AVSTS
SPRING MEETING
11th APRIL 2012

SOFT TISSUE SURGERY
What’s new and hot?

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BRITISH SMALL ANIMAL VETERINARY ASSOCIATION
AVSTS Spring meeting 2012
Hall 6, International Convention Centre, Birmingham, UK

9:00-9:30 Registration
9:30- 10:00 Abstract Session

**What’s Hot and New in Adrenal Surgery**

10:00-10:20 Biochemical diagnosis of Pheochromocytoma. The medics view: Harriet Syme
10:20-10:50 Oral approach to the brain for surgery of the endocrine master gland: Bjorn Meij
10:50- 11:00 Questions

**11:00- 11:20: Tea/ Coffee**

11:20-11:50 Through the keyhole- laparoscopic adrenalectomy in dogs: Manuel Jimenez Pelaez
11:50- 12:20 How to remove the invading adrenal mass: Rob White
12:20- 12:30 Questions
12:30-12:50 AVSTS Business Meeting

**12:50-13:50 LUNCH (Provided)**

13:50- 14:10 Peter Holt Price and winning abstract
14:10- 14:50 The human experience of adrenal resection: (Sponsored by Ethicon) Jonathan Hubbard

**Laryngeal Paralysis update**

14:50-15:20 Laryngeal paralysis in the older dog...Why call it GOLPP Bryden Stanley
15:20- 15:30 Questions

**15:30- 15:50 Tea/ Coffee**

**What’s Hot and New in Wound Management**

15:50-16:20 Challenging wounds and methods of closure: Michael Pavletic
16:20-16:50 Update on negative pressure wound management: Bryden Stanley
16:50-17:20 Wound Dehiscence: Causes and Solutions: Michael Pavletic
17:20-17:30 Questions and Closure of Meeting
Speakers

**Dr Harriet Syme BSc, BVetMED, PhD, Dip ACVIM, Dip ECVIM**

Harriet graduated from the Royal Veterinary College in 1994 and then completed a Junior Clinical Training Scholarship at the RVC. She went on to do a Small Animal Internship and then a Small Animal Medicine Residency at Purdue University in the USA from 1995 to 1999. She studied for a PhD at the RVC from 1999 to 2003. Harriet gained her Diplomate ACVIM in 1999 and her Diplomate ECVIM-CA in 2002.

She was awarded the International Renal Interest Society (IRIS) Award in 2002 for her contribution to the field of veterinary nephrology & urology and the Dame Olga Uvarov award for clinical research in 2008.

**Björn Meij DVM PhD DipECVS**

Björn Meij graduated from the University of Ghent, and completed a residency in small animal surgery at Utrecht University. He completed his PhD investigating transsphenoidal hypophysectomy in 1997 in Utrecht and then moved to Charlottesville for a neurological fellowship at the University of Virginia from 1999 to 2000. He went back to Utrecht and became an associate professor in orthopaedics and neurosurgery at the Department of Clinical Sciences of Companion Animals, Utrecht University. Björn has a particular interest in pituitary adenomas and disorders of the canine spine in dogs and cats.

**Manuel Jimenez Pelaez DVM Dip ECVS**

Manuel qualified from Córdoba in Spain in 2000 and, following internships in Spain and France undertook an ECVS residency at the CHV Frégis in Paris. He was then Senior clinician in soft tissue surgery and neurosurgery at the Animal Health Trust, Newmarket before joining Davies Veterinary Specialists in 2010.
**Rob White BSc BVetMed, Cert VA, DSAS, Dip ECVS**

Rob graduated from the Royal Veterinary College (RVC) in 1989. He worked in general practice for a short time before completing a residency in soft tissue surgery and anaesthesia at the RVC. Rob was Head of Soft Tissue Surgery at Davies White Veterinary Specialists from 1998 to 2004 before setting up his own referral business, providing his surgical services on a peripatetic basis to veterinary practices, referral centres and universities on a national basis.

In 2002 Rob was awarded the BSAVA Simon Award for outstanding contributions to veterinary surgery. He has held the position of Honorary Senior Lecturer in Small Animal Surgery within the Department of Clinical Veterinary Science at the University of Bristol and has been Special Professor of Small Animal Soft Tissue Surgery at the University of Nottingham since 2006.

**Jonathan Hubbard MBBS MD FRCS EBQ (European Board qualification in Endocrine Surgery)**

He is an endocrine/ thyroid consultant and a general surgeon. He works at the Guy’s & St Thomas Hospital and King’s College Hospital.

His interest are Minimally invasive parathyroid surgery, assessment of thyroid including FNA, thyroid cancer surgery, thyrotoxicosis, multinodular goitre, laparoscopic adrenalectomy, laparoscopic cholecystectomy, inguinal hernia, umbilical hernia, epigastric hernia, lumps and bumps

**Bryden J. Stanley BVMS MACVSc MVetSc DipACVS**

Bryden Stanley graduated from Murdoch University, Western Australia, in 1982. After two years in private practice, she returned to Murdoch to undertake an internship, which was followed by a surgical registrar position at Sydney University. Bryden completed a residency in small animal surgery and a Master’s degree at the University of Saskatchewan, Canada. In 1990, Bryden took up a faculty appointment at the University of Edinburgh. In 1998 she
accepted a faculty position at Michigan State University. Her clinical and research interests are in laryngeal paralysis, wound healing and cutaneous reconstruction.

**Michael M. Pavletic DVM DipACVS**

Michael Pavletic is a 1974 graduate of the University of Illinois. Michael completed his internship and surgical residency at Angell Animal Medical Center in 1977. Michael is a 1981 Diplomate of the ACVS. He is the director of surgery at Boston’s Angell Animal Medical Center. Michael has published over one hundred surgical articles to date and is the author of Atlas of Small Animal Wound Management and Reconstructive Surgery (2010). Michael was the 2007 president of the ACVS. He is the recipient of several awards, including the Bourgelat Award presented by the BSAVA in 1996.
ABSTRACT SESSION

Novel management of bilateral ureteric trauma in a cat

Nicola Bound, Elvin Kulendra, Zoe Halfacree

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A seven year old female neutered Burmilla cat presented after a suspected traumatic episode with marked abdominal pain, bruising and obtundation. Biochemistry revealed a severe azotaemia (creatinine 1130 [RI 50-140 µmol/l], urea off scale) and hyperkalaemia (6.31 [RI 3.6-4.6 mmol/l]). An intravenous urogram demonstrated reduced contrast uptake in both kidneys. An exploratory laparotomy was performed where bilateral ureteric trauma and obstruction was noted. Bilateral renal decompression was achieved by placement of 22 gauge intravenous catheters into the renal pelvices, confirming ongoing renal function bilaterally. Anterograde guidewire placement (WeaselWire, 180 cm x .018” angled, Infiniti Medical) was achieved bilaterally allowing identification of the ureteral lumen and subsequent retrograde placement of ureteric stents (Vet Stent-Ureter, 2.5F, 14cm, 0.018, Infiniti Medical). A left ureteral resection and anastomosis was performed. Due to extensive crush injury to the mid right ureter, this portion was removed and a resection and anastomosis over a ureteric stent was performed. In addition, a nephropsoas and nephrocystopexy were performed due to the short length of ureter remaining. The cat made an excellent recovery and was clinically normal, however mild azotaemia persisted (creatinine 196 [RI 107-193 mmol/l]; urea 18.9 [RI 6.1-12 mmol/l]). Three months following the surgery, the cat developed dysuria and was diagnosed with sterile cystitis, presumably due to the presence of the stents. Following failure of medical management, removal of the stents was considered necessary however it was unclear if the stents could be removed without causing ureteral trauma. Renal scintigraphy was performed preoperatively to assess the relative contribution of each kidney to GFR (right 33% and left 66%); it was therefore considered paramount to preserve both kidneys. A ventral cystotomy was performed and stent removal via gentle traction was performed; no intra-operative problems were encountered. The cat made a good initial recovery but then represented depressed and anuric four days post-operatively. Serum biochemistry revealed severe azotaemia and hyperkalaemia (urea and creatinine were off the scale; potassium 9.45 (RI 3.6-4.6 mmol/l). Renal ultrasonography revealed bilateral renal pelvic dilatation consistent with bilateral ureteric obstruction. A further surgery was required to replace the stents bilaterally. Multiple sites of ureteric stricture were present making replacement of the stents challenging. The cat made a good recovery but six months later requires ongoing medical management for dysuria associated with sterile cystitis.

A sublumbar abscess is an uncommon condition characterized by abscessation within the hypaxial musculature. Various imaging techniques have been used for diagnosis prior to surgical debridement. Prognosis is often considered guarded. This study examined the success of surgical treatment and whether prognosis should be re-evaluated.

Medical records of 46 cases of sublumbar abscesses diagnosed at DVS between December 2000 and February 2011 were reviewed to determine pre-operative clinical findings, intra-operative techniques and post-operative treatment. Follow-up period (minimum 6 months) was determined by contacting the referring veterinary surgeon.

Highest ranking breed was the springer spaniel 12/46. Duration of clinical signs ranged 1 - 96 weeks. In 41/46 cases surgical exploration and debridement was performed with antibiotic administration. A midline celiotomy alone or combined with other approaches was used (32/41). Foreign material was found in 9/41 dogs. Omentisation was performed (24/41) and surgical drains placed (22/41). Bacteriologic culture and sensitivity was performed in 28 cases (13 yielding positive bacterial growth). Common respiratory bacteria were cultured. Broad spectrum antibiosis ranged 2-12weeks (mean 5 weeks). Follow-up period was obtained for all cases except 2. Six cases recurred, 2 of which were euthanased. One dog died suddenly 10 days post-surgery. Surgery was successful in 32/39 with a recurrence-free interval ranging 8-111 months (mean 33 months).

This study challenges that prognosis in dogs with sublumbar abscesses was guarded as 32/39 (82%) dogs were successfully treated surgically. The success rate was high even though foreign material was not found in most cases. Duration of clinical signs did not influence outcome.
Biochemical diagnosis of pheochromocytoma: The medic’s view
Harriet M. Syme BSc BVetMed PhD FHEA DipACVIM DipECVIM MRCVS

Pheochromocytomas are endocrine tumours arising from chromaffin cells of the adrenal medulla. Clinical signs associated with pheochromocytoma may result from the release of catecholamines leading to a variety of nonspecific, and often paroxysmal, clinical findings including hypertension, tachyarrhythmias, weakness and collapse. In addition, pheochromocytomas may lead to vena caval thrombi which, although usually asymptomatic, may be associated with the development of ascites.

The optimal treatment for pheochromocytoma is surgical excision. However, this may be associated with complications such as hyper- or hypotension, tachyarrhythmias and intraoperative haemorrhage from the tumour site. Treatment with phenoxybenzamine prior to adrenalectomy has been reported to significantly decrease perioperative mortality in dogs with pheochromocytoma (Herrera et al. 2008). Therefore, identifying affected patients prior to adrenalectomy is necessary to allow beneficial anti-hypertensive medication to be started prior to adrenalectomy and to ensure sufficient care is given in the pre- and post-operative periods. Appropriate identification of patients with non-functional tumours among the increasing number of dogs that have incidentally discovered adrenal masses will also prevent unnecessary surgeries being performed.

Biochemical diagnosis of pheochromocytoma in humans was initially based on the documentation of increased urinary excretion of epinephrine, nor-epinephrine, dopamine or the metabolite vanillylmandelic acid (VMA). None of these tests in isolation was highly sensitive or specific. These tests have now, largely, been superseded by the measurement of metanephrines in plasma and/or urine. Metanephrine (MN) and normetanephrine (NMN), collectively called metanephrines, are metabolites of epinephrine and nor-epinephrine, respectively. They are produced by the action of the enzyme catechol O-methyl transferase (COMT) which occurs in both soluble and membrane bound forms. Pheochromocytoma tissue contains a high concentration of COMT and therefore MN and NMN concentrations are particularly increased in affected patients. It has been estimated that approximately 90% of the circulating free metanephrines in a human pheochromocytoma patient are produced by the tumour itself. Once formed metanephrines are further metabolised in the circulation to sulphated conjugates which are present at much higher concentration than the parent molecules. When metanephrines are measured in plasma it is usually the free, un-sulphated molecule that is measured. Assays of urine metanephrine concentrations employ a deconjugation step so the majority of what is measured is the sulphated metabolite.

Dogs with pheochromocytoma have been documented to have significantly higher urinary epinephrine, nor-epinephrine and NMN to creatinine ratios than healthy dogs (Kook et al. 2010). MN to creatinine ratios were not significantly increased. However, critical illness (Cameron et al. 2010) and even the stress of hospitalisation in normal dogs (Kook et al. 2007) have been shown to increase urinary catecholamine and metanephrine excretion. Importantly, when catecholamine and metanephrine to creatinine ratios were compared in dogs with pheochromocytoma and dogs with hyperadrenocorticism (adrenal and pituitary-dependent forms) there was considerable overlap between groups; only NMN to creatinine ratio was significantly higher in dogs with pheochromocytoma (Quante et al. 2010). This has clinical significance because testing for
pheochromocytoma is most often performed when an adrenal mass has been documented and hyperadrenocorticism is the most important differential diagnosis in that setting.

Plasma free metanephrine concentrations have also been measured in a small study of dogs with pheochromocytomas and compared with normal dogs, dogs with non-adrenal illness and dogs with adrenal-dependent hyperadrenocorticism (Gostelow and Syme 2011). Both MN and NMN were significantly increased in dogs with pheochromocytoma compared with each of the other the other groups and in fact there was very little overlap in values. Measurement of NMN, in particular, was both sensitive and specific for the diagnosis of pheochromocytoma. MN was specific but less sensitive. These promising results now need to be validated in a larger study.

Unfortunately sample handling and submission for measurement of urinary and plasma metanephrine measurement is not straightforward and the analysis, which is generally by liquid chromatography-tandem mass spectrometry (LC-MS/MS) or high-pressure liquid chromatography (HPLC), is not widely performed. Urine samples need to be acidified and chilled before submission and plasma (an EDTA sample) should be quickly spun and frozen prior to shipment. Plasma samples for metanephrines can be sent to the RVC diagnostic laboratory (01707 666208) for shipment to the Netherlands for analysis. If a different laboratory is used it is important to recognise that MN and NMN concentrations in dogs are very much higher than in humans; using a human laboratory reference range will result in many normal dogs being diagnosed with pheochromocytoma. Radio-immunoassays and ELISA methods for measurement on MN and NMN have been described so it is possible that in the future these will be validated for use in dogs and sending samples for analysis will be easier.

Although measurement of metanephrines in the diagnosis of pheochromocytoma appears promising these tests should not be over-utilised. Due to the very low pre-test probability of pheochromocytoma in the absence of a documented adrenal mass, measurement of metanephrines should only be done to rule out the diagnosis (i.e. due to normal values); if metanephrines are elevated the chance of the patient actually having a pheochromocytoma remains low.

References
ORAL APPROACH TO THE BRAIN FOR SURGERY OF THE ENDOCRINE MASTER GLAND

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Introduction

Transsphenoidal selective adenomectomy is the primary therapy for Cushing’s disease in humans. The most common approach in humans is by the standard microsurgical submucosal transseptal transsphenoidal procedure. There are many virtues of the transsphenoidal approach. Most importantly, it is the least traumatic route of surgical access to the sella. The lack of visual scars, lower morbidity and mortality as compared with transcranial procedures, the necessity of only a brief hospital stay, the relatively brief recuperative period, and the overall safety of the procedure add to the procedure’s appeal. There are three approaches to the air-filled sphenoid sinus in humans: the endonasal submucosal approach, the sublabial approach, and the direct transnasal septal pushover approach. All procedures require the introduction of a nasal speculum. Magnification and the light source are provided by a neurosurgical operating microscope. New developments in pituitary surgery in humans include the intraoperative use of neuronavigational guidance for accurate localisation and the use of intraoperative MRI for assessment of complete tumor removal. More and more human pituitary surgeons employ the pure endoscopic endonasal transsphenoidal surgical approach for pituitary tumor removal using rigid endoscopes. The pure endoscopic approach is facilitated by the regional anatomy in humans: the sphenoid sinus is air-filled and there is thin bony separation between the sellar floor within the sphenoid sinus and the pituitary fossa.

In dogs the most common method of treatment for Cushing’s disease or pituitary-dependent hyperadrenocorticism (PDH) is medical treatment with mitotane (o,p’-DDD), which causes destruction of the adrenal cortex, or with trilostane, which is a competitive inhibitor of 3β-hydroxysteroid dehydrogenase, an essential enzyme for the synthesis of cortisol, aldosterone, and androstenedione. Medical therapy leaves the pituitary adenoma, which is the underlying cause of PDH, untreated. Also, it may be hypothesised that the removal of the chronic negative feedback exerted by the glucocorticoid excess at the pituitary level, may actually stimulate pituitary tumor proliferation and expansion.

At the Utrecht University transsphenoidal hypophysectomy has become an important tool over the last decade in the complex management of Cushing’s disease in dogs and cats (3-8). In dogs the indications for pituitary surgery now include pituitary corticotroph adenomas (causing Cushing’s disease), debulking of clinically nonfunctioning pituitary adenomas (NFAs causing central neurological signs by the tumor mass effect on surrounding brain structures) and occasional meningiomas in the sellar region.
Advanced imaging techniques such as computed tomography (CT) and magnetic resonance imaging (MRI) are a prerequisite for pituitary surgery to assess the pituitary size and the surgical landmarks (5, 11). Since the surgical landmarks are bone structures, they are more difficult to discern on MR images than on CT images. Pituitary imaging using a helical CT unit has proven to be practical, fast and accurate for detection of pituitary abnormalities, also when compared to MRI using a magnet with 0.2 Tesla strength. Surgical localisation of the pituitary gland in the various skull types of our patients is dependent on the continuous visual assessment of typical bone features during the transsphenoidal approach and relating those, real-time, to the CT images in the operating room. Direct imaging of the pituitary adenoma is only possible when the imaging characteristics of the adenoma are different from those of the surrounding normal pituitary tissue (9-11). Unfortunately, in contrast with humans with Cushing’s disease, the finding of well-defined pituitary (micro)adenomas in dogs and cats is rare. The enhancement pattern of the neurohypophysis during dynamic contrast enhanced CT has been called the ‘pituitary flush’ (9-11). The displacement, distortion, or disappearance of the pituitary ‘flush sign’ in dynamic CT examinations can be used to confirm left or right-sided lateralization of (micro)adenomas (9,11).

**Surgical Technique**

Pituitary surgical techniques include selective removal of the pituitary adenoma (adenomectomy), removal of the adenohypophysis (adenohypophysectomy), removal of a significant part of pituitary tumor mass in the case of a macroadenoma (pituitary debulking), or complete removal of the pituitary gland including the tumor (hypophysectomy). Hypophysectomy in the dog and cat is performed by the midline transoral, transnasopharyngeal, transsphenoidal, microsurgical approach (7). Recently, an alternative approach was reported in experimental dogs using a ventral paramedian approach medial to the rami of the mandible, exposing and removing the pituitary gland en bloc by manipulation and ultrasonic aspiration (1).

Hypophysectomy in dogs and cats is performed under general inhalation anesthesia with the animal in sternal recumbency (7). The maxilla rests on a metal frame and the mandibula is lightly pulled downwards with elastic bandage. The neck is supported by a cushion and the skull is immobilized to the metal frame using tape. Following electrosurgical midline incision of the palatine mucosa, the soft palate is retracted by a Gelpi retractor, the mucoperiosteum is elevated, and the exact position of the burr slot is determined by correlating the pterygoid hamular processes and the shape of the outer cortical lamina to the location of the pituitary fossa and pituitary gland on sequential, contrast-enhanced CT images (7). Access to the pituitary fossa is obtained with an air-powered burr. When the pituitary gland becomes visible through the paper-thin inner cortical layer, burring is discontinued and a 3.3x operating loupe is used to provide magnification. Bone punches are used to enlarge the opening created in the inner cortical lamina of the sphenoid bone. The
dura mater is incised in a cruciate pattern and usually pituitary tissue will start to protrude through the resulting opening. The pituitary adenoma is detached from the fossa circumferentially using a small ball-tipped hook and is extracted through the dural opening using fine neurosurgical grasping forceps. During extraction of the pituitary the basal cisterns will be opened resulting in a continuous flow of cerebrospinal fluid. The pituitary is disrupted at the level of the pituitary stalk opening the third ventricle. During extraction of more and more pituitary tissue, an empty fossa will become visible. The hypophyseal fossa is inspected for completeness of hypophysectomy by the following criteria: 1) unobstructed view of the ventral hypothalamic surface and the opening to the third ventricle, and 2) absence of pituitary remnants upon careful exploration of the left, right, rostral, and caudal extensions of the hypophyseal fossa. At this stage the pituitary fossa can be inspected for pituitary tumor remnants using rigid endoscopes, e.g., and endoscope with a diameter of 2.7 mm and a 30 degree viewing angle.

When the actual (micro)adenoma cannot be visualized by preoperative pituitary imaging or confirmed during surgery, selective pituitary adenomectomy is not an option in veterinary medicine. In most cases the complete adenohypophysis is usually affected by the adenomatous tissue or there is no sharp definition between adenomatous adenohypophyseal tissue and unaffected adenohypophyseal tissue during surgery, even under magnification. Therefore, complete hypophysectomy still remains the aim of the surgical treatment. The technique of transsphenoidal hypophysectomy has largely remained unchanged since our report in 1997 (7). In increasing frequency dogs are referred with macroadenomas or giant pituitary adenomas with a pituitary size up to a diameter of 2 cm, not seldom after treatment with o,p'-DDD. The aim for these patients is debulking hypophysectomy, trying to remove as much of the tumor tissue as possible to reduce the mass effect. Following hypophysectomy, the pituitary fossa is meticulously explored to check for remnants of pituitary tumor. Rostral extension of the pituitary adenoma is by far the most difficult whereas dorsal and caudal extensions are usually easier to explore and remove. In macroadenomas and giant adenomas, the tumor tissue is removed as far dorsally until a clean hypothalamic surface comes into view which usually carries an indentation due to the tumor mass effect. Caudal extension can be followed over and beyond the dorsum sellae. Fortunately, most macroadenomas of the pituitary in dogs do not invade the cavernous sinus, like they often do in humans, and tumor tissue can be detached from the medial dural layer of the cavernous sinus.

Closure starts by filling the pituitary fossa with absorbable gelatine sponge, followed by filling the burr slot in the sphenoid bone with bone wax, and suturing the soft palate in two separate layers.

Postoperative care in the intensive care unit includes close monitoring of vital functions, plasma electrolytes (sodium and potassium), plasma osmolality, and central venous pressure. These parameters guide the administration of IV fluids; however, spontaneous
oral water intake is encouraged as soon as the patient is awake. Postoperative medication includes antibiotics and analgesics. Hormone replacement is started immediately and consists of hydrocortisone (1 mg/kg IV every 6 hours) and desmopressin, a vasopressin analogue (4 µg administered as a drop into the conjunctival sac every 8 hours). As soon as the dog has resumed eating and drinking, oral replacement therapy is started: cortisone acetate (1 mg/kg every 12 hours) and thyroxine (15 µg/kg every 12 hours). Over a period of 4 weeks the dose of cortisone acetate is gradually tapered to 0.25 mg/kg every 12 hours. Desmopressin (0.01%) is administered for 2 weeks, 1 drop into the conjunctival sac every 8 hours. Endocrine functions (urinary corticoid/creatinine ratios and plasma thyroxine) are monitored after hypophysectomy, preferably every 4 to 6 months.

Results and Complications

The efficacy of transsphenoidal hypophysectomy in the treatment of dogs with PDH has been investigated in a prospective study in 181 dogs with a median age of 9 years (3-6). The 1-, 2-, 3-, and 4- year estimated survival rates were 86%, 83%, 80%, and 79%, respectively (4). Treatment failures included postoperative mortalities (= death within 4 weeks after surgery irrespective of the cause of death, 14 dogs), and incomplete hypophysectomies (12 dogs). The 1-, 2-, 3-, 4-year estimated relapse-free fractions were 90%, 77%, 72%, and 62%, respectively (4). Survival and disease-free fractions after hypophysectomy were markedly higher in dogs with nonenlarged pituitaries than in dogs with enlarged pituitaries (3). The main postoperative complications after hypophysectomy are postoperative reduction in tear production (<5 mm on STT) which occurred in 31% of the dogs and prolonged diabetes insipidus (DI, > 2 weeks) which occurred in 53% of the dogs (3). Tear production restored to normal values in 79% of the dogs that were affected over a median period of 9 weeks. Diabetes insipidus occurred more frequently in dogs with enlarged pituitaries than in dogs with nonenlarged pituitaries and was permanent in 22% of the dogs (3). The results compare favourably with those of 129 dogs treated in the same institution in another time frame with o,p'-DDD (3). With longer follow-up time, hypophysectomy leads to better results than o,p'-DDD treatment, although there may have been a bias in the selection of dogs for surgery or for o,p'-DDD treatment.

Pituitary and Adrenocortical Function after Hypophysectomy

After hypophysectomy, serum chemistry parameters normalize in dogs with Cushing's disease (12). The levels of pituitary hormones, such as ACTH and a-MSH, decrease sharply after hypophysectomy and removal of the adenoma and unaffected adenohypophyseal tissue. When hypophysectomy is the aim of the treatment these levels should approach the lower limit of the hormone assay (6). Therefore it may be hypothesised that when ACTH levels are still measurable immediately after surgery, hypophysectomy is not complete and residual adenoma tissue is present in the fossa. In the case of residual unaffected adenohypophyseal tissue after pituitary surgery, plasma ACTH concentration would still be
low early after surgery due to the preoperative long term negative feedback on normal corticotrophs by the chronic glucocorticoid excess.

Adrenocortical function after hypophysectomy can easily be measured using the basal urinary cortisol/creatinine ratio (UCCR) in samples collected at home. When the patient leaves the hospital, usually 3 days after surgery, owners receive tubes for urine collection at 2 weeks, 8 weeks, 6 months, and 1 year after surgery. Thereafter yearly assessment of adrenocortical function is advised. Urine samples are collected at home when the dog is 24 hours free of cortisone medication. The early (<8 weeks) UCCR has prognostic value when considering long term survival and disease free fractions. In dogs with early postoperative UCCR < 5 x 10^-6, the survival and disease free fractions are greater than in dogs with early postoperative values between 5 and 10 x 10^-6 (4).

**Pituitary Surgery in Cats**

The indications for transsphenoidal hypophysectomy in cats are twofold: Cushing’s disease caused by an ACTH-cell pituitary adenoma (8) or acromegaly caused by a GH-cell pituitary adenoma (13). Both conditions in cats are usually accompanied by diabetes mellitus requiring insulin administration. Transsphenoidal hypophysectomy has a higher morbidity and mortality in cats with PDH than in dogs (8). Thorough pre-surgical screening of cats for coexisting disease is imperative to prevent surgical mortality. In cats with PDH there is considerable co-morbidity due to hypophysectomy. However, hypophysectomy has resulted in disappearance of diabetes mellitus and discontinuation of insulin administration within months after surgery. Acromegaly in cats holds a better prognosis, morbidity is less then for cats with PDH and insulin requirements dramatically decrease to zero values within 1 to 4 weeks after surgery (13).

Pituitary surgery in cats has led to some remarkable findings. In a 9-year-old castrated male cat with insulin-resistant diabetes and elevated urinary corticoids that were suppressible by a low dose of dexamethasone, PDH was diagnosed. On CT an enlarged pituitary was confirmed. However, also strongly elevated GH and IGF-I levels were found. The cat underwent transsphenoidal hypophysectomy after which insulin resistance disappeared. On histopathological and immunocytochemical examination of the surgical specimen a double pituitary adenoma was found, consisting of a corticotroph adenoma and a somatotroph adenoma separated by unaffected pituitary tissue (14). In a 13-year-old male, castrated cat with a ravenous appetite and dull coat, that was referred with insulin-resistant diabetes mellitus, normal levels of urinary corticoids were found. ACTH levels were normal but α-MSH levels were strongly elevated and CT revealed a pituitary tumor originating from the pars intermedia. After transsphenoidal hypophysectomy, the clinical signs resolved and the cat no longer required insulin administration. Immunocytochemical examination of the surgical specimen revealed a melanotroph pituitary adenoma immunostaining positive for α-MSH and weakly for ACTH (15).
References

THROUGH THE KEYHOLE: LAPAROSCOPIC ADRENALECTOMY IN DOGS

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Key Points

• Adrenalectomy can readily be performed using laparoscopy; however, prompt conversion to an open approach may be required and equipment required should be available and ready on the surgical table.
• Laparoscopic adrenalectomy in dogs is usually performed via a paralumbar fossa, or flank approach. An initial abdominal exploration may, however, be carried out through a port on the ventral midline, using gravity as an aid.
• Laparoscopic adrenalectomy is feasible in dogs for right and left adrenal tumors which do not invade the caudal vena cava; however, given the different anatomic relationships, right-sided adrenal tumors are particularly challenging to remove. Vascular invasion is a clear contraindication to laparoscopic removal; contrast CT may increase the ability to diagnose vascular invasion prior to laparoscopic exploration.
• Using an advanced tissue and vessel-sealing device is of a paramount importance improving safety and reducing surgical time. Such a device can be used for both haemostasis of the phrenico-abdominal vein and dissection of the gland.
• Good case selection, experience and availability of high-quality equipment are critical to avoid high levels of procedural complications and conversion rates.

Surgical Technique:

The caudal aspect of the hemithorax and the lateral abdomen on the affected side are clipped and prepared aseptically for surgery. Dogs are positioned in lateral recumbency on the unaffected side, with a cushion placed under the erector spinae muscle group to raise the spine towards the surgeons who are positioned at the animal’s ventral aspect (Fig 1).
Fig 1. Schematic representation of the dog’s surgical position (lateral recumbency) and orientation of the portals. A triangular cushion was placed under the erector spinae muscle group in order to raise the spine towards the surgeons standing by the animal’s ventral side.

The video monitor is positioned in front of the surgeons on the dorsal side of the dog.

A 5- or 10-mm (30° or 0°) laparoscope is connected to a video camera and a light source.

Images are viewed on a video monitor and recorded. The endoscopic equipment includes an irrigation–suction unit, a self-retaining fan retractor, grasping forceps, scissors and dissectors connected to an electrosurgical unit, as well as endoscopic hemoclips. Most importantly, a feedback-controlled, bipolar vessel-sealing system device is used to achieve hemostasis of the phrenico-abdominal vein and dissection of the gland.

Although adrenalectomy in dogs is usually done via a paralumbar fossa (flank) approach, an initial abdominal exploration may be made with a port on the ventral midline, using gravity to evaluate the dorsal, cranial, and caudal aspects of the abdomen. This retro-umbilical port is not a very useful position for the endoscope during adrenalectomy and does not improve the view, and manipulation becomes difficult. Once the abdominal exploration has been completed, the patient is re-positioned in almost lateral recumbency for the adrenalectomy. A Veress needle was inserted at a level just caudal to the 13th rib in the paralumbar fossa ipsilateral to the affected side. The abdomen is inflated with CO₂ until an intra-abdominal pressure of 8–10mm Hg is achieved. Inflation is adjusted according to the dog’s size and physiologic variables.

Four portals are located in the paralumbar fossa. Three 5-mm portals are placed along a virtual half-circle with kidney of the affected side as the center point. A fourth instrumental portal (5–12mm) for the self-retaining fan retractor and suction device is located above the kidney. The half-circle radius is determined subjectively, according to dog and instrument size (Fig 2).
Fig 2. Positions of the surgical portals along the paralumbar fossa.

The surgeon should triangulate ports toward the affected adrenal gland. The laparoscope is inserted through portal 1 and the instruments through portals 2 and 3. Laparoscope and instruments can be exchanged alternatively from one portal to another to improve visualization and dissection.

Exposure and dissection of the adrenal glands are performed differently on the right and left sides because of anatomic differences:

- **Right adrenalectomy:**
  To achieve wide exposure of the right adrenal gland, the right lateral hepatic lobe is retracted cranially and the kidney was retracted dorsally. Because dogs are positioned in lateral recumbency with a cushion under the erector spinae muscle group (Fig 1), the descending duodenum or other organs are displaced by gravity.

- **Left adrenalectomy:**
  For exposure of the left adrenal gland, the descending colon is reflected medially, the left kidney is reflected dorsally, and the spleen ventrally.

Immediately after exposure of the adrenal gland, evaluate the phrenicoabdominal vein, renal vein, and caudal vena cava (CVC) in each case. Then careful dissection and hemostasis of the phrenicoabdominal vein is achieved on both sides by the use of either haemostatic endoclips or a vessel-sealing device. Dissection between the right adrenal gland and the caudal vena cava has to be to be performed with special care.

In an attempt to minimize manipulation of the adrenal gland, the peritoneum is incised laterally away from the adrenal gland. Any direct manipulation or grasping of the adrenal capsule must be avoided as inadvertent capsule penetration is likely to happen. The vessel-sealing device helps to perform a complete circumferential dissection of the gland with minimal manipulation of the gland itself. The renal blood supply is retracted medially to avoid accidental hemorrhage during dissection. Further hemostasis of vessels on the caudal and cranial parts of the gland is also achieved using the vessel-sealing device. The gland should be removed using an endoscopic retrieval bag.

The abdomen is inspected for hemorrhage, and the adrenalectomy site is lavaged.

The abdomen is freed of gas and closure of the portal wounds is performed in a routine manner.

**Discussion:**

Currently, adrenalectomy is the treatment of choice for adrenal tumors, unless metastatic lesions are encountered preoperatively. Some of the more common techniques used for
Open adrenalectomy in dogs include ventral median celiotomy and retrocostal or flank laparotomy. Selection of approach is based on adrenal gland size, surgeon’s preference, affected side, and presence of neoplastic invasion of the caudal vena cava. Pros and cons of various approaches have been reported. A retroperitoneal approach via flank incision is usually recommended for small lesions within the right adrenal gland in the absence of invasion of the caudal vena cava. The left adrenal gland can be exposed without much difficulty by flank or ventral median approaches. The latter approach is recommended for large tumors, pheochromocytomas, or tumors extending in the caudal vena cava, regardless of lateralization.

Laparoscopic adrenalectomy in humans was reported in 1992 and is most commonly used, but not exclusively, for benign functional and nonfunctional tumors (< 12cm in size) of the adrenal glands; however, the true upper limit may not have been reached with the advent of morcellators. The benefits of laparoscopic adrenalectomy are well documented in people and include fewer wound complications, reduced morbidity, improved comfort and cosmetic appeal, reduced bleeding, better observation of abdominal organs, shorter hospital stays, and faster recovery periods.

Advantages of minimally invasive surgical procedures in dogs compared with open surgical procedures have been reported. For example laparoscopic ovariohysterectomy reduces postoperative pain and surgical stress compared with the open technique. Furthermore one can expect that laparoscopic adrenalectomy would offer the advantages of minimally invasive procedures which include limited manipulation of others abdominal organs, decreased surgical wound complication, improved postoperative comfort, shorter recovery periods and excellent view of abdominal structures. This magnification is especially helpful during dissection between the right adrenal gland and caudal vena cava.

Inadvertent opening of the capsule (suctioning of the contents and removal of the remainder) was not problematic in the case series we previously reported. Problems associated with capsular rupture are unknown, no apparent complications occurred, but a larger study would be required to evaluate the effect on survival. Capsular rupture observed in these first few cases is likely due to a combination of the learning curve and the absence of a vessel-sealing device. Capsule rupture is more likely to occur during right adrenalectomy given its anatomic position.

Trans-abdominal or retro-peritoneal approaches have been described but the lateral trans-abdominal approach is the most commonly used technique in human laparoscopic adrenalectomy because the large view provides good orientation and visualization of familiar landmarks known from open surgery. The retroperitoneal approach provides a more direct access to the adrenal gland and avoids abdominal adhesions in patients who have had previous abdominal surgery. However, dissection and exposure are more difficult, the working space is limited, and this approach does not permit full abdominal exploration. For these reasons as well as body size the trans-abdominal laparoscopic approach is also preferred in dogs. As in human
beings our patients are placed in lateral recumbency on the unaffected side, with a cushion placed under the erector spinae muscles to rise the spine towards the surgeons who were standing on the ventral side of the animal. The surgical portals are placed at different levels along the paralumbar fossa using a trans-peritoneal approach (Fig. 2). This allows excellent exposure of the adrenal gland and very good view during its dissection, especially between right adrenal gland and the caudal vena cava.

Dissection distant from the adrenal gland without entering it or disrupting the CVC must be accomplished. It is especially difficult and challenging during dissection between the right adrenal gland and the CVC because the right adrenal gland is extremely close to the CVC and on its medial aspect the capsule is continuous with the tunica adventitia of the CVC.

Dissection of the phrenico-abdominal vein must be carefully performed to avoid bleeding and gland effraction. Haemostasis of the right phrenico-abdominal vein is performed at its junction with the caudal vena cava. Because of left phrenico-abdominal vein enters the left renal vein and doesn’t join directly with the CVC, its dissection is easier to perform. Bleeding is the most common complication during and after laparoscopic adrenalectomy in people, and accounts for approximately 40% of all complications. Nonetheless, blood transfusions are required in less than 5% of cases. In dogs, use of surgical devices as Harmonic Scalpel® or LigaSure® helps preventing bleeding efficiently.

In the series we published and other unpublished data from several authors, all dogs presented without CVC invasion were operated laparoscopically and no dog required conversion to open surgery. In dogs, laparoscopy was used with adrenal masses of no more than 48 mm in diameter. Conversion to an open procedure occurred in approximately 2% of human cases (ranged, 0-13%) and the main indication for conversion is uncontrollable bleeding (40% of all complications).The next most common reason for conversion is malignancy with local and vascular invasion detected upon laparoscopic exploration.

In people postoperative complications after laparoscopic adrenalectomy include bleeding, wound infection or hematoma, as well as thromboembolic, urinary, gastrointestinal, pulmonary, and cardiovascular problems. Injury to peritoneal and retroperitoneal organs represents only 5% of all complications and includes injury to the liver parenchyma, spleen, pancreas, colon, lymphatic system, and adrenal gland (specimen fragmentation). Minor splenic injury and controllable bleeding are the most often complications reported during laparoscopic procedures in dogs. Acute pancreatitis with peritonitis has been reported to be responsible of 8 to 25% of mortality after open adrenalectomy, especially with the ventral midline approach. In the reported case series, no pancreatitis has been observed. Further investigation is required in order to evaluate the role of the minimally invasive surgical approach in this major difference. No iatrogenic injury was noted as a result of trocar insertion in the cases reported.
Causes of death after laparoscopic adrenalectomy in humans included massive hemorrhage, necrotizing pancreatitis, pulmonary embolism, sepsis, and cardiopulmonary failure. When compared with open adrenalectomy, laparoscopic approach reduces the likelihood of perioperative complications in human patients undergoing adrenalectomy. Positive impacts on intraoperative bleeding and postoperative pulmonary complications have been demonstrated. The overall mortality rate in people appears ranged of 0.2-1.2% after a period of 30 days post-procedure.

In the series we published the perioperative mortality rate for adrenocortical tumors was 28% (2/7 dogs, both in the postoperative period). Although this number is high it should be compared with reported mortality rate of 19 (4/21), 21% (6/28), 28% (10/36), and 60% (15/25) from other studies. Major postoperative complication included severe respiratory distress in 2 of 7 dogs, (both died 48 hours after surgery and none of which had a definitive diagnosis for the cause). Thoracic radiographs were compatible with pulmonary thromboembolism, which is a well known postoperative complication in animals and men suffering from hyperadrenocorticism. Dogs with hyperadrenocorticism that undergo surgery (e.g. adrenalectomy) are at increased risk of developing pulmonary thromboembolism. In humans beings, it has been shown that these thromboembolic complications may be reduced by perioperative anticoagulation treatment. Although we do not routinely anticoagulate patients with Cushing’s syndrome, it may be advisable to start preoperative low-dose heparin therapy and to continue administration for several days afterward, to help reduce the chances for embolic events. However, pulmonary thromboembolism has also been described in series of dogs treated with an anticoagulant protocol (heparin) during and after open adrenalectomy. At this moment, to our knowledge no studies have demonstrated the benefit of this treatment to prevent pulmonary thromboembolism in dogs. Further studies are also needed to establish if, in addition, intermittent positive pressure ventilation and pneumoperitoneum increase the likelihood of thromboembolism in Cushing patients, regardless of the type of surgical procedure. In people, laparoscopy induces specific pathophysiological changes in response to pneumoperitoneum which is felt to predispose to deep venous thrombosis. No studies are available confirming this in dogs. Information on the incidence of venous thromboembolism following laparoscopic procedures is insufficient to warrant the need for thromboprophylaxis. In addition, venous thromboembolism remains a common and severe complication after cancer surgery in people. It’s the most common cause of death at 30 days after cancer surgery.

In our patients, the perioperative mortality of open surgery (22%) would not be expected to be any different with laparoscopic surgery, nor would the overall survival (690d).

Pheochromocytomas can be also removed laparoscopically. No major change in blood pressure of human patients with pheochromocytoma occurred when CO₂ insufflation was performed. Consideration to alpha/beta receptor blockade should be made; however, as would be done for open surgery, as laparoscopy will not minimize these complicating factors.
Laparoscopic surgery is presumably less painful because of smaller incisional size and decreased skin and muscular trauma. Although in any of the cases pain scores were evaluated, all dogs were standing up the day after surgery and palpation of the abdomen was not painful. Dogs were discharged 72 hours after surgery and no dogs required analgesic drugs at home. Wound complications (infections, delayed wound healing) are well known complications in animals with hyperadrenocorticism, so minimizing wound size can only be beneficial. Abdominal incision dehiscence has been reported in 10% of cases after open adrenalectomy. In the reported case series, despite some severe preexisting skin lesions, no wound complications other than mild cellulitis were observed.

Disadvantages or problems reported with laparoscopic adrenalectomy include, increased surgical time, the specific instrumentation required, technical difficulties and intraoperative complications during dissection (mild bleeding and gland rupture). As with any laparoscopic technique, laparoscopic adrenalectomy may be potentially longer to perform and more technically demanding than conventional techniques until familiarity allows full confidence. The reported mean surgical time for laparoscopic adrenalectomy in dogs, from Veress needle insertion to complete closure is 113 minutes (range 90-150 minutes). Because of different anatomic position, mean surgical time for right adrenal gland (133 minutes, range 120-150 minutes) was longer than mean surgical time for left adrenal gland (99 minutes, range 90-110 minutes). In some cases, surgical time with the open approach may be shorter to perform, but to our knowledge, this surgical time is only reported in a few studies and it varied from 100 to 180 minutes. Laparoscopic removal may take longer in people (258 vs 166 min), but certainly is related to surgeon experience, size of the tumor, body condition score, and ability to visualize the organ. As any minimally invasive procedure, it requires specific instrumentation which is more expensive. However use of reusable instruments can decrease instrumentation costs.

In human surgery, the role of laparoscopic adrenalectomy in the management of adrenocortical cancer is controversial because of its high morbidity. Most adrenocortical cancers are generally treated by open adrenalectomy. Relative contraindications to laparoscopic adrenalectomy include large tumors and suspected adrenocortical cancer. However, laparoscopic adrenalectomy appears to be safe and effective for malignant adrenal tumors in people (adrenocortical carcinoma and malignant pheochromocytoma) without local or vascular invasion confirmed and if the rules of oncologic surgery can be respected. Local and/or port-site tumor recurrence and intra-abdominal carcinomatosis from laparoscopic adrenalectomy for malignant adrenal tumors have been described in several reports. Other reports have described no local and no port-site recurrence after laparoscopic adrenalectomy for malignant tumors with negative margins in all cases. In patients with adrenocortical cancer, loco-regional recurrence rates were 60%, a rate similar to that reported for open adrenalectomy. Despite effraction of the gland capsule, no evidence of local or port site recurrence has been observed in the cases which have been reported.
Laparoscopic adrenalectomy is feasible in dogs for right and left adrenal tumors not involving the caudal vena cava. It offers the advantages of a mini-invasive surgery including decreased pain, better visualization, less risk of dehiscence and postoperative wound complications, and shortened hospitalization time and convalescence. Although promising, further studies are required in order to compare the short and long term results of laparoscopic adrenalectomy in dogs with the ventral midline or retro-costal open approaches.

References:


How to remove the invading adrenal mass?

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Despite challenges associated with surgery, it is generally agreed that adrenalectomy is indicated in animals with functional tumours and those with characteristics of malignancy (Adin and Nelson 2012).

Anatomy (Adin and Nelson 2012)

The paired adrenal glands are located in the retroperitoneal space, closely associated with the aorta and vena cava in the cranial abdomen. The left adrenal gland is located medial to the cranial pole of the left kidney and is loosely adhered to fascia of the psoas minor muscle and the transverse process of the second lumbar vertebra. The left adrenal gland is adjacent to the left side of the abdominal aorta medially, and its caudal aspect borders the left renal artery. The right adrenal, which is further cranial than the left, is located ventral to the thirteenth thoracic vertebra and is adhered to the right side of the vena cava. In many instances, the adrenal capsule is actually contiguous with vascular adventitia. The right adrenal gland is covered by the caudal extension of the right lateral liver lobe; access to the region can be further complicated by hepatomegaly that accompanies hyperadrenocorticism. Both adrenal glands are also obscured by adipose tissue that accumulates in this region of the retroperitoneal space; however, they are easily identified by the beige appearance of the adrenal cortical tissue and by the phrenicoabdominal vein that crosses the ventral surface of each gland.

The arterial supply to the adrenal glands consists of 20 to 30 small branches arising from the phrenicoabdominal, renal, and cranial abdominal arteries and directly from the adjacent aorta. These arteries form a plexus, which is visible through the thick adrenal capsule, and send penetrating branches into the cortex and medulla. Venous blood is collected in sinusoids and drains into a single adrenal vein. The right adrenal vein empties directly into the vena cava, and the left adrenal vein empties into the left renal vein.

Surgical approaches

Flank

Advantages

- Improved exposure to dorsal abdomen
- Avoids risk of abdominal herniation (poor healing with hyperadrenocorticism)

Disadvantages

- Most suited for unilateral, uncomplicated adrenal masses (especially small lesions within the right adrenal gland)
- Requires advanced imaging to rule out other organ involvement
- Provides poor exposure of the vena cava; limited ability for vascular occlusion for cases with caval thrombi
**Ventral midline**

Advantages

- Permits examination of both adrenal glands
- Permits surgical manipulation of both adrenal glands
- Permits examination of other organs for evidence of metastatic disease
- Good exposure of the vena cava; approach of choice for cases with caval thrombi

Disadvantages

- Risk of abdominal herniation (poor healing with hyperadrenocorticism)
- Higher morbidity compared to flank approach?
- Exposure of the dorsal retroperitoneal space may be challenging in deep-chested dogs

**Laparoscopy**

- Laparoscopic adrenalectomy was first reported in 1992 and is most commonly performed for benign functional and non-functional tumours (<12 cm in size) of the adrenal glands. Laparoscopic adrenal surgery may offer several advantages including fewer wound complications, reduced morbidity, improved comfort and cosmetic appeal, reduced bleeding, better observation of abdominal organs, shorter hospital stays, and faster recovery periods (Jiménez Peláez and others 2008).

**Caval invasion**

Caval thrombi are reported in 11% to 16% of dogs with adrenocortical tumours and in 35% to 55% of dogs with pheochromocytoma. Although caval invasion is more commonly associated with right-sided adrenal masses, it was noted in 20% of dogs with left-sided tumours in one series (Kyles and others 2003).

Surgical options for the removal of caval invasion/thrombi

- Use of vascular snares – temporary, complete vascular occlusion of the caudal vena
- Placement of temporary venous bypass conduit
  - Extra-luminal
  - Intra-luminal
  - Requirement for heparinisation (100-150 IU/kg) – no requirement for protamine sulphate reversal

The classic procedure using the temporary, complete vascular occlusion of the caudal vena involves the exposure of the affected adrenal gland, the placement of vascular snares around the vena cava, cranial and caudal to the tumour thrombus (Adin and Nelson 2012).

*Note - the positioning of the venous snares is of some importance. Ideally, the caudal snares...*
should be placed cranial to the entrance of the right renal vein so that venous drainage from both kidneys is excluded from the surgical field during the venotomy/venectomy procedure. In dogs with a large thrombus extending into intraheptic vena cava, the cranial snare may be placed around the prehepatic vena cava. The snare will be left loose during the initial removal of the thrombus and only closed once the thrombus has been removed to a position that is caudal to the site of the snare. Premature tightening of a cranial snare used in this way should be avoided since it might result in the break-up of the thrombus and the development of a life-threatening pulmonary thromboembolism.

The adrenal gland is then dissected from all attachments with exception of the area where the tumour thrombus enters the vena cava. The vascular snares are then tightened, and thrombectomy is performed via an adjacent caval venotomy or partial venectomy. The site of venotomy/venectomy is closed using continuous 4-0, 5-0 or 6-0 polypropylene or polybutester (Vascufil, Covidien). In some cases, the venotomy site may be closed after placement of a partial vascular occlusion clamp across the opening allowing the early partial restoration of caval blood flow.

Note - it is often easier (and quicker) to repair the defect without placement of a partial vascular occlusion clamp).

The surgery carries a risk of significant blood loss and the surgery should, ideally, not be undertaken without the facilities to provide intra-operative and/or postoperative blood transfusions. Some surgeons advocate the use of intraoperative hypothermia in animals undergoing temporary venous occlusion of the vena cava. This may be achieved with active surface cooling (oesophageal temperature of 32°C) or by not keeping an animal with an open abdomen actively warmed during the surgery.

In most instances, the caval thrombus can be removed without performing a venectomy that, following its repair, would cause a significant venous constriction and associated compromise in venous flow. In rare instances, a significant portion of the caval wall will require resection. In such cases, repair of the resultant defect may be best accomplished by the placement of autologous venous graft (most commonly, the vein graft is harvested by sacrificing either the left or right external jugular vein). These individuals will be best heparinised to minimise the incidence of intraoperative clot formation – see below.

Malignant tumours may invade renal vasculature or parenchyma. In such cases, a concurrent unilateral nephrectomy may be required to achieve complete resection of the tumour.

There are a number of unreported techniques that can be used to maintain caval blood flow during the period of venotomy/venectomy and thrombus removal. These techniques
require either the extra-luminal or intra-luminal placement of a temporary venous bypass conduit. As a consequence of this both techniques will also require the heparinisation of the patient during the period of venous conduit use. In simple terms, this can be achieved by the intravenous administration of the 100-150 IU/kg of heparin. Ideally, an activated clotting time should be measured (with a result of >3 minutes). In most instances, there will be no requirement for the postoperative reversal of the heparin as liver metabolism of the heparin will result in a return to normal clotting function within 2-3 hours.

The routine use of perioperative anticoagulation to reduce the incidence of thromboembolic complications remains controversial. There is evidence in man that the use of perioperative anticoagulation can significantly reduce the incidence of thromboembolic complications in patients with Cushing’s syndrome (Boscaro and others 2002). The evidence for prophylactic heparinisation of small animals undergoing adrenalectomy surgery is lacking at the present.

References and further reading


**Peter Holt Prize**

**Vascular endothelial growth factor (VEGF) expression in liver biopsies from dogs with congenital portosystemic shunts**


Complete attenuation of congenital portosystemic shunts (CPSS) is associated with resolution of clinical signs in most dogs. Following surgery liver mass increases, intrahepatic portal vasculature develops and liver function improves. Vascular endothelial growth factor (VEGF) is a key regulator of angiogenesis and may be involved in the response to surgery. Our hypothesis was that hepatic VEGF and it receptor would increase following partial attenuation of CPSS associated with a corresponding increase in hepatic portal vasculature.

A retrospective study was performed on liver biopsies from dogs treated surgically for CPSS between June 2004 and June 2010. Dogs that could only tolerate partial attenuation had a second surgery performed to allow full attenuation. Immunohistochemistry was performed using a rabbit anti-human VEGF polyclonal antibody and a mouse anti-human VEGF receptor 2 (VEGFR2) monoclonal antibody. The severity of histopathological changes associated with CPSS was also assessed, including vacuolation, steatosis, portal vein hypoplasia, arteriole hyperplasia, biliary hyperplasia, fibrosis and haemosiderin. Hepatic portal vasculature development was graded on portovenogram findings both before and after temporary complete shunt attenuation. Significance for statistical analysis was set at the 5% level.

Ninety nine dogs consisting of 80 extrahepatic CPSS and 19 intrahepatic CPSS were included. Complete suture attenuation was possible in 40 dogs. A second surgery was performed in 44/59 dogs with partial attenuation. The proportion of samples expressing VEGF was significantly greater in samples from dogs with CPSS compared with control samples ($P=0.04$) and the proportion of samples expressing VEGFR2 was significantly greater in control samples compared with samples from dogs with CPSS ($P=0.04$). Between first and second surgery VEGF grade decreased significantly ($P=0.038$) and VEGFR2 grade increased significantly ($P=0.046$). There was no significant difference in VEGF expression associated with portovenogram grade or any histopathological variable. However, portovenogram grade did increase significantly between first and second surgery ($P<0.001$).

The decrease in VEGF may reflect transient expression, preferential expression of other factors, reperfusion of existing vessels and/or increased angiogenesis before surgery in the form of arterialization and subsequent reduction due to improved portal blood flow. Partial suture attenuation was associated with a degree of ‘normalization’ of VEGF and VEGFR2 expression when compared with the control samples. Further investigation is needed to provide more information on the hepatic response to CPSS surgery.
The Human experience of adrenal surgery (Sponsored by Ethicon)

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LARYNGEAL PARALYSIS IN THE OLDER DOG...WHY CALL IT GOLPP?

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ANATOMY

The rigid complex of mucosa-covered cartilage and muscle at the cranial aspect of the trachea acts largely and usually effectively to protect the airway from aspiration of unwelcome materials. These 5 laryngeal cartilages also coordinate to modulate airflow during increased exertion, expectoration, coughing, increased intra-abdominal pressure, and vocalization (more critical in some species than others). The rima glottidis airflow is controlled by active abduction or adduction of the paired arytenoids dorsally and tensing of the vocal cords ventrally (“sliding doors”). Further fortification against aspiration during swallowing is obtained by passive caudal movement of the hinged epiglottis (“trapdoor”). The only true abductor of the intrinsic laryngeal muscles is the dorsal cricoarytenoideus muscle.

Laryngeal Innervation

Laryngeal innervation is more complex and variable than is usually described, with remarkable variation within and between species; and frequent erroneous extrapolations between species have occurred. The typical description in the canine larynx includes paired cranial laryngeal nerves (CrLN) and recurrent laryngeal nerves (RLN), both arising from the vagus. The CrLN arises dorsal and rostral to the larynx, from the nodose ganglion. A small external branch innervates the cricothyroid muscle, which tilts the cricoid to the thyroid and tenses the vocal cords. The larger, internal ramus of the CrLN branches extensively to provide sensory innervation to the supraglottic larynx. The remaining intrinsic laryngeal muscles (and infraglottic sensation) are innervated via the RLNs, which branch off their parent vagus nerves in the thorax. Specifically the left RLN arises from the left vagus near the arch of the aorta, immediately caudal to the origin of the left subclavian artery. It courses caudad and curls around the dorsal aspect of the ligamentum arteriosum to run cranially alongside the trachea and toward the larynx. The right RLN arises from the right vagus opposite the 1st rib, and curls around the right subclavian artery, and subsequently runs up the right of the trachea. Both RLNs terminate as the right and left caudal laryngeal nerve. Although confusion is evident in the literature concerning the use of the term ‘caudal laryngeal nerve’ and ‘recurrent laryngeal nerve’, the accepted terminology in recent anatomic texts concur that the RLN becomes the caudal laryngeal nerve at the level of the caudal border of the cricoid. When performing anatomic dissection, this is the level at which the RLN can be seen disappearing mediad to the cricopharyngeus muscle.

Variations described in the carnivore include a separate middle laryngeal nerve in place of the external branch of the CrLN. The ramus anastomoticus (Galen’s anastomosis) is a connection between the cranial and caudal innervation of the larynx. Its exact pattern, variations, and function are neither clearly nor consistently described.

ACQUIRED LARYNGEAL PARALYSIS – WHAT WE KNEW

Acquired laryngeal paralysis has been documented in the literature for almost 40 years, presenting as a common condition in older dogs, particularly the Labrador retriever, but also other purebreds (such as German Shepherds, Golden Retrievers, Australian Shepherds, Borzois, Greyhounds, Newfoundlands, Brittany Spaniels) and mixed breeds. Because a specific cause was not identified, the term “idiopathic laryngeal paralysis”
became the universal descriptor. The condition is insidious in onset, characterized by signs of upper respiratory obstruction (stridor, dyspnea, exercise intolerance) often with severe compromise (hyperthermia, collapse). A changed bark is noted about half the time, and two-thirds of dogs have gagging, throat-clearing, ‘choking’ or coughing, usually associated with eating and drinking. Many dogs will either present as emergencies to the veterinarian, or become emergent upon routine appointment.

The acutely distressed patient will require immediate therapy to alleviate their dyspnea and hypoxia, including oxygenation, fluids, sedation, fan cooling. The patient should be observed closely for progression of obstruction. If dog is in complete airway obstruction --> intravenous barbiturate --> intubate --> either temporary tracheostomy, or “tie-back” surgery.

Surgical intervention is common, usually in the form of a unilateral crico- or thyro-arytenoid laryngoplasty, which asymmetrically widens the glottis and effectively provides a patent airway. Reported complication rates, however, are high, with aspiration pneumonia being the most clinically important (10-24%). Aspiration pneumonia can occur as early as the night of surgery, but can also develop months or even years later. Its appearance has been attributed to the surgical procedure increasing susceptibility to laryngotracheal aspiration, which is a reasonable explanation. Although several different techniques and modifications have been proposed to reduce this complication, thus far we have been unable to prevent or even significantly reduce the incidence of aspiration pneumonia. Luckily, most cases respond well to management of their pneumonia, especially when owners are educated to watch for the earliest signs – inappetence, lethargy and fever.

WHY CALL IT GOLPP

We had no way to predict which dogs will experience aspiration pneumonia, even months or years later. Once we started questioning owners carefully with a standardized questionnaire, we noted common concomitant signs of throat-clearing/gagging, so we considered looking at esophageal dysfunction (poor esophageal function is a known risk factor for aspiration pneumonia) in dogs with “idiopathic laryngeal paralysis”.

Upon closer anatomic inspection of cadavers, and an exhaustive review of the literature, we realized that the innervation of the larynx and the cranial esophagus are quite similar. Because we know the nerves to the larynx degenerate, we wondered if the nerves to the cranial esophagus also degenerated. If this were so, laryngeal and esophageal dysfunction may occur concurrently and risk of aspiration pneumonia may be able to be predicted based on esophageal function.

We conducted a 2 year, prospective study to compare esophageal function in dogs with “idiopathic laryngeal paralysis” with age- and breed-matched controls, and to see if any esophageal dysfunction could be related to the development of aspiration pneumonia during a one year follow-up. Additionally, a comparison of neurologic status was made every few months over the study period. A total of 66 dogs were enrolled – 32 affected dogs, 34 controls. Each dog underwent 3-phase esophagrams (liquid, canned food, kibble), and was scored by independent, blinded observers. After unilateral cricoarytenoid laryngoplasty, affected dogs were re-examined, including thoracic radiography, at 1, 3, 6, and 12 months. Neurologic examinations repeated at 3, 6, and 12 months.

The three most clinically significant findings of the study were:

1. Esophageal dysfunction in dogs with laryngeal paralysis was significantly worse compared to control dogs, most notably in the liquid phase. Dysfunction was more pronounced in the cranial esophagus.

2. Dogs that experienced aspiration pneumonia in the study period (18%) had significantly worse esophageal dysfunction than those dogs that did not develop aspiration pneumonia.
3. One third of affected dogs had generalized neurologic signs on enrollment, and all dogs had signs of polyneuropathy at study end (12 months).

We concluded that the disorder we have been calling “idiopathic laryngeal paralysis” for many years, is actually a chronic, progressive, polyneuropathy with early manifestations of laryngeal and esophageal dysfunction. These findings have also now been found by others. A more accurate term for the disease may be “geriatric onset laryngeal paralysis polyneuropathy”, or GOLPP. We now have over 180 dogs enrolled into our GOLPP study, where we are attempting to accurately and completely characterize the condition. We are performing esophagrams, peripheral nerve and muscle biopsies, EMGs and nerve conduction testing, and collecting DNA for genome wide association studies. We are also testing various ways of improving swallowing and decreasing regurgitation.

CURRENT PROTOCOL FOR GOLPP DOGS

Recognition of the generalized nature of this condition has probably been hampered by the fact that the laryngeal surgery is usually performed in a referral setting, and dogs return to their regular veterinarian for extended follow up; and that the neurodegeneration is slow and insidious in nature. In such cases, subsequent neurologic deterioration and swallowing issues may not have been linked to the laryngeal dysfunction. Additionally, affected dogs are often in marked respiratory distress and veterinary attention is focused on the upper airway. Without careful and rigorous neurologic assessment, early neurologic dysfunction may have been misinterpreted as weakness from hypoxia or orthopedic conditions (which are also common in these dogs). In an effort to accurately describe the natural history of this condition, the following procedures are now routinely recommended on all GOLPP dogs at MSU VTH:

- **Standardized history questionnaire**: This questionnaire is designed so that all relevant questions will be asked in a standardized manner and responses scored.
- **Neurologic examination; Ophthalmic examination; Orthopedic examination**: It is clear that neurologic issues need to be discerned from orthopedic issues, and a dedicated GOLPP Neurologic Exam form has been developed to record responses to the careful and complete neurologic exam. We have additionally seen some ocular changes in these dogs and are now completing full ophthalmic examinations by one of our veterinary ophthalmologists.
- **Pre-operative standing esophagram**: Evaluation of esophageal function in all phases of swallowing is performed fluoroscopically, in standing positions. We have designed and built an esophageal stanchion, so that dogs can eat naturally. Esophageal function is scored, esophageal transit times recorded, gastro-esophageal reflux scored, and hiatal herniation noted. If a dog has very poor esophageal function, we discuss this finding with the owners in depth, and in consideration of the dog’s respiratory compromise.
- **Laryngoscopy**: Laryngeal function is recorded on induction with a digital video-otoscope with a standard induction protocol, including 1 mg/kg doxapram IV to enhance respiratory excursions when needed.
- **Unilateral cricoarytenoid laryngoplasty**: Standardized left lateral approach is performed with disarticulation of the cricoarytenoid joint, no cricothyroid disarticulation, no interarytenoid band transection, two 0-polypropylene sutures passed around the caudal edge of cricoid and through articualr facet of the muscular process of the arytenoid. Sutures are pulled snug, but not over-tightened. Abduction is confirmed on extubation and recorded with digital still images.
• **Muscle and nerve biopsies:** At time of laryngeal surgery, the dorsal cricoarytenoideus muscle is biopsied. Left sided cranial tibialis muscle and peroneal nerve biopsies are performed in a standardized manner per previously described protocol.

• **Anesthesia protocol:** In all cases, even if esophageal function is normal on esophagram, the esophagus is suctioned immediately following induction, intraoperatively and immediately post-operatively, before recovery. Additionally, all dogs are placed on a metoclopramide CRI before surgery (1-2 mg/kg/day) and continued into the next day. Hydromorphone is avoided as a premedicating agent.

• **Electrodiagnostics:** Under anesthesia, electromyography is performed in the tongue, palatinus, esophageal, cricoarytenoideus dorsalis, cricothyroideus, superficial digital flexor, extensor carpi radialis, triceps, biceps, gastrocnemius, cranial tibialis, semimembranosus, semitendinosus, and quadriceps femoris muscles. Motor NCS are performed in the right sciatic-tibial and left ulnar nerves. Typical time for electrodiagnostics is currently 45-60 minutes.

• **Management of esophageal dysfunction:** Based on preliminary results from a positional esophagram study just completed, we recommend feeding at a 30 degree incline plane with head up, and maintaining the dog in sitting position for 10 minutes post prandially. We also prescribe metoclopramide in dogs with moderate esophageal dysfunction, and add cisapride in dogs with severe dysfunction. We do not have reliable results for the effects of cisapride, but most owners feel that metoclopramide is helpful when given before feeding and before bedtime.

• **Physical therapy:** Water treadmill physiotherapy is recommended for all dogs post-operatively. The aim is to maintain muscle mass as long as possible in the face of neurogenic atrophy. Home exercise is also encouraged, with daily long, slow walks.

• **Owner education:** We have developed owner handouts and constructed a GOLPP website (http://cvm.msu.edu/golpp) to inform owners of GOLPP dogs on this disease and its progression. Owners are educated to identify early signs of aspiration pneumonia (inappetence, lethargy, fever), as we have good success with treatment when caught early. We have found that these dogs are longtime companions and almost always regarded as much-loved members of their human family. As the condition progresses relentlessly over months to several years, euthanasia is typically requested by owners when their pet becomes non-ambulatory, or experiences repeated episodes of aspiration pneumonia from regurgitation, gagging, and/or dysphagia. Occasionally dogs will go into a cart for several months.

• **Follow up:** It is vital for us to follow affected dogs out for the remainder of their life in order for us to understand the natural history of this disease. We now follow our GOLPP dogs out every 3 months until their demise. It is already clear that most dogs will progress at a fairly steady rate, with euthanasia requested within 2-3 years. However, some dogs will progress at remarkably rapid rate. There is also a small group of dogs in which we have noted a surprisingly slow rate of neurologic deterioration. We encourage owners to participate in our post mortem donor scheme so that we can analyze brain and spinal cord tissues.

In addition to studying the natural history of this disease, we are also collecting pedigrees and blood for DNA extraction from affected dogs. We welcome the participation in many parts of our investigations by ACVS board-certified surgeons and their teams. Eventually we will understand this devastating and frustrating disease, enabling us to diagnose it earlier and manage it better, and maybe even identify a causal gene mutation.
Recommended Reading

6. Pierard JAM: Comparative anatomy of the carnivore larynx: with special reference to the cartilages and muscles of the larynx in the dog. MS: Cornell University, 1963.
Challenging Wounds and Methods of Closure

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Introduction:

From a historical perspective, veterinary reconstructive surgery is comparatively new compared to humans. Surgical reconstructive techniques have been referenced centuries ago for the management of wounds in humans. In the 1st Archibald Edition of Canine Surgery, published in 1965, ten pages were devoted to reconstructive surgery. This book was the key textbook used in most veterinary schools into the 1970’s. Today, the 3rd Edition of my Atlas of Small Animal Wound Management and Reconstructive Surgery is 680 Pages. I developed a number of these techniques to close a variety of defects involving the skin, trunk, limbs, facial region, oral cavity, and the pinna.

While use of reconstructive surgery was use largely for skin loss secondary to trauma, plastic surgery has become a necessary part of veterinary oncology. Wide resection of neoplasms has necessitated the use of a variety of flap techniques to restore function to the surgical area while improving the patient’s quality of life. Although not a primary goal per se in veterinary surgery, cosmetic results can be remarkably good in many of these challenging surgical procedures.

The Challenging Wound: Closure Options

Challenging wounds are not necessarily large but they all are problematic for various reasons. Location, size, and the tissues involved largely influence the closure options. Infection, excessive incisional tension, presence of foreign material, neoplasia, nutritional deficiencies, and inherent healing disorders [alone or in combination] can retard the healing process. When dealing with the challenging wound, close attention to the injury is required to determine the cause (causes) contributing to the failure in healing. Understanding and eliminating these causes better assures a successful outcome.

For the purposes of this one hour lecture, I will present a series of challenging cases that required the use of the following techniques:

- Transposition Flaps
- Postoperative Protection of Olecranon Wounds
- Axial Pattern Flaps
- Skin Stretchers
- Muscle Flaps
Reference:

NEGATIVE PRESSURE WOUND THERAPY

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The management of traumatic degloving and shear injuries are a continuous challenge in veterinary medicine. Frequent dressing changes over a prolonged period until the wound is suitable for reconstruction or until the wound has healed by second intention (fibroplasia, contraction and epithelialization) have been the standard-of-care management for centuries. Over the last decade, several mechanical adjuncts have been developed to enhance wound healing, including electromagnetic stimulation, magnetic therapy, ultrasound therapy, low-intensity laser, hyperbaric oxygen therapy, compression therapies, and negative pressure therapy. Of these, negative pressure wound therapy has shown the most clinical promise, not only for wound management but also in plastic, reconstructive, orthopedic, cardiothoracic, and general surgical applications.

Negative pressure wound therapy (NPWT) (also called vacuum-assisted closure, V.A.C. Therapy®, topical negative pressure therapy, sub-atmospheric dressings) was originally developed and marketed to ameliorate the healing of chronic wounds in debilitated patients, but is now widely employed in both acute and chronic wounds as well as other surgical applications, such as free skin grafts, compromised flaps, incisional dehiscences, cytotoxic sloughs, abdominal drainage, orthopedic trauma, and burns. NPWT has also become the first line of therapy in the battlefield to address complex soft tissue wounds sustained in the military arena, facilitating transport of the wounded personnel to a military hospital whilst the wound is protected, immobilized, and under NPWT. Shorter hospitalization and lower treatment costs have been documented with NPWT in human medicine. There are many case reports and series in human medicine, and several randomized clinical trials. Although experience in companion animals limited at this stage (see below, The Veterinary Experience), results have been extremely promising and this modality may well prove to be an invaluable adjunct to wound management for both large and small animal veterinarians.

NPWT MECHANISMS OF ACTION

NPWT therapy involves the distribution of a subatmospheric pressure uniformly to all tissues within the wound. Following cleansing of the wound and periwound skin, and meticulous debridement, a porous, open-cell polyurethane ether foam or saline-moistened open-weave gauze is packed onto the defect. Fenestrated tubing (or tubing with a fenestrated disc) is placed within the packing, and the whole wound area sealed with transparent, impermeable, adhesive sheets. Skin adhesive can be used to ensure contact with at least 2.5 cm of intact skin beyond wound edges. The evacuation tubing is then connected to a the reservoir canister of a programmable vacuum pump and either continuous or intermittent negative pressure applied to the sealed wound, between -80 to -125 mmHg. Once powered on, the dressing should contract noticeably, become firm to the touch and ‘raisin-like’. NPWT dressings are changed every 48 - 72 hours in small animals. It is important to check on dressing integrity and machine function regularly during this period (see below, NPWT: Practical Application).

Several mechanisms of action of NPWT have been investigated, mostly regarding fluid movement and the mechanical effects of strain on cellular behavior. This modality has been shown to decrease interstitial edema, thus increasing hydrostatic pressure within the capillaries and increase perfusion to the wound and periwound. It has been shown that the mechanical strain of the negative pressure on fibroblasts stimulates them to divide and produce collagen. The mechanical deformation of other cells within and around the wound

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and shear forces that deform the extracellular matrix are thought to result in a higher mitotic rate and increased production of granulation tissue. Enhanced bacterial clearance (i.e., a reduction in the number of bacteria in infected wounds) is claimed, but this has been inconsistently documented. Early studies in swine, now also supported in dog studies, have consistently shown significantly earlier appearance of granulation tissue, with a smoother appearance.

The use of NPWT in veterinary medicine is extremely promising, with one of the advantages being prolonged time between dressing changes (up to 72 hours). We have used this mechanical adjunct over 70 animals (mostly dogs, but also cats, horses and a rhinoceros), and it was our clinical impression that granulation tissue appears earlier in the wound, and the quality of the granulation tissue is superior. However, for NPWT to be accepted and validated in veterinary wound care, randomized, controlled, experimental comparisons in companion animals are indicated. We have recently evaluated this modality in two studies, one comparing the healing of open wounds, and the other on the acceptance of free skin grafts. These publications will further refine and validate the use of topical negative pressure therapy in veterinary medicine.

THE VETERINARY EXPERIENCE

Veterinary publications

In contrast to the plethora of publications in the medical literature, the veterinary application of NPWT has been reported infrequently. There are a handful of case reports in several species ranging from a rhinoceros to a tortoise, a retrospective clinical case series in dogs (n=15), and a recent controlled study on the effect of NPWT on the healing of open wounds in dogs.

The use of vacuum-assisted closure therapy for the treatment of distal extremity wounds in 15 dogs.


This clinical case series evaluated the outcome in 15 dogs with traumatic extremity wounds undergoing foam-based NPWT. All animals underwent successful reconstruction at an average of 4.6 days (range 2 – 7) of NPWT, following rapid development of granulation tissue within the wounds. Reconstructive procedures included 7 flaps and 8 skin grafts, with NPWT being applied following grafting as well. Complications were considered minor and included dermatitis at the wound margin and loss of vacuum causing wound desiccation. It was concluded that VAC therapy is an effective ancillary treatment for traumatic distal extremity wounds, and that VAC provides an effective method of securing skin grafts over the wound bed.

The effects of NPWT on the healing of open wounds in dogs.


This randomized, controlled, experimental study NPWT (both foam and gauze), with standard-of-care wound management in 20 forelimb wounds on 10 dogs. As the 4x4 cm wounds healed, the following outcomes were compared, at 8 time points over 21 days:

. First appearance of granulation tissue
. Smoothness of granulation tissue
. Exuberance
. Percent epithelialization of the wounds
. Percent contraction of the wounds
Histology was also performed at 5 time points, and cultures taken at 2 time points. The dogs were monitored for comfort, bandage integrity and function of NPWT machines every 4 hours during day, and every 6 hours overnight. Transducer measurements were taken at the level of the wound every 4-6 hours to verify accuracy of NPWT machine settings. Granulation tissue appeared in the NPWT wounds much earlier than in the control wounds (Day 2 v. Day 7). Quality of the granulation tissue was smoother and more consistent in the NPWT wounds, and notably irregular and exuberant in the control wounds. The NPWT wounds did not contract as well as the control wounds after Day 7; and NPWT wounds did not epithelialize as well after Day 11. Histologically, NPWT wounds appeared to reach peak acute inflammation earlier than the CON wounds: Day 4 v. Day 7. Histologic indicators of repair were similar in all wounds. It was concluded that NPWT accelerated the appearance of smooth, non-exuberant granulation tissue, however, prolonged use of NPWT impairs wound contraction and epithelializaation. All dogs were adopted at the end of the study.

Effects of NPWT on acceptance of free cutaneous grafts in dogs

Stanley BJ, Pitt KA, Weder CD, Fritz MC, Hauptman JG, Steficek BA, Michigan State University

NPWT or standard dressings were placed over 10 full-thickness, meshed sheet skin grafts. Outcomes of graft acceptance were compared between groups. Negative pressure was applied to the NPWT grafts until Day 7, then both groups were given identical bandaging. On Days 2,4,7,10,14 and 17 both CON and NPT grafts were redressed and evaluated on the following variables:

. First appearance of granulation tissue
. Percent graft necrosis
. Percentage of open mesh holes (to compare epithelialization of the meshes)
. Graft color, graft mobility and seroma formation
. Histologic indicators of acute inflammation
. Histologic neovascularization, epidermal necrosis, and epidermal hyperplasia.

First appearance of granulation tissue was significantly earlier in the NPWT grafts (2 days v 7 days). Superficial necrosis and epidermal sloughing was observed in 12.1% of the CON grafts; compared to none (0%) in the NPWT grafts. Percentage of open meshed area was significantly smaller in NPWT compared to CON grafts. NPWT grafts showed higher discoloration scores (dark purple, black) compared to NPWT grafts. Three seromas were seen under the CON grafts compared to 1 in the NPWT grafts. On Days 4 and 7, four control grafts were mobile compared with none of the NPWT grafts. Although some histologic differences were seen, they were not statistically significant. It was concluded that NPWT can be used to optimize graft survival, and may be especially valuable for large grafting procedures where immobilization is challenging. All dogs were adopted at the end of the study.

Clinical Experience

Pitt KA, Stanley BJ: condensed from Veterinary Wound Management Society Newsletter, Spring 2010

We present experience using NPWT (both gauze and foam) at Michigan State University Veterinary Teaching Hospital from 2006-2010. The following summarizes 41 wounds, comprising mostly dogs, but also a few cats, horses, and a rhinoceros. Just over half the cases presented with acute or subacute traumatic wounds, defined as no granulation tissue present within the wound. The remaining cases were usually several months old, with a few over 6 months old. Most wounds were on the limbs, with some animals having various concurrent injuries, largely fractures or other underlying orthopedic trauma (such as shear injuries, joint exposure,
hardware exposure). Cause of injury was vehicular trauma in most cases, but bite wounds were also seen, and also the occasional incisional dehiscence.

Following initial triage and any required stabilization of the patient, all wounds underwent initial management before NPWT was applied. This included periwound cleansing and assessment, wound culture, surgical wound debridement with aseptic technique, copious wound lavage with a pulsed irrigation system (Interpulse®, Stryker, Kalamazoo MI), intravenous fluids, and the administration of antibiotics and painkillers. Systems used during this time included the foam-based system, and two gauze-based systems. The foam, gauze, and other materials needed to apply the NPWT were provided in kits by their respective manufacturers. Patients had NPWT started within 2 days of admission on average, and the mean length of time on NPWT was 5.3 days (range 1 – 22). Manufacturers’ recommendations for use of NPWT changed over this time, thus some of the earlier cases were managed with intermittent suction (5 minutes on, 2 minutes off) whereas more recently cases were managed with continuous suction of between -85 and -125 mmHg. Dressing changes were performed every 2 – 3 days for both foam and gauze-based systems. The majority of patients were treated with NPWT within the hospital setting; however three patients were managed at home with NPWT and came in for their dressing changes every 72 hours. Final closure method in most of the wounds was either delayed primary or secondary closure, using a tension-relieving technique, skin flap or free graft. Some wounds were allowed to heal by second intention, and in these cases NPWT was discontinued once a smooth, vascular granulation tissue bed was evident. The wound was then managed with traditional wound dressings (ie, a non-adherent, semi-occlusive dressing). In the cases that underwent surgical closure, the NPWT machine was removed either immediately before or the day before the reconstructive effort. However, when free skin grafts were applied, NPWT was re-applied post-grafting.

Complications associated with NPWT were minor, especially as clinicians and staff gained experience in applying and utilizing this modality. Early challenges included loss of vacuum due to inadequate periwound adhesion, especially in areas such as the digits, where crevices and movement can cause drape detachment and leakage. Meticulous attention to clipping and cleansing the periwound skin, using a spray adhesive and building up of uneven surfaces such as interdigital areas with stoma paste enabled us to overcome this issue. Chewing or kinking of the tubing also caused failure of the device, but only in a couple of cases. The addition of coiled tubing to hold the suction tubing above the patient was useful in the more active patient. Once these technical issues were resolved, management became much easier. A few cases experienced superficial wound infections, and a couple of the grafts experienced partial failure (these were probably grafted too early). It was noted that cats did not tolerate the intermittent mode - there was sometimes flinching, and occasionally vocalization, when the pump started up. Although many cases developed mild skin irritation with prolonged NPWT this was reduced by allowing the original adhesive drape to remain on the periwound skin, and just cutting off the dressing immediately over the wound bed during dressing changes.

Our patients tolerate NPWT well, and maintenance of the therapy is generally without problems once we overcame initial technical hurdles and learnt tricks of ensuring adequate periwound adhesion. We are impressed with the rapid formation of a smooth granulation tissue bed, and the lack of exuberant granulation tissue formation, even in the horses. It seems that this modality may be most useful in the preparation of the wound bed for a reconstructive procedure, as a ‘bridge to reconstruction’. It also appears to ‘kick-start’ the wound bed into the reparative phase, optimizing the wound environment for epithelialization and contraction. One of the biggest advantages in using NPWT, especially in the early, highly-exudative stage of wound management, is the avoidance of daily anesthesia or sedation to change wet-to-dry dressings. The system can remain in place for 2 – 3 days between dressing changes, allowing the patient to recover adequately, eat, drink and perform other conscious functions. Additionally, strike-through is eliminated in NPWT as all exudate and wound fluids are collected into the canister.
NPWT: PRACTICAL APPLICATION

Fritz MC, Stanley BJ: condensed from Veterinary Wound Management Society Newsletter, Summer 2010

Several commercial systems are now available for the veterinarian. The most commonly employed uses a polyurethane foam and fenestrated disc, that also detects the pressure at the level of the dressing. There are also gauze based systems that obtain negative pressure through a fenestrated tube embedded into the gauze dressing. The main differences between these systems vary with the choice of primary dressing (foam or gauze) and exit drain (disc pad or fenestrated drain), and whether or not there is a sensor at the level of the dressing.

1. Ensure the patient is not contraindicated for NPWT, including a concurrent coagulopathy, poor periwound skin condition, or multiple puncture wounds that would preclude a seal. Before managing a wound, assess the patient’s overall health status and administer an appropriate level of analgesia.
2. Prepare the unit: Ensure pump battery is charged, set up the reservoir canister, and attach the line connecting the canister to the drain.
3. Prepare the wound: This is typically performed under general anesthesia immediately prior to application of NPWT. Surgically clip the periwound with liberal margins, 15 cm minimum, to ensure adequate contact area for the adhesive drape. The wound and periwound skin should be adequately cleansed and devitalized tissue debrided before placement of the apparatus. Ensure the periwound is completely dry, as any moisture will weaken adhesion of the drape. A hairdryer on low setting can be used. Apply a skin adhesive, avoiding the wound edge; allow drying period recommended by manufacturer. Many NPWT kits provide skin adhesive but other adhesives can also be applied.
4. Apply the dressing: Using aseptic technique, cut foam or fold the saline-moistened gauze dressing to wound size. The dressing should fit just inside the wound edge to avoid compression of the wound edge and adjacent periwound. Incorporate the evacuation drain within the primary dressing per manufacturer’s instructions. Gauze dressings: cut the fenestrated drain to length and tuck it within the gauze layers so that the tip lies 0.5 cm short of the wound edge. Foam dressings: the foam is cut to size and does not require moistening. The drain may sit in a pre-cut groove or there may be a fenestrated disc that adheres to the superficial aspect of the dressing. Any exposed bone, orthopedic hardware, or free graft should be covered with, a paraffin-impregnated dressing before the negative pressure dressing is placed.
5. Secure the drain: Secure the drain to the wound edge with an adhesive hydrogel (gauze drains). Place one strip directly on the skin, 2cm from the wound edge and parallel to the drain; wrap a second strip around the drain itself. Enforce the drain by covering with a horizontal strip of adhesive. It is critical to eliminate potential leaks by filling all potential depressions with coloplast or stoma paste. This is particularly important on the distal limb, where the digits can cause irregularities. The tubing from the fenestrated discs do not need securing, as they emerge from the top of the dressing.
6. Occlude the wound: Cover the primary wound dressing and the periwound with the provided occlusive adhesive drapes. When the dressing is occluded, promptly connect the end of the drain to the canister line. Turn pump to the appropriate pressure; -100 to -125 mmHg for open wounds, -60 to -80 mmHg for free grafts. If properly placed, the dressing will shrink and harden, resembling a raisin. Listen closely to the dressing for sounds of leakage (a low, moist whistling sound). Pressure may be applied continuously or intermittently, with guidelines unclear at this time.
7. Bandage: The NPWT dressing should be covered with a soft, padded bandage, incorporating the evacuation tubing into the bandage layers. Patient ambulation should be considered when measuring evacuation tubing length. Provide adequate tubing to extend from the bandage to the patient’s dorsum throughout full range of motion. Do not, however, allow too much slack so that the patient could become tangled. For limb applications, a 3-4 inch Elasticon wrap around the thorax helps to secure the evacuation tubing.
8. Monitoring and troubleshooting: Exudate may accumulate in areas of the line with a narrow lumen which will require occasional flushing. Clamp the drain distally to avoid loss of negative pressure at the wound surface and disconnect the line from the drain and canister. Using a 60cc syringe and tap water, flush the line until clear; reattach and resume NPWT. Pumps are designed to alarm with loss of pressure due to disruption of the occlusive dressing. In this case, either reinforce the dressing to regain pressure or change the dressing as soon as possible (within hours) as wound maceration may occur. To prevent pressure loss, take extra care during placement to ensure dressing integrity.
9. Dressing changes: NPWT is redressed every 48 to 72 hours and typically requires only 2-3 dressing changes before achieving adequate granulation tissue. Dressing changes take approximately 15 minutes and are usually performed under sedation or brief anesthesia. Advantages of NPWT include early appearance and improved-quality of granulation tissue, decreased dressing changes with less frequent patient sedation, and decreased overall cost. Strike through is eliminated, as all exudate is collected within the canister.

In summary, it appears that NPWT will play a beneficial role in veterinary medicine, and it has now been validated in the early management of traumatic open wounds and to increase the acceptance of free skin grafts. It also seems to be of benefit in dehiscences, flaps and possibly even closed wounds under tension. This mechanical adjunct of applying a subatmospheric pressure to wounds should be further validated with a large scale randomized clinical trial in veterinary medicine. Studies should be performed in equine, food animal as well as further clinical trials in small animals.

REFERENCES:


Wound Dehiscence: Causes and Solutions

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No clinician enjoys seeing a gaping wound present in the area of a previous surgical closure. When you consider the costs associated with open wound care, sedation, anesthesia, and a second surgery, the final bill may effectively double for the unfortunate pet owner.

There are several causes of wound dehiscence alone or in combination. They include:

- Wound closure under excessive tension
- Improper selection of suture material, patterns, and/or their placement.
- Premature suture removal.
- Circulatory compromise to the skin secondary to surgical manipulation
- Progressive circulatory compromise and necrosis secondary to trauma
- Excessive moisture resulting in tissue maceration.
- Presence of underlying infection, necrotic tissue, foreign bodies, neoplasia, or excessive fluid accumulation.
- Suturing tissues with diminished suture holding capability.
- Underlying healing disorders
- Lack of proper postoperative immobilization or protection of the surgical area (including patient licking).

Looking at this list, one can note how a combination of these causes can contribute to dehiscence. For example, closing skin, with partially compromised circulation secondary to vehicular trauma, under tension can cause further ischemia. With the presence of motion, the sutures stretch and tear through the skin (suture “cut out.” ) The patient may lick at the sensitive area, enhancing local trauma and introducing bacterial contamination. In this realistic example, both the veterinarian and pet owner play an important role in preventing wound dehiscence.

In otherwise healthy wounds (resection a mast cell tumor, for example), avoiding excessive incisional tension, using the appropriate supportive suture patterns, and the proper postoperative protection from disruptive forces alone can dramatically reduce the risk of wound dehiscence. Reducing incisional tension may include careful undermining of the skin (minimizing circulatory compromise), effective selection of tension relieving techniques (release incisions, Z-plasty), use of local skin flaps (especially the transposition flap), and the use of tension relieving devices (including skin stretchers prior to surgery or postoperatively) can dramatically reduce the risk of dehiscence. My personal choice of suture patterns for
closing a problematic wound include: buried absorbable intradermal sutures; simple interrupted suture closure combined with vertical mattress suture placement in those incisional areas under tension. A layer of surgical cyanoacrylate glue can be applied over the suture line for an added footprint of security. Skin staples are best avoided to close skin closed under tension: metallic staples have a tendency to deform and open in this situation.

Postoperatively, bandages and splints may be used to reduce motion regional motion( the carpal area as one example). Elizabethan collars, cervical collars, and body braces also can be used to prevent the patient from disturbing the incision.

Prior to surgery, the veterinarian should assess the regional skin tension, the potential local donor area(s) for flap development, and the potential risks based on location. Referring potentially problematic cases to an experienced surgeon may be a sensible option to reduce the trials and tribulations of wound dehiscence.

Reference: