**Through the keyhole: Veterinary Laparoscopy**

Small animal minimally invasive surgical (MIS) techniques conventionally included multiport laparoscopy and video-assisted thoracoscopic surgery (VATS)\(^1\)\(^-\)\(^2\). More recently, single-port approach devices and natural orifice transluminal endosurgery (NOTES) have been described\(^1\)\(^-\)\(^3\). Whilst the more advanced techniques, especially robotics, are rarely available for veterinary patients largely due to technical challenges and the prohibitive cost of some instrumentation and single use disposable components, veterinary MIS is advancing rapidly and small animal patients can benefit from the documented advantages of these increasingly used procedures\(^1\)\(^-\)\(^4\). These can include shorter hospitalisation time, reduced postoperative pain\(^5\), lower postoperative levels of inflammatory mediators\(^6\), quicker return to function\(^7\), improved visualisation of certain structures and reduced surgical site infection rates\(^8\), although it should be recognised that findings between studies can be inconsistent\(^1\). It is generally accepted that the surgeries take longer\(^3\)\(^,\)\(^9\) and there is, as for many surgical procedures, an initial learning curve to achieve proficiency\(^19\)\(^-\)\(^20\). Skills training, using different instrument designs and surgeon video gaming proficiency can improve performance\(^22\)\(^-\)\(^22\).

**Equipment**

Laparoscopic kit includes:

- The telescope (or endoscope), which attaches to a video camera head and light guide cable. We generally use a 5mm diameter 0° telescope (i.e. it looks directly forwards). 30° telescopes can be useful to improve the field of view around viscera and allow the surgeon to look down onto a point of interest e.g. when tying intracorporeal sutures.

- The tower, which consists of the light source, camera unit, monitor and CO\(_2\) insufflator. High definition cameras and monitors provide exceptional quality images. Newer technology can perform real-time endoscopic fluorescent imaging by emitting and receiving different wavelengths of light. This will allow us to identify tissue with increased perfusion (inflammation and neoplasia) intra-operatively when resecting a mass and identify lymphatic chains to determine which local lymph nodes are most appropriate to remove for oncological staging and possible therapeutic benefit. 3D cameras are also now available.

- Cannulae (with trochars) through which the ‘scope and instruments access the abdominal cavity. Cannulae may be threaded or smooth depending on surgeon preference and the intended use of the portal. They generally contain some device to maintain an airtight seal when used for laparoscopy.

- Surgical instrumentation to manipulate organs (e.g. blunt probe, various forceps, fan retractors), ligating clip applicators and staplers, ligating ligature loops, electrosurgical ligating and dividing instruments, needle holders, scissors, knot pushers, suction irrigation devices and retrieval bags.

- Miscellaneous instrumentation, such as single incision access devices and multiport cannulae.
Laparoscopic techniques

Currently recognised techniques can be broadly categorised into:

- **Multiple port laparoscopy**

  Three or four portal laparoscopy is most commonly performed, although some procedures such as ovarietomy can be performed with a two portal technique that may be associated with reduced patient morbidity and can be quicker than open surgery. For patients having a procedure whilst positioned in dorsal recumbency, the portals can be placed directly along the midline or triangulated at approximately 60° to each other to allow appropriate working space to visualise and manipulate tissue. Other procedures may be better performed in lateral or even sternal recumbency. Changing the position of a patient during the procedure is often necessary to appropriately visualise structures.

- **Single incision laparoscopic procedures**

  A single incision is made and either a multiple lumen port or specially designed wound retractor is used to gain access to the abdominal contents. Use of angled instrumentation facilitate the use of multiple port cannulae helping to prevent instrument clashing. Low tech alternatives using rubber gloves and instruments placed through the fingers are possible.

- **Laparoscopically assisted procedures**

  This means that a laparoscope is used to explore the abdomen and identify structures, but then the target organ is either exposed at the portal site, which is enlarged to a small incision, or exteriorised for a procedure to be performed in a more conventional manner. This can include lap-assisted cystotomy, urolith retrieval procedures, ovariohysterectomy and intestinal surgery (such as enterotomy / enterectomy).

- **Natural orifice transluminal endoscopic surgery (NOTES)**

  This technique gains access to the abdomen via natural orifices (e.g. down the oesophagus and through the stomach wall or through the vaginal wall). Whilst the cosmetic benefits of this are considerable in people, I think that the value for veterinary patients is limited and the procedures can be lengthy, complex and awkward.
complication resulting from use of a Veress needle is very low and can be minimised using a right 9\(^{th}\) intercostal entry site\(^{34,35}\).

**Commonly performed laparoscopic procedures in small animals**

I recommend the new ‘Small Animal Laparoscopy and Thoracoscopy’\(^2\) textbook and a recent review paper\(^1\) for excellent summaries of the currently performed small animal laparoscopic procedures. The most commonly performed of these in our hospital include:

- **Diagnostic laparoscopy**

  We perform a considerable number of exploratory laparoscopy procedures, and have matched the price of laparoscopically retrieved liver biopsy and gall bladder aspiration with that of ultrasound guided samples to encourage the uptake of this service. We are therefore able to offer the advantage of a visual inspection of the abdominal cavity free of charge (at the time of writing). Other organs which can be biopsied include neoplastic masses, the pancreas (using a particular type of cup forcep), the kidneys (by guiding a Tru-cut needle)\(^1,37\) and recently extirpation of sublumbar lymph nodes has been described\(^38\) (additional biopsies increase the fee).

- **Laparoscopic and laparoscopically-assisted -pexy procedures**

  These include gastropexy\(^9,39\), cystopexy\(^40\) and colopexy\(^41\). We can also place gastrostomy and cystostomy\(^19\) tubes using a laparoscopic technique, but feel that there is little benefit compared to a minimal surgical approach to place the tube and pexy the organ into the short incision. Gastropexy performed using intracorporeal suturing can be facilitated using self-anchoring sutures\(^39\), which have been shown to create secure in-vitro attachments\(^42\), and are quicker to place than standard intracorporeal sutures. Adequate needle bites must be ensured before pulling the suture through the tissue since ‘unlacing’ the suture is not possible.

- **Routine neutering (ovariectomy), ovariohysterectomy for disease\(^30\) (pyometra/neoplasia), ovarian remnant syndrome\(^43\) and cryptorchidectomy\(^44-45\)**

  We routinely perform ovariectomy laparoscopically using a bipolar tissue sealing device (ENSEAL; Ethicon) or an ultrasonic cutting and coapting device (harmonic ACE; Ethicon) using a two-port technique. We have a fixed fee of £350 incl. VAT for this service and discharge animals on the same day of surgery.

- **Percutaneous cystolithotomy\(^28\)**

  We prefer this technique compared to laparoscopic cystotomy\(^19\) where the bladder is sutured into the incision, since it is less time consuming, has an excellent outcome with consistent removal of all cystoliths and offers the advantage of a minimal approach compared with conventional surgery. The bladder is elevated to a small midline incision and a cannula inserted through the bladder wall. The ‘scope and retrieval instruments can then be placed directly into the bladder.
Where are we going?

Uncommonly performed procedures

There are several procedures that are less commonly performed, either due to their complexity or because there are important restrictions on when they can be used:

- **Splenectomy**\(^{1,2, 46}\)
  
  Massive splenomegaly, significant haemabdomen with on-going haemorrhage or uncorrected coagulopathy may limit this procedure to smaller masses or to treatment of immune mediated haemolytic anaemia or thrombocytopenia (although this is not an exhaustive list)\(^2\).

- **Cholecystectomy**\(^{1,2, 47}\)
  
  The presence of bile peritonitis or extrahepatic biliary obstruction rules out laparoscopic surgery in many patients. Uncomplicated mucocoele and cholelithiasis without choledochal stones can be treated with this procedure, although it is still somewhat controversial whether non-symptomatic incidentally diagnosed mucocoeles require surgical intervention.

- **Adrenalectomy**\(^{1,2, 25-27, (REF)}\)
  
  Appropriate patient selection is vitally important, probably limiting laparoscopic adrenalectomy to tumours smaller than approximately 4-5cm that do not invade the caudal vena cava (preferably confirmed using dual phase CT angiography). The left adrenal is further caudal and not so obscured by the liver, although it can be closely associated with the aorta. The right adrenal is more difficult to access and closely associated with the caudal vena cava. Positioning dogs in sternal recumbency with the abdomen dependent (supports under the chest and the pelvis) may help improve visualisation\(^27\).

- **Ureteronephrectomy and nephrolith removal**\(^{1,2, 48}\)
  
  Renal masses or hydronephrosis are often diagnosed when the kidney is large, with the disease relatively advanced and therefore challenging to remove laparoscopically. Retroperitoneal and capsular haemorrhage can be problematic even for small or benign tumours due to increase in local vascularity. Marked hydronephrosis or hydroureter will likely require conversion. Abscessation and masses greater than 5-7cm or pyelonephritis are also contraindications.

- **Herniorrhaphy**\(^2\)
  
  Diaphragmatic and inguinal herniorrhaphy are described. Automated suture devices, synthetic mesh and knotless sutures are extremely useful to aid closure. Chronic hernias are more likely to require conversion to open surgery since reduction of the hernia contents and apposition of fibrosed edges may be more challenging. Herniation of the spleen is reported to be more difficult to reduce.
With increased complexity, conversion to open surgery is more likely\textsuperscript{52}, but should be considered a change in strategy rather than a failure. It’s unlikely that the people working with you will ever want to perform another laparoscopic procedure if they routinely last until midnight.

**The future?**

NOTES and robotic surgeries may become more commonplace in the future, but are currently limited by equipment cost and the complexity of the procedures. NOTES in particular would seem to be of limited value in veterinary patients (in my opinion).

The most exciting next development in veterinary laparoscopy is likely to be the introduction of endoscopic fluorescent imaging, working with human colleagues to determine how these modalities can be most useful for the real time determination of tumour margins and lymphatic drainage. Dyes (such as indocyanine green) can be given intravascularly (either local to a tumour or non-selectively into the general circulation) and fluorescence of the chemical using near infrared frequencies detected using a camera. This highlights areas of increased vascularity, and whilst not necessarily showing the margin of a tumour, can identify the marginal zone of peritumoural inflammation helping to determine the extent of a mass. Another application may be to inject it into tumours and track the lymphatic drainage to determine which lymph nodes should be removed for oncological staging (potentially laparoscopically\textsuperscript{38}. There may be potential to directly inject the lymphatic system (e.g. via the popliteal lymph node) and then identify intra-abdominal lymphatic abnormalities, or the cysterchn chyli when performing ablation as part of the treatment for chylothorax. It is currently used in some human procedures to assess tissue perfusion, identifying the bile duct during cholecystectomy and recognise lymphatic vessels. Autofluorescence (AF) uses the endogenous fluorescence of the mucus membrane for the early differentiation of benign tissue from malignant tumours arising in the mucosa. With photodynamic diagnostics (PDD), pathological accumulations of fluorescent porphyrin products can be detected in bladder tumours to allow more rigorous treatment of these malignant changes. All of these real time imaging modalities allow clinicians to make more accurate diagnoses and guide decision making. Nanotechnology (the used of engineered atoms and molecules) may also have a role in future laparoscopic procedures, labelling either normal or neoplastic tissues that would then be identifiable. Some of the substances that can be injected can have additional therapeutic value, treating the neoplastic process whilst allowing it to be more readily identified. We have great plans for these exciting new modalities!

**References**

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