60*</td>
<td>Fox et al (1985)</td>
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<tr>
<td>Incisional</td>
<td>Open</td>
<td>58</td>
<td>61.98 ± 14.65</td>
<td>Waschak et al (1997)</td>
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<tr>
<td>Laparoscopic stapled</td>
<td>Laparoscopic</td>
<td>30</td>
<td>72.93 ± 18.01</td>
<td>Hardie et al (1996)</td>
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<tr>
<td>Laparoscopic</td>
<td>Laparoscopic</td>
<td>50</td>
<td>76.55 ± 22.78</td>
<td>Wilson et al (1996)</td>
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<tr>
<td>Laparoscopic-assisted</td>
<td>Laparoscopic</td>
<td>30</td>
<td>106.5 ± 45.6</td>
<td>Rawlings et al (2001)</td>
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<tr>
<td>Circumcostal</td>
<td>Open</td>
<td>21</td>
<td>109*</td>
<td>Fox et al (1985)</td>
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**TABLE 1**: Comparison of open and laparoscopic gastropexy techniques with regards to the breaking strength at time of assessment. *SD not available.

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**SURGICAL TECHNIQUES**

**Ovariohysterectomy and ovarioectomy**

Numerous laparoscopic methods of female sterilisation have been described in the literature (Wildt & Lawler, 1985, Minami et al, 1997, Dharmaceelan et al, 2000, Austin et al, 2003, Hamdane et al, 2003, Davidson et al, 2004, Devitt et al, 2005, Hancock et al, 2005) however they have not been widely adopted by veterinarians, due to the cost and complexity of laparoscopic equipment, the difficulty in mastering laparoscopic technique, the knowledge about the benefits. Laparoscopic ovariohysterectomy (OVH) can be performed as a complete laparoscopic procedure or via a laparoscopic-assisted approach. Laparoscopic-assisted OVH (LAOVH) techniques are able to maintain the minimally invasive attributes of laparoscopic technique while incorporating extracorporeal techniques to improve the efficiency of more complex procedures (Minami et al, 1997, Davidson et al, 2004, Devitt et al, 2005). Ovariectomy can also be completed laparoscopically (Dharmaceelan et al, 2000, Hamdane et al, 2003, Van Goethem et al, 2003, Van Nimwegen et al, 2005) and is being promoted as a relatively rapid, minimally invasive approach providing excellent observation of the genitalia and tract and other visceral areas (Van Goethem et al, 2003).

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Laparoscopy offers two important advantages in animals with non descended testes: insertion of the laparoscope permits rapid exploration of the inguinal ring, to determine if the testicle has exited the abdomen, thereby enabling exploration to be limited to the inguinal region (if it has) and secondarily in animals with intra-abdominal testes it offers excellent visibility of ligation with endoscopic ligating clips and transection of implants (Gallagher 2005). Also described was a laparoscopic-assisted technique which involves exteriorisation of the testicle and ligation externally, which simplifies ligation of the testicular vasculature and ductus deferens as well as forgoing the need for intra-corporeal ligation (Miller et al 2004). Other techniques include: intra-corporeal ligation with endoscopic ligating clips and transection of the vessels and the vas deferens between the ligation implants (Gallagher et al 1992, Spinella et al 2003) and applying a manual knot of absorbable material (Lew et al 2005). All of the intra-corporeal ligation techniques described involve the use of an extraction bag in which to place the testicles prior to removal (Gallagher et al 1992, Spinella et al 2003, Lew et al 2005). A report of 15 cases of laparoscopic cryptorchidectomy with intra-corporeal ligation detailed an average surgery time of about 15min, with the shortest procedure lasting 11min (unilateral) and the longest, 28min (bilateral). An extraction bag was used when the observed testes was enlarged, in order to restrict contact of possible neoplastic material with tissues of the abdominal wall (Lew et al 2005). A novel cryptorchidectomy technique forgoing abdominal insufflation in 10 dogs has been discussed which used a Y-shaped, abdominal wall, lifting device inserted in the abdominal cavity, through a 20mm incision, to complete a gasless, hand-assisted laparoscopic cryptorchidectomy (Catone et al 2005). Laparoscopic techniques of male sterilisation via disruption of a fragment of the ductus deferens have also been described (Silva et al 1993, Wildt et al 1981a).

A case of laparoscopic deferentopexy has been reported in the management of a male dog with refractory incompetence of the urethral sphincter mechanism (USMI) (Salomon et al 2002). The procedure improved the dog’s clinical status, but some nocturnal, passive urine leakage persisted one month after surgery. When combined with the alpha-adrenergic drug, phenylpropanolamine, the incontinence resolved. The author commented that the laparoscopic procedure can be easily performed with low morbidity and high efficacy and is a simple, safe and quick technique.

Cystotomy

Cystotomy has been used to prevent retro-flexion of the urinary bladder in male dogs with a perineal hernia (Huber et al 1997) and in female dogs with a pelvic bladder as a treatment of USMI (Massat et al 1993, White 2001). Eight male and seven female dogs were used to develop a technique for laparoscopic-assisted cystotomy which was subsequently performed in three client-owned dogs with retro-flexion of the bladder (Rawlings et al 2002b). All dogs were noted to have recovered rapidly after the cystotomy and were able to void urine normally. All of the dogs (except for one female) were euthanised within 30 days after surgery and mechanical load testing was performed on the tissues. The mean ±SD (Newtons) of the failing load was 89.8 ±77.9 N which, on review of gastropexy load data, indicate a dependable pexy strength. No cystotomy load data exist in the literature. In two of the three clinical cases, both dogs had no recurrences and normal urine voiding at nine and 10 months post-operatively. One dog was euthanised 11 days after surgery due to complications arising from leakage at a colopexy site, which was performed at the same time as the cystotomy.

For cystic calculi too large for removal by urohydropropulsion and not amendable to medical dissolution, surgery has been recommended (Waldron 2003). Laparoscopic-assisted cystotomy provides a minimally invasive alternative for removal of urinary calculi and is reported an easy procedure to perform. It also limits injury to tissues that may be caused by an open laparotomy and cystotomy as well as potentially reducing urine contamination of the peritoneal cavity (Rawlings et al 2003b). According to the authors’ knowledge no comparative evaluation of cystostomy techniques exists.

Feeding Tubes

Duodenostomy and jejunostomy feeding tubes can be placed by exteriorising a segment of intestine through the abdominal wall via a laparoscope and securing the tube externally (Rawlings et al 2002a, Hewitt et al 2004). Reported complication rates of the procedure are low and associated complications were mild and non-life threatening. In an experimental case series, laparoscopic-assisted, jejunal tube placement was completed in 10 dogs and via a traditional coeliotomy approach in five dogs. Reportedly the minor complications rates were not significantly different between groups (Hewitt et al 2004). In an experimental case series of eight male dogs undergoing laparoscopic-assisted enterostomy tube placement no post-operative complications were detected (Rawlings et al 2002a).

Porto-systemic Shunt Attenuation

Laparoscopic porto-systemic shunt attenuation has been successfully performed in a clinical setting (Miller & Fowler 2006). Two dogs with extrahepatic portocaval vessels were confirmed using laparoscopic visualisation and attenuated with laparoscopically placed cellophane bands (Miller & Fowler 2006). Both dogs had minimal post-operative morbidity and biochemical evidence of adequate shunt ligation was present at follow-up examination (Miller & Fowler 2006). This result demonstrates that further evaluation of laparoscopy for identifying and banding portozygous and intra-hepatic vessels are warranted (Miller & Fowler 2006).

Splenectomy

Successful laparoscopic splenectomy has been reported in two canine and five porcine models utilising four-to-seven trochars (Thibault et al 1992). The reported surgeries took an average of 1hr 50min and did not require an open conversion (Thibault et al 1992). All animals were euthanised at the completion of the surgery (Thibault et al 1992). While this human clinical report did not describe the canine procedure in detail, it does support further investigation into the feasibility of this operation in a practical setting (Thibault et al 1992).
Pyloric Surgery
Different laparoscopic pyloric surgery techniques have been trialled in dogs: Ramstedt pyloromyotomy (n=5) (Sanchez-Margallo et al 2005); Heineke-Mikulicz (n=5) (Sanchez-Margallo et al 2005) and Finney Pyloroplasty (n=6) (Sanchez-Margallo et al 2007). The technique was found to be technically feasible and was performed without complication. Laparoscopic pyloric surgery was found to be as effective as open surgery in reducing gastric emptying times in a study of 20 clinically normal dogs without surgical complication (Sanchez-Margallo et al 2005).

End-to-end Intestinal Anastomosis
Successful laparoscopic end-to-end intestinal anastomosis has been reported in 50 dogs and 30 pigs with only one reported complication (Bohm et al 1993). Laparoscopic oncological right colectomy, with intra-peritoneal ileocolic anastomosis, was performed in 21 dogs without any major intra-operative complications (Bohm et al 1995b).

Other Procedures
Other laparoscopic procedures have been described: laparoscopic cholecystectomy is now considered a routine therapy in humans (Chin 1996) and has been demonstrated in canine models (Moscovici et al 1988, Bass et al 1994, Zografakis et al 2003); canine laparoscopic liver resection (Machado et al 2004, Frezza & Wachtel 2006); cryoablation for treatment of renal tumours (Stephenson et al 1996); distal pancreatectomy (Naitoh et al 2002); and laparoscopic assisted end-on Jeyunostomy for faecal diversion (Chandler et al 2005).

CONTRAINDICATIONS
Laparoscopy has a wide range of indications in the healthy animal and in debilitated animals, as procedures can be completed with minimal sedation. However, laparoscopy has both relative and absolute contraindications in some disease states (Table 2).

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Laparoscopy is a minimally invasive technique as each incision only needs to be large enough to insert an instrument port and in doing so results in a marked reduction in risk of surgical wound dehiscence and eventration. The relative risk of eventration from a 1cm laparoscopic incision compared to a 10-15cm laparotomy is significantly lower.

A reduction in post-operative pain has been touted as a great benefit of laparoscopic procedures but has not been extensively investigated in the veterinary literature. A few comparative studies of laparoscopic and traditional OVH have been reported. Hancock et al (2005) compared post-operative pain after OVH by harmonic scalpel4 assisted laparoscopic OVH (HALO) (n=8) and OVH via median celiotomy and ligation (n=8). In a blinded assessment they found that HALO dogs exhibited less pain according to the University of Melbourne Pain Scores (UMPS) than the traditional approach. No significant differences were observed between groups for heart rate, respiratory rate, temperature or for CPK and glucose concentrations. However, the traditional group had significantly higher mean UMPS than the HALO group at all post-operative times (2, 6, 12, 24, 48, and 72hr). Also, the HALO group tolerated significantly higher palpation pressures when assessing the mean nociceptive threshold measurements during all time periods except at 72hr. Another comparison between open (n=18) and laparoscopic OVH (n=16) (Davidson et al 2004) found significantly lower pain scores (2 of 10 subjective categories; 8 of 10 objective categories – UMPS) associated with laparoscopic OVH when compared to the traditional approach at one or more post-operative time periods (2, 8 and 24hr). A comparison between open OVH (n=10) and LAOVH (n=10) by Devitt et al (2005) discovered pain scores for the traditional OVH were higher at all time intervals than for the LAOVH (pain system based on quantitative changes in physiologically parameters and behavioural changes). Based on post-operative pain scores (maximum score attainable was 19), nine out of 10 dogs from the traditional approach required additional pain relief compared with none of the dogs from the LAOVH group (additional pain relief was indicated when any pain score reached greater than or equal to six). Further investigation of post-operative pain, following a broad range of laparoscopic procedures, is indicated to confirm the post-operative pain benefits.

Laparoscopic handling of tissues has been suggested to

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result in less tissue trauma and less intra-abdominal contamination than with open procedures, giving rise to many claims that laparoscopy reduces the incidence of post-operative adhesions in people (Gutt et al. 2004). Abdominal adhesion formation in humans is reportedly associated with bowel obstructions, infertility and chronic abdominal pain (Schippers et al. 1998, Gamal et al. 2001, Gutt et al. 2004) and impedes surgical re-entry. A review of 15 clinical and experimental studies comparing surgery via laparoscopy and laparotomy found a reduction in adhesion formation after laparoscopic surgery (Gutt et al. 2004). This conclusion was drawn from a “preponderance of evidence, rather than a systematic analysis” as a meta-analysis was impossible to conduct due to the variability of the studies in regard to the design, animal model and adhesion scoring system (Gutt et al. 2004). This result supports the safety of surgical re-entry following laparoscopy (Gutt et al. 2004) and the finding that laparoscopic procedures can be repeated frequently (Wildt 1980).

Human clinical observations following laparoscopic surgery indicate a shorter period of post-operative ileus, than after conventional surgery, as a result of less induced abdominal trauma. In an attempt to objectively assess this hypothesis, numerous studies have compared post-operative gastrointestinal motility following open and laparoscopic cholecystectomy (Ludwig et al. 1993, Schippers et al. 1993, Titel et al. 1995, Hotokczaka et al. 1996a), colonic resection (Bohm et al. 1995a, Hotokezaka et al. 1996b, Carlson & Frantzides 1997; Davies et al. 1997, Titel et al. 2001) and distal pancreatectomy (Naitoh et al. 2002). Assessing the electromyographic activity of the gastrointestinal tract or transit of radionuclide spheres several studies support the claim of reduced post-operative “physiological ileus” (Schippers et al. 1993, Bohm et al. 1995a, Titel et al. 1995, Hotokczaka et al. 1996b, Davies et al. 1997, Titel et al. 2001, Naitoh et al. 2002). However, other studies’ conclusions were in direct contrast, finding no significant difference in post-operative gastrointestinal electromyographic activity after laparoscopic and conventional surgery (Ludwig et al. 1993, Carlson & Frantzides 1997, Titel et al. 2001). The disagreement between these studies demonstrates the limitations of clinical parameters to adequately define supposed benefits and there is demand for alternate techniques to comparatively assess gastric motility between approaches.

Increased peri toneal CO₂ pressure has been shown to reduce bleeding time following spleenic capsule injury (Papp et al. 2003) suggesting that it may enhance spontaneous haemostasis during laparoscopy with a pressurised pneumoperitoneum.

Laparoscopic procedures are believed to result in a reduced surgical stress response when compared to the traditional open approaches. The biochemical stress response was evaluated in 35 dogs undergoing laparoscopic (n=12) and open surgical nephrectomy (n=12) against an open surgery sham (n=6) and pneumoperitoneum only (n=5) (Marcovich et al. 2001). Serum concentrations of cortisol and glucose were chosen as the biochemical stress markers as they are reportedly more accurate than subjective assessments.

However, the serum glucose concentrations showed no significant pattern of variability and were omitted from the results (Marcovich et al. 2001). It was concluded that “cortisol concentrations were consistently higher at the time of skin closure in animals that underwent laparoscopic nephrectomy than in those that had open surgery; but overall, cortisol decreased significantly more rapidly in the laparoscopic group than in the open surgery group” (Marcovich et al. 2001). Whether this rise in cortisol in the laparoscopic groups is attributed to noxious stimulus or is an indirect result of hypercarbia is unknown and as such the significance of these results is difficult to interpret. Laparoscopic and conventional distal pancreatectomies were performed and compared in a group of 10 randomly assigned dogs. Serum cortisol levels were found to rapidly return to normal at 8hr after the trauma onset in the laparoscopic group while remaining significantly higher in the traditional group (Naitoh et al. 2002). However, the peak cortisol levels (at 4hr) were not different between the groups. In the same study, interleukin-1 levels were found to be significantly higher in the conventional group when compared to the laparoscopic approach (Naitoh et al. 2002). In the previously discussed laparoscopic ovariohysterectomy versus OVH study by Devitt et al (2005), the OVH group had significantly higher plasma cortisol concentrations at one and 2hr post-extubation. Although many would dispute the clinical significance of currently employed measures of biochemical stress, current evidence demonstrates a lower biochemical stress response of laparoscopic over open procedures.

DISADVANTAGES

Costs

Costs are repeatedly put forward as a pertinent hurdle to the adoption of new technology however the potential for inward financial return also exists. The purchased equipment is not limited to laparoscopy but can also be used in thoracoscopy, rhinoscopy, cystoscopy and otoscopy. Expert opinion suggests that thoracoscopy and laparoscopy are very similar in technique, instrumentation requirements and basic indications and that thorascopic procedures are easier to perform (McCarthy 1999). Additionally, second-hand equipment can be sourced through hospital sales or surgical equipment companies.

Times

Surgical time is a pressing issue for clinicians. A comparison between traditional and laparoscopic methods is best achieved when investigating methods of female sterilisation as these are amongst the most common laparoscopic techniques practised and is the area of research where the most information is available. Harmonic scalpel-assisted LOVH means surgical time (55.7min) was significantly longer than the traditional OVH (31.7min) (Hancock et al. 2005). Mean surgical time for LOVH (120min; range, 47-175min) was significantly longer than for OVH (69min; range, 25-140min) (Davidson et al. 2004). The authors of this study believe that LOVH can routinely be performed in less than 1hr with experience (Davidson et al. 2004). Mean ± SD duration of surgery (initiation of pneumoperitoneum to final skin suture) for LAOVH (20.8 ± 4.0min) was not significantly longer than the traditional OVH (18.6 ±
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3.9min) (Devitt et al 2005). Three alternative techniques of laparoscopic ovarioectomy were compared and the mean time to complete the surgical procedure with each technique were 60.16 ± 1.64 min, 42.83 ± 1.40 min and 71.83 ± 1.62min (Dharmaceelan et al 2000). These results are similar to the laparoscopic ovarioectomy times of laser-assisted OVE (36.9 ± 9.7min) and bipolar-electrocoagulation OVE (39.3 ± 9.6min) (Van Nimwegen et al 2005). A comparison between mono-polar (MEC) and bipolar electrocoagulation (BEC) techniques found the surgical time for MEC-OVE to be (52.7 ± 14min) and for BEC-OVE (40.8 ± 10min) (Van Goethem et al 2003). Although laparoscopic OVH and OVE techniques do reportedly take longer than the traditional procedures, the purported benefits and potential for improvement with experience support expansion to non routine procedures. It also serves to positively demonstrate veterinary surgeons’ attitude towards surgical progression and providing best practice care.

Training

The need for extensive training is also another perceived drawback of the technique. Training is definitely a necessity as the dexterity and haptic feedback required for instrument manipulation is unlike traditional surgical techniques. It is also important that trainees understand the physiology of, and access to, the pneumoperitoneum (Clavien et al 2005). There are no reported case numbers or training hours that correlate with operator proficiency. However, it is logical that surgeons master basic laparoscopic procedures (e.g. diagnostic laparoscopy) earlier in their training rather than advanced laparoscopic techniques. It may be suggested then, that by completing the former, surgeons can simultaneously provide income and training for the latter. Laparoscopic training techniques have been addressed in the literature (van Velthoven & Hoffmann 2006, Clavien et al 2005). Outside of the operating room, training can be completed on animate (cadavers) specimens or purpose built inanimate laboratories. Inanimate laboratories encompass video trainers; an opaque box with trocars allowing access to the interior wherein various physical materials can be manipulated in specific exercises (Clavien et al 2005) and virtual reality. Training facilities can be accessed in human hospitals and in medical university facilities.

Limitations

The inherent limitations of the equipment are that only a two dimensional image is provided, the laparoscopic port acting as a fulcrum (which restricts movement of the instruments) and only a restricted sense of tactile sensation is obtained (Richter 2001). While all of these are concerns, they are generally features that are overcome through experience.

COMPLICATIONS ATTRIBUTED TO THE SURGICAL PROCEDURE

Laparoscopy is no different to any other surgical procedure in that standard surgical complications occur. In addition to the standard set of surgical complications, reported laparoscopic complications are associated with gas embolisation, visceral perforation, gastrointestinal effects and the secondary impacts on the cardio-pulmonary system. The specific complications of establishing and maintaining a pneumoperitoneum and obtaining biopsy specimens include: subcutaneous emphysema; omental emphysema; abdominal or diaphragmatic rupture secondary to over-distension; viscous perforation; solid organ trauma; and haemorrhage following biopsy (McCarthy 2005).

Fatal air embolism is described as a complication of peritoneal insufflation in the dog (Gilroy & Anson 1987, Dion et al 1995). An experimental study was performed in five dogs in which the potential for CO2 embolisation from a 1cm infra-renal vena cava (IVC) laceration was evaluated against the effect produced by CO2 bolus injections into the jugular vein. In a total of 11 insults to the IVC under CO2 pneumoperitoneum of 12-15mmHg, no major hemodynamic effects were detected (ie. no significant elevation of the pulmonary arterial pressure) (Dion et al 1995). Air bubbles, as detected via transoesophageal echocardiography, were detected in the right heart cavities in only two of the insults (Dion et al 1995). While the results of this study suggest that fatal gas embolisation does not result from a large venotomy, caution should still be exerted when laparoscopic surgery is performed near large veins. A single case report described almost immediate cardiopulmonary arrest following inadvertent Veress needle puncture of the spleen (Gilroy & Anson 1987). At necropsy, fatal air embolism was the confirmed method of death as three 1cm bullae were found in the lungs and numerous air bubbles and crepitice throughout the spleen were present (Gilroy & Anson 1987). Carbon dioxide embolisation during laparoscopy is a recognised and potentially fatal complication and a large prospective case series, investigating air embolisation during a range of procedures, is required to truly quantify the risk.

A rapid reduction of jejunal blood flow was detected by laser-doppler flowmetry and a tonometric catheter leading to the conclusion that laparoscopy should be avoided where intestinal ischaemia is present until further research is completed (Kotzampassi et al 1993). The cardiovascular and respiratory effects of maintaining a pneumoperitoneum are a new challenge for practitioners to overcome. Many factors contribute to the circulatory instability during laparoscopy, the most important one being raised IAP (Kotzampassi et al 1993). The severity of cardiopulmonary disturbance is exacerbated at raised IAP and metabolic effects are influenced by the gas type used. It has been suggested that respiratory minute volume is decreased by 30% with peritoneal insufflation during laparoscopy (Jones et al 1985) while cardiac output is decreased by more than 40% in dogs with IAP between 20 to 40mmHg (Ivankovich et al 1975). Insufflation pressure may increase cranial movement in the diaphragm, mechanically compressing the lungs and further reducing functional residual capacity and lung compliance (Gross et al 1993). Elevated IAP may provoke an increase in systemic vascular resistance (Kotzampassi et al 1993). An abundance of literature focusing on the cardiopulmonary effects of establishing a pneumoperitoneum exists but central to the issue is the recommendation that appropriate methods of monitoring anaesthesia be considered throughout laparoscopic...
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procedures. It has been recommended that a capnograph is a reasonable monitoring method for CO₂ and the physiological effects of hypercarbia, in medium sized dogs without cardiopulmonary disease, but arterial blood gas analysis may need to be performed in critical patients to better monitor for hypercarbia (Duke et al 1996).

CONCLUSION

Laparoscopy is a rapidly developing field of veterinary science that provides a minimally invasive approach to a wide variety of diagnostic and surgical procedures. Laparoscopy enables the procurement of abdominal biopsy specimens from a comprehensive range of organs and is associated with a high diagnostic yield, when compared with other minimally invasive techniques. Laparoscopy is used in abdominal tumour staging, reproductive evaluation and in combination with other diagnostic techniques. Surgical procedures including OLV, OVE, gastrectomy, cryptorchid removal, cystoscopy, placement of feeding tubes and porto-systemic shunt attenuation are just some of the procedures completed in dogs in a clinical setting. A broader range of surgical procedures has been completed in research models and provides scope for the development of advanced procedures. The list of procedural contraindications is small and the advantages of the technique are easy to overcome with experience. The advantages include: reduced patient morbidity, reduced biochemical stress response and reduced post-operative pain response, less tissue trauma and subsequent less adhesion formation, as well as a potential for the reduction in post-operative ileus. In the majority of patients surgical complications do not preclude laparoscopic procedures and are avoidable when the correct technique is employed. Laparoscopy represents a major advancement in veterinary science and demonstrates a forward thinking approach to patient care.

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Cats and their catch

Should the ASAVA, the AVA group representative of small animals, also be instrumental in helping to create a system for the control of feral cats and to be seen to be influential in and supportive of that process? Their documented species catch now includes 186 native birds, 64 mammals, 87 reptiles and 10 frogs. Refuges, with exclusive fencing and selective shooting, seem to be the only way to make natural areas free of feral cats.