NVF Veterinary Foundation

• SKILL • KNOWLEDGE • EMPOVERMENT • LEADERSHIP

1st & 2nd March, 2025

Venue:

RPS College of Veterinary Sciences
Mahendergarh, Haryana

NVF Hands-On Workshop

Prime Sponsor

drools®
Feed Real. Feed Clean.

VET EXPERT BASED ON EVIDENCE · SAVAVET Shaping the Future · TACO · ROYAL CANIN INCREDIBLE IN EVERY DETAIL · ENAVANT PETCARE · SKY EC Committed to Quality

ORGANISER

NVF VETERINARY FOUNDATION®

Regd. Office : 5/39, Old Rajinder Nagar, New Delhi-110060
E-mail: nvfworld@gmail.com • **Website:** www.nvf.world

NVF BOARD MEMBERS

Dr. K.G. Umesh
President
Board Member

Dr. Lakshmi Srinivasan
Board Member

Dr. S. Ayyappan
Board Member

Dr. Yathiraj
Board Member

Dr. Jasjeet Josan
Board Member

Dr. Rishi Sood
Board Member

Dr. Praydut Sarmah
Board Member

NVF Scientific Advisory Committee (NVF-SAC)

Dr. Umesh Karkare
Vet. Surgeon, Mumbai
Chairman, Scientific Advisory

Dr. G N Purohit
Professor, Dept. of Veterinary Gynaecology And Obstretics, RUVAS, Rajasthan

Dr. Nagarajan L
Professor, TANUVAS, Presently at University of The West Indies, St. Augustine

Dr. Nambi A P
Professor and Head, Dept. of Veterinary Preventive Medicine, TANUVAS, Chennai

Dr. T K Gahlot
Professor and Head, Dept of Veterinary Surgery & Radiology, RUVAS, Rajasthan

Dr. Naresk K Rakha
Professor and Dean-PGS, LUVAS, Hisar, Haryana

Dr. Ramani
Professor,Dept. of Veterinary Surgery And Radiology, TANUVAS, Chennai

Dr. Jeyaraja K.
Professor,Dept. of Veterinary Clinical Medicine, Madras Veterinary College, Chennai

Dr. P Sridevi
Professor,Dept. of Clinics, TANUVAS, Chennai

Dr. S P Tyagi
Professor and Head, Dept of Veterinary Surgery & Radiology, CSKHPKV, Palampur

NVF CE Moderators and Advisory Committee (NVF-CMAC)

Dr. Shiwani Tandal
Vet. Surgeon, Mumbai

Dr. Sunita Nauriyal
Vet. Surgeon, New Delhi

NVF Animal Welfare and Ethics Advisory Committee (NVF-AWEAC)

Maj.Gen. R.M. Kharb AVSM
Chairman, Animal Welfare Board of India

Dr. S. Chinny Krishna
Board Member, World Society For the Protection of Animals (WSPA)

NVF Advisory Committee (NVF-AC)

Dr. Amardeep Singh
Vet. Surgeon, Uttarakhand

Dr. Amarnath M.
Vet. Surgeon, Salem

Dr. Amber Mishra
Vet. Surgeon, UP

Dr. Sanjib Kakoti
Vet. Surgeon, New Delhi

Dr. Annie Varghese
Vet. Surgeon, Trivandrum

Dr. Praveen Kumar
Vet. Surgeon, Hyderabad

Dr. S.P. Singh
Vet. Surgeon, Shimla

Dr. Vinay Gorhe
Vet. Surgeon, Pune

Dr. Parampal Singh
Vet. Surgeon,Bathinda

Dr. Bhanu Khajuria
Vet. Surgeon, Jammu

Dr. Aparajita
Vet. Surgeon, Kolkata

Dr. Manmohan Sharma
Sr. Vet. Surgeon, New Delhi

Dr. Neelam Singh Josan
Vet. Surgeon, Gurgaon

Dr. Kunal Sharma
Vet. Surgeon, New Delhi

Dr. Manjeet Singh
Vet. Surgeon, Punjab

Dr. Sanmant Jain
Vet. Surgeon, Ghaziabad

Dr. P.S. Mohan Kumar
Department of Biomedical Sciences
Josiah Meigs Distinguished
Teaching Professor

Biography
Research Interests
Neuroendocrinology Reproductive Aging, Stress Axis and Metabolic Function Neuroendocrine-Immune Interactions Prenatal Programming and its Neuroendocrine Consequences Neuroendocrine Effects of Exposure to Environmentally Relevant Chemicals

Educational Background
BVSC (1988)- Madras Veterinary College, India
PhD (1993) Neuroendocrinology, Kansas State University, Manhattan, KS
Postdoctoral (1994-1997) Neuroendocrinology, Department of Molecular & Integrative Physiology, University of Kansas Medical Center, Kansas City, KS

Clinical Anatomy Lectures 1-6

Puliyur S. MohanKumar
Josiah Meigs Distinguished Professor
College of Veterinary Medicine
University of Georgia, Athens, GA 30602, USA

Importance of anatomy in clinical practice – Lecture 1

Puliyur S. MohanKumar, BVSc, PhD
Josiah Meigs Distinguished Professor
College of Veterinary Medicine
University of Georgia, Athens, GA 30602, USA

Canine Abdominal Anatomy: Implications for surgical procedures – Abdominal wall, peritoneum and omenta (Lecture 2)

Puliyur S. MohanKumar, BVSc, PhD
Josiah Meigs Distinguished Professor
College of Veterinary Medicine
University of Georgia, Athens, GA 30602, USA

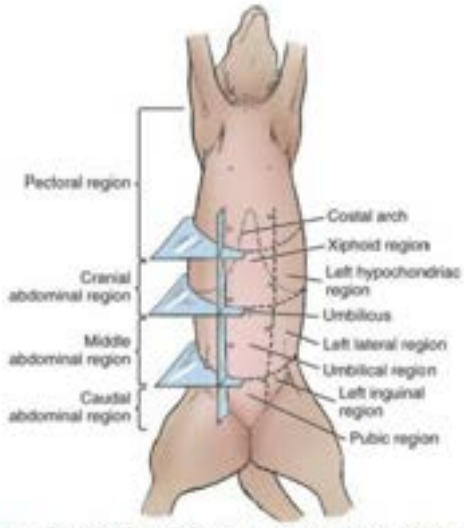


FIG. 7.33 Regions of the abdomen as determined by sagittal and transverse planes.

Abdominal wall

- Muscles
  - Ventrolateral group – 4 muscles
  - 3 broadsheets superimposed on each other with different fiber orientation
  - An aponeurotic tendon inserting upon the midline – ***LINEA ALBA***
    - ***External abdominal oblique (EAO)*** – *arises from lateral ribs and lumbar fascia – caudoventral direction to its insertion on* ***linea alba*** *and pelvic brim.*
    - ***Internal abdominal oblique (IAO)*** – *arises from tuber coxae (and surrounding fascia and lumbar transverse processes) – passes craniоventral to last rib and* ***linea alba.***
    - ***Transverse abdominal*** – *arises from inner surfaces of last ribs and transverse processes of lumbar vertebrae - inserts upon* ***linea alba*** *- does not extend beyond the caudal part of tuber coxae – the caudal part remains uncovered dorsally*
    - ***Rectus abdominus*** – *arises from ventral ribs and sternum and inserts on the* ***pelvic brim*** *and* ***prepubic tendon***

Dorsolateral group (Sublumbar): Psoas Minor, Iliopsoas (psoas major and iliacus), Quadratus lumborum

From Miller and Evans' Anatomy of the Dog

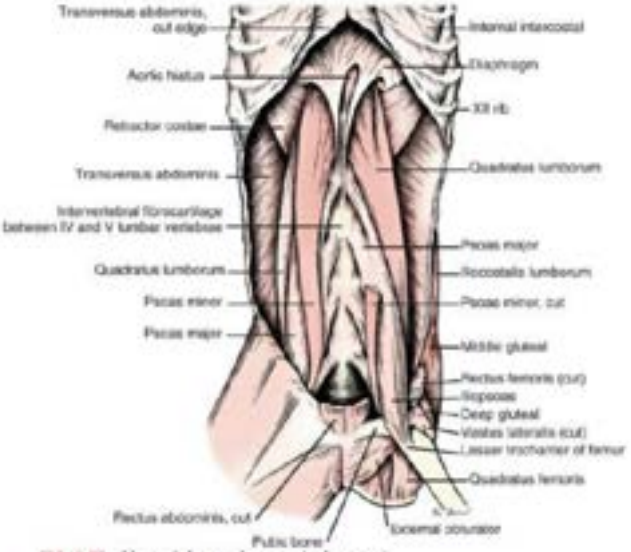
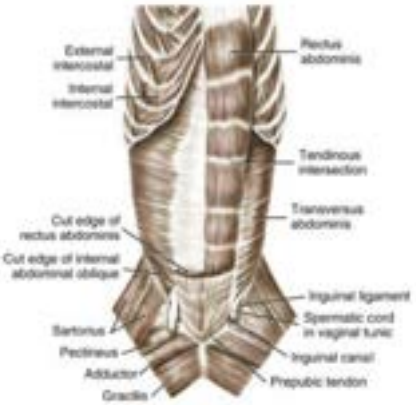


FIG. 6.67 Hypaxial muscles, ventral aspect.

FIG. 6.37 Superficial muscles of trunk, ventral aspect. (M. pectoralis profundus removed.)

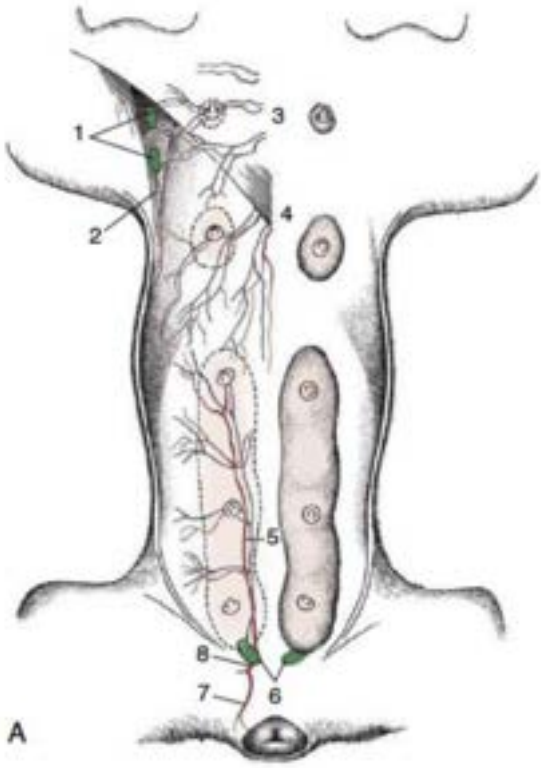


Interactive exercises

Blood supply to abdominal wall

- Segmental lumbar arteries from aorta
- Cranial abdominal a. from Phrenicoabdominal
- Deep circumflex a. – paralumbar fossa area
- Cranial superficial epigastric a.
- Caudal superficial epigastric a.

The superficial epigastric arteries are well developed in lactating animals



From Textbook of Veterinary Anatomy, Dyce, Sack and Wensing

Interactive exercises

- Virtual skills/dissection

Innervation to abdominal wall

- More relevant in large animals
- Epaxial muscles – dorsal branches of spinal nerves
- Skin on the dorsal ½ of the abdomen – lateral thoracic nerve

Peritoneum

- **Serous membranes lining the abdominal and pelvic cavities and the abdominal organs**
  - Parietal – lining of the abdominal and pelvic cavities
  - Visceral – covering of the abdominal organs
- Organs covered on only one surface by peritoneum are called **'retroperitoneal'** and organs that receive nearly complete covering are called **'intraperitoneal'**.
- Parietal and visceral layers are continuous with one another at a number of sites – consists of two layers – Ex. Ligaments, mesenteries, omenta
- Between the parietal and visceral layers are various amounts of connective tissue, fat and lymph nodes. Vessels and nerves supplying organs also run through these layers.
  - None of these structures lie in the peritoneal cavity

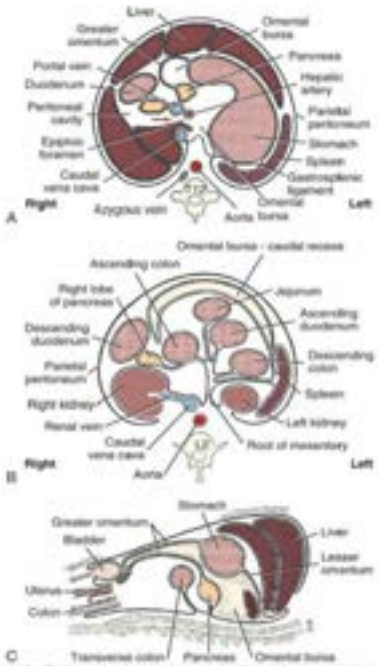


FIG. 7.36 Peritoneal schema as viewed with the dog in a supine position. A, Transverse section through the epiploic foramen (*red arrow*). B, Transverse section through the root of the mesentery. C, Sagittal section.

From Miller and Evans' Anatomy of the Dog

Peritoneum

<u>Ligaments:</u>

Peritoneal ligaments connect organs, or to the lateral and ventral body wall.

<u>Mesentery:</u>

Suspends organs from dorsal body wall – Prefix 'meso'

<u>Root of mesentery:</u>

Mesentery 'bunching up' like a curtain – intestine in suspended in from a small area – vessels and nerves to the intestines arise at this area – <u>Constant between species</u> – **Ventral to L2** – <u>important surgical radiographic landmark.</u>

Figure 3–32 Schematic transverse section through the abdomen of the dog. *1*, Visceral peritoneum *(continuous line)*; *2*, parietal peritoneum *(broken line)*; *3*, root of mesentery; *4*, *4'*, right and left kidneys (retroperitoneal); *5*, spleen; *6*, jejunum; *7*, descending duodenum.

From Miller and Evans' Anatomy of the Dog

Omentum

- **Greater omentum**
  - Is the dorsal mesogastrium
  - **Attaches the greater curvature of the stomach to the body wall**
  - Superficial leaf
  - Deep leaft
  - **Omental bursa** - hernia
  - **Epiploic foramen** – right of the median plane – Boundaries: craniodorsal – caudate process of the liver and the caudal veneca; Caudoventral – portal vein
  - **Phrenicosplenic ligament; Gastrosplenic ligament**
- **Lesser omentum**
  - Is the ventral mesogastrium
  - **Attaches the lesser curvature of the stomach to the liver**
  - **Hepatoduodenal ligament** – portion of the lesser omentum that goes from the liver to the duodenum
  - **Hepatogastric ligament** – the lesser omentum that goes from the liver to the stomach

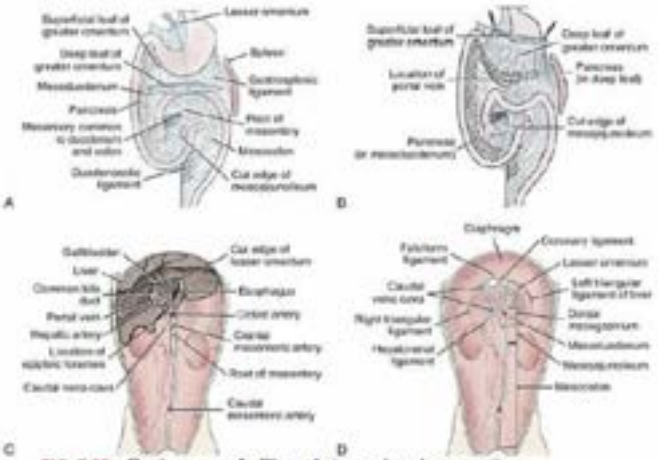


FIG. 7.35 Peritoneum. **A**, Plan of visceral and connecting peritoneum, ventral aspect. The greater omentum is transected caudal to the stomach. Red arrow in epiploic foramen. **B**, Plan of peritoneum with greater omentum reflected cranially. The transverse colon is displaced caudally. **C**, Plan of the dorsal reflections of the connecting and parietal peritoneum. The stomach and intestines removed. **D**, Plan of the dorsal reflections of the connecting and parietal peritoneum. All abdominal viscera removed.

From Miller and Evans' Anatomy of the Dog

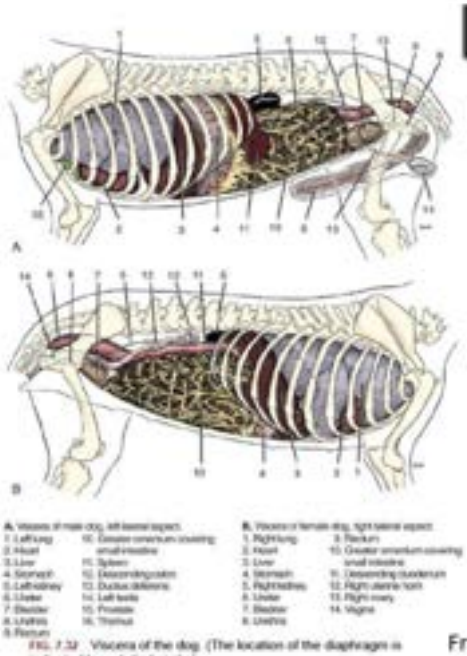


FIG. 7.32 Viscera of the dog. (The location of the diaphragm is indicated by a dotted circle.)

From Miller and Evans' Anatomy of the Dog

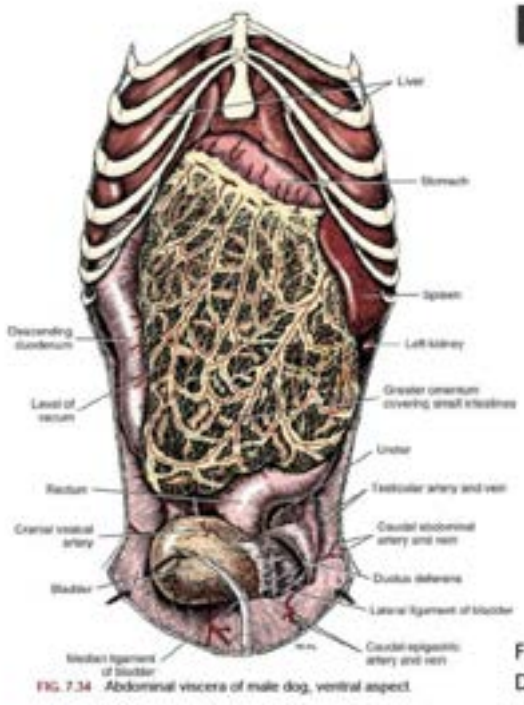


FIG. 7.34 Abdominal viscera of male dog, ventral aspect.

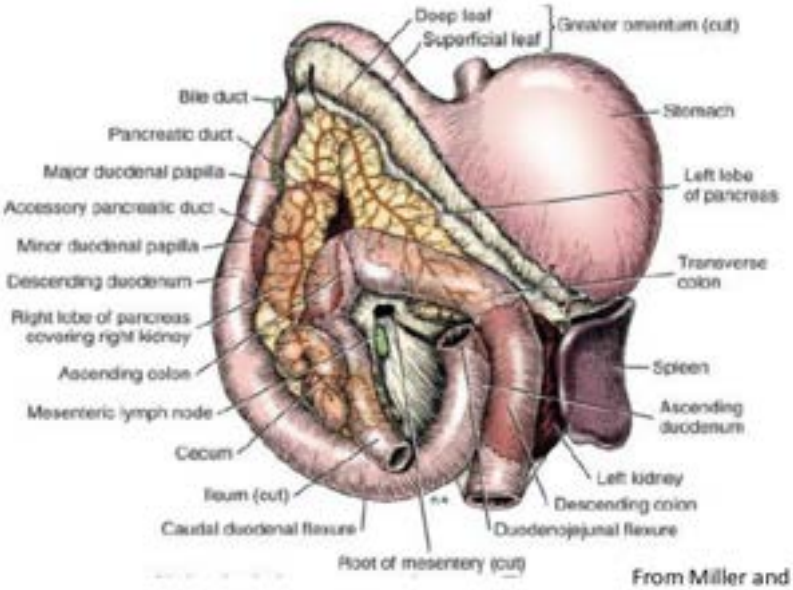
From Miller and Evans' Anatomy of the Dog

Canine Abdominal Topographical Anatomy: Implications for surgical procedures (Topography, Peritoneum, Diaphragm) (Lecture 3)

Puliyur S. MohanKumar, BVSc, PhD
Josiah Meigs Distinguished Professor
College of Veterinary Medicine
University of Georgia, Athens, GA 30602, USA

Topographical Abdominal Anatomy - interactive

- Structures on the left of midline
  - Parts of the stomach, spleen, ascending duodenum (?), left lobe of pancreas, lobes of liver, left kidney, descending colon
- Structures on the right of midline
  - Parts of the stomach, descending duodenum, caecum, ascending colon, right kidney, right lobe of the pancreas,
- Structures along the midline
  - Abdominal aorta
  - Caudal venecava
  - Root of mesentery
  - Vessels providing the abdominal viscera – orgination
  - Autonomic structures



From Miller and Evans' Anatomy of the Dog

Importance of knowing the topography

- Palpation
- Ultrasound
- Surgeries

Interactive exercises

- Virtual skills

Diaphragm

- Musculotendinous separation between thoracic and abdominal cavities
- Projects into the thoracic cavity like a dome
- Attaches to the ventral surfaces of the vertebrae, the ribs and sternum
- The central tendon
- Thoracic side
  - Pleura??
  - Separated from the pleura by the endothoracic fascia
- Abdominal side
  - Separated from the peritoneum by transversalis fascia

Diaphragm (continued)

- Crus of the diaphragm
- Openings for structures to pass through
  - Aorta
  - Venecava
  - Esophagus

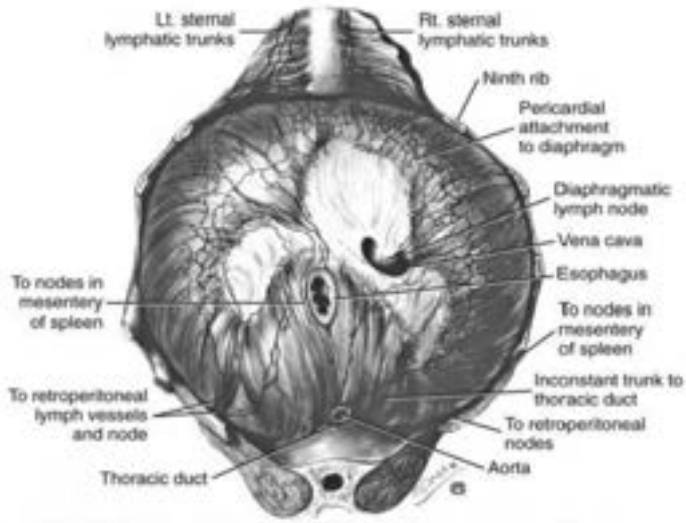


FIG. 13.11 The pleural surface of the diaphragm in a dog after the intraperitoneal injection of a graphite preparation. (From Higgins GM, Graham AS: Lymph drainage from the peritoneal cavity in the dog, *Arch Surg* 19:453–465, 1929. Copyright 1929, American Medical Association.)

From Miller and Evans' Anatomy of the Dog

Blood supply and innervation

- Blood supply: Caudal phrenic and other branches from aorta
- Nerve: Phrenic nerve

Interactive exercises

Canine Abdominal Anatomy: Stomach, Liver, Gall bladder, Spleen and Kidney (Lecture 4)

Puliyur S. MohanKumar, BVSc, PhD
Josiah Meigs Distinguished Professor
College of Veterinary Medicine
University of Georgia, Athens, GA 30602, USA

Liver

- Lies almost entirely on the intrathoracic part of the abdomen
- Immediately caudal to the diaphragm
- Diaphragmatic surface (cranial) is convex (adapts to the concavity of the diaphragm)
- Visceral surface (caudal) is concave and is related to stomach.
- Dorsal border is related to esophagus, right crus of the diaphragm and caudal venecava

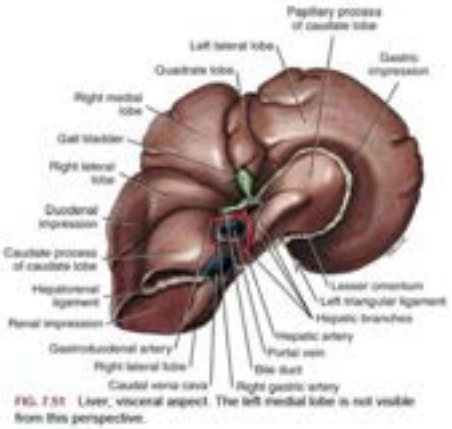
Blood supply and ligaments

- Receives arterial and venous supply
- Hepatic artery
- Portal vein
- Falciform ligament
- Round ligament of the liver
- Coronary ligament
- Triangular ligaments
- Hepatorenal ligament
- Lesser omentum

From Miller and Evans' Anatomy of the Dog

Lobes of the liver

- Left medial
- Left lateral
- Right medial
- Right lateral
- Quadrate
- Caudate – Caudate and papillary processes
- Renal fossa/impression



From Miller and Evans' Anatomy of the Dog

Gall bladder

- Embedded in the fossa between _____ lobe and _____ lobe
- Cystic duct
- Hepatic duct
- Bile duct (Major duodenal papilla – where is it located?)

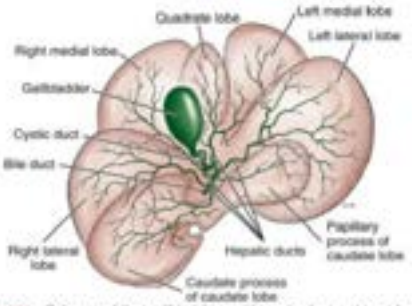
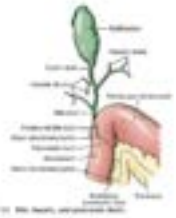


FIG. 7.52 Schema of the gallbladder and hepatic ducts, visceral aspect.



From Miller and Evans' Anatomy of the Dog

Spleen

- Located on the left side of the abdominal wall
- Vessels enter and leave the hilus
- Blood supply: splenic artery

Stomach

- Greater and lesser curvatures
- Cardiac, Fundus and Body
- Pyloric part (consists of all three below)
  - Pyloric antrum – funnel shaped proximal part
  - Pyloric canal – the narrower, tubular distal part
  - Pylorus – opening between stomach and duodenum – pyloric sphincter

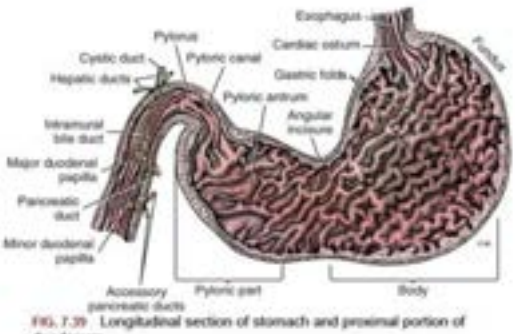


FIG. 7.39 Longitudinal section of stomach and proximal portion of duodenum.

From Miller and Evans' Anatomy of the Dog

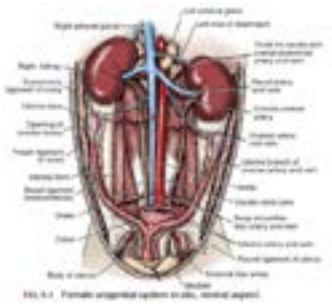
Interactive exercises

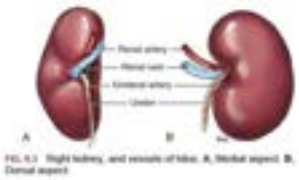
Blood supply and innervation

- Branches of abdominal aorta
- Autonomic nervous system

Kidneys

- Paired – which is more cranial?
- Blood supply
  - Renal artery
- Innervation
  - Autonomic

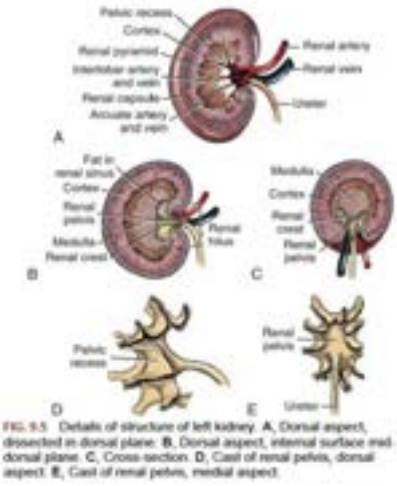




From Miller and Evans' Anatomy of the Dog

Kidneys

- Enclosed by a tough fibrous tissue capsule
- Cortex – contains most of the glomeruli
- Medulla – primary tubules
- Dog: Cortex, Medulla, Renal crest, Pelvis, ureter
- Renal pyramid, Renal papilla
- Hilus – receives renal vessels and has the ureter
- Renal sinus



From Miller and Evans' Anatomy of the Dog

Ureter

- Penetrates the dorsal wall of the bladder at an oblique angle near its neck
- Ectopic ureters – may end blindly – causes hydronephrosis or may terminate in uterus, vagina or urethra causing urinary incontinence

Bladder

- Apex, body, neck, trigone
- Detrusor muscle
- Sphincter – Primarily a physiological (not an anatomical) structure
- Ligaments:
  - Lateral ligaments, Median ligament
- Blood supply:
  - Cranial and caudal vesicular arteries
- Innervation
  - Autonomic and somatic

Urethra

- Intrapelvic and extrapelvic
- Female urethra is short and is completely intrapelvic

Canine Thoracic Anatomy - 1 (Lecture 5)

Puliyur S. MohanKumar, BVSc, PhD
Josiah Meigs Distinguished Professor
College of Veterinary Medicine
University of Georgia, Athens, GA 30602, USA

Bony thorax

- Thoracic vertebrae dorsally, ribs laterally and sternum ventrally
- Thoracic inlet
  - T1 vertebra, first pair of ribs, manubrium of sternum
- Caudal thoracic opening (thoracic outlet)
  - Last thoracic vertebrae, last pair of ribs, costal arch and xiphoid process of sternum – sealed by the diaphragm
- The first 4-5 pairs of ribs are straight and relatively fixed and provide support
  - Caudal pairs are curved and swing in a 'bucket handle' fashion; swinging cranially widens and shortens the thoracic cavity and coupled with caudal movement of the contracting diaphragm increases the volume of the thoracic cavity and draws air into the lungs
- Epaxial muscles
- Hypaxial muscles

Blood supply and innervation

- Arterial
  - Intercostal arteries
  - Dorsal from aorta
  - Ventral from internal thoracic artery
- Venous
  - Intercostal veins
    - Dorsal intercostal veins drain into azygos
    - Ventral intercostal veins drain into the internal thoracic vein (unpaired) and then into the cranial venecava
- Innervation

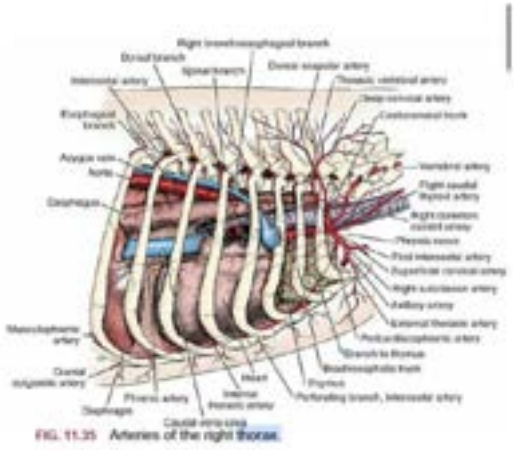
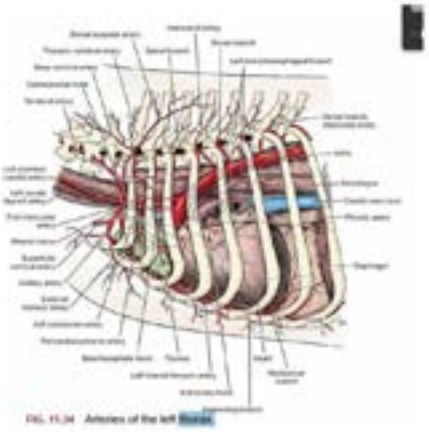
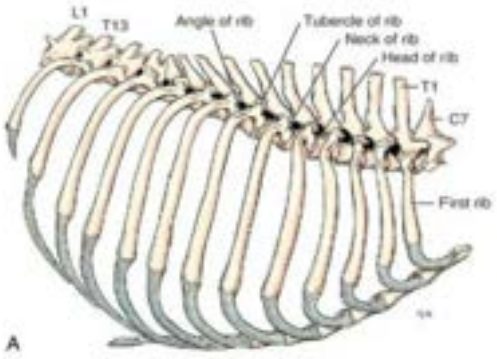


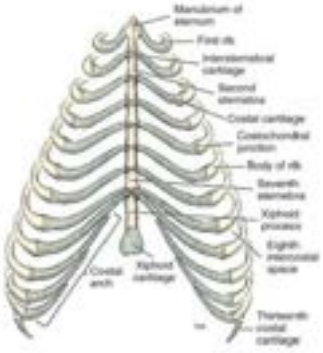
FIG. 11.35 Arteries of the right thorax.



From Miller and Evans' Anatomy of the Dog

Ribs and sternum





From Miller and Evans' Anatomy of the Dog

Interactive exercise

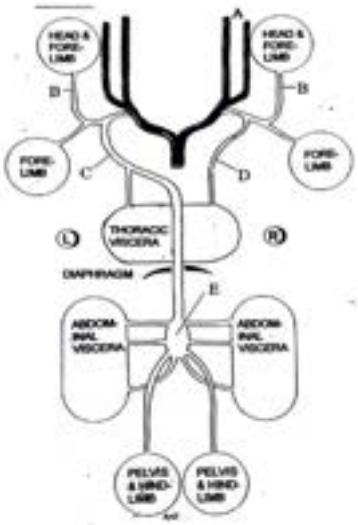
- Bifid sternum

Mediastinum

- Space between left and right pleural sacs
- More or less median in the thorax
- Heart and other organs are located
- It is unclear whether the two pleural sacs communicate
  - Unilateral Pneumothorax or pyothorax tends to remain unilateral, but to be safe one should consider any traumatic pneumothorax including surgical thoracotomy to be bilateral and provide mechanical assistance to breathe.

Lymphatic system in the thorax

- Lymph vessels return fluids from the tissue interstitium to the blood stream via the great veins
- Lymph nodes - situated along the length of the lymphatic vessels are like filters – remove and destroy any particulate matter, microorganisms within the lymph.
- The left lymphatic duct – Thoracic duct
  - Major – drains the left side of the thoracic viscera and from the entire body caudal to the diaphragm
- The right lymphatic duct
  - Drains from the right side of the thorax



Lymphatics

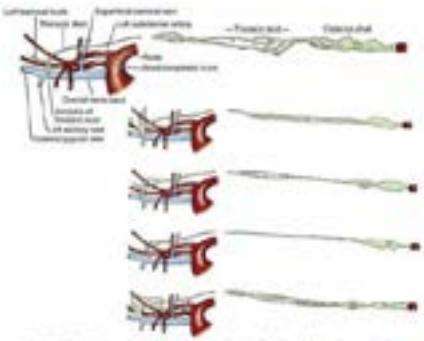
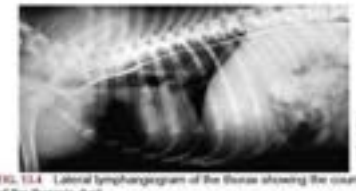


FIG. 13.3 Some variations of the thoracic duct and its entrance into the cranial vena cava. (Modified from Haller F. *Der Ductus thoracicus*. Inaugural dissertation, Dresden, 1908.)



From Miller and Evans' Anatomy of the Dog

FIG. 13.4 Lateral lymphangiogram of the thorax showing the course of the thoracic duct.

Chylothorax

Canine Thoracic Anatomy - 2
(Lecture 6)

Puliyur S. MohanKumar, BVSc, PhD
Josiah Meigs Distinguished Professor
College of Veterinary Medicine
University of Georgia, Athens, GA 30602, USA

Swallowing vs normal respiration

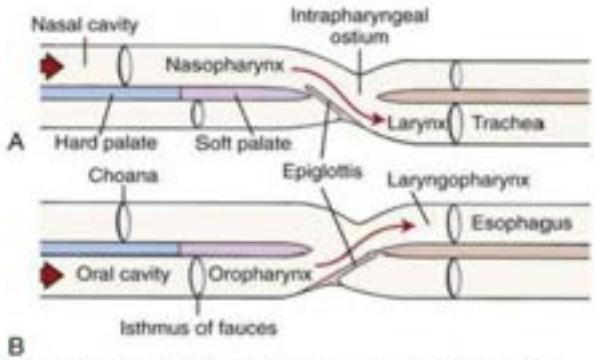


FIG. 8.10 Diagram showing relation of portions of pharynx to esophagus and trachea. **A**, During normal respiration. **B**, During swallowing.

From Miller and Evans' Anatomy of the Dog

Trachea and airways

- Trachea bifurcates above base of heart
  - Left and right principal/primary bronchi
  - Lobar/secondary bronchi which enter each lung lobe
- Lung lobes are determined by the presence of lobar bronchi and NOT by external fissures

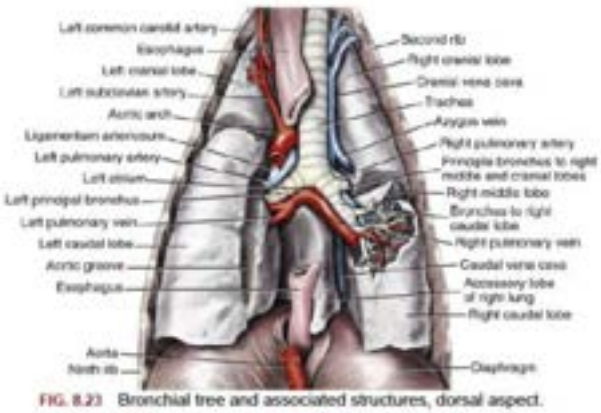
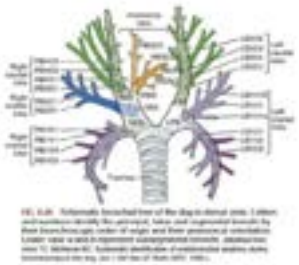


FIG. 8.23 Bronchial tree and associated structures, dorsal aspect.

From Miller and Evans' Anatomy of the Dog



Pleural membranes

- Pleurae
- Visceral and parietal pleurae are held together by negative pressure (vaccum) existing within the pleural sac
  - Surgical or traumatic opening in the chest wall may allow an intake of air into the pleural cavity – recoils the lungs – pneumothorax
  - Fluid (pus, blood, lymph, etc.) may accumulate between the pleural layers – difficulty in breathing – named after the type of fluid
  - Inflammation of the pleural membranes (pleuritis or pleurisy) – can cause them to adhere to one other – difficult and painful respiratory movements

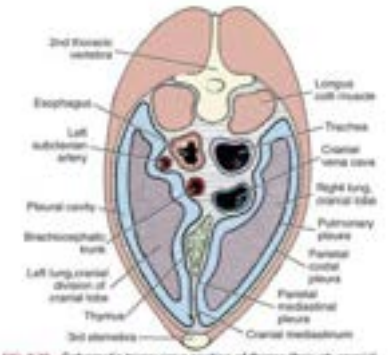


FIG. 8.30 Schematic transverse section of thorax through cranial mediastinum and lungs. Caudal aspect. Orientation differs from that of Fig. 8.29.

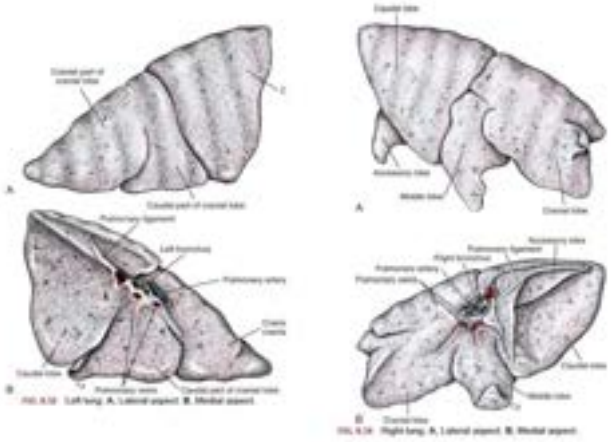
From Miller and Evans' Anatomy of the Dog

Pleurae and recess

- Lungs don't occupy the thoracic cavity fully
  - Costodiaphragmatic recess
  - Pleural cupula
    - May extend past the first rib
    - Vulnerable for puncture wounds of the neck

Lungs

- Left
  - Cranial lobe
    - Cranial part
    - Caudal part
  - Caudal lobe
- Right
  - Cranial lobe
  - Middle lobe
  - Caudal lobe
  - Accessory lobe



From Miller and Evans' Anatomy of the Dog

Cardiac notch

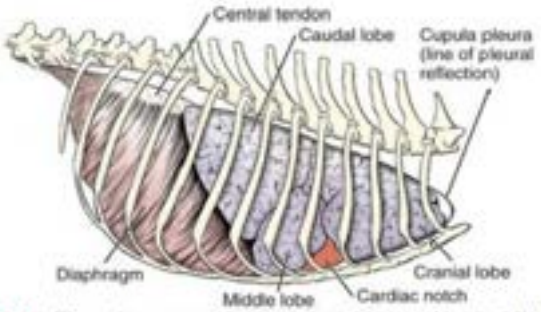
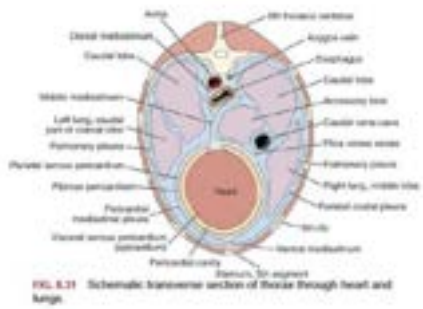


FIG. 8.33 Thoracic cage and lungs. (Lungs hardened in situ.) Right side.

From Miller and Evans' Anatomy of the Dog

1. Right cranial lung lobe
2. Right middle lung lobe
3. Right caudal lung lobe
4. Accessory lung lobe
5. Cranial part of left cranial lung lobe
6. Caudal part of left cranial lung lobe
7. Left caudal lung lobe
8. Caudal mediastinum
9. Trachea
10. Right ventricle
11. Left ventricle
12. Aorta
13. Caudal vena cava
14. Heart



From Miller and Evans' Anatomy of the Dog

Interactive exercises

Heart

- Chambers
- Flow of blood in the fetus
- Flow of blood in the adult
- Vascular ring abnormalities
- Developmental abnormalities
- Membranes of the heart

Interactive exercises

Nerves in the thoracic cavity

- Somatic structures
- Autonomic structures

Dr. Chad Schmiedt

Small Animal Medicine & Surgery,
Soft Tissue Surgery Service,
Veterinary Teaching Hospital
Professor Alison Bradbury Chair in Feline Health

Dr. Chad Schmiedt received his DVM from the University of Georgia, College of Veterinary Medicine in 2000. Following five years of post-graduate surgical training at the University of Tennessee, the Dallas Veterinary Surgical Center, and the University of Wisconsin-Madisonand a two year clinical instructorship at the University of Wisconsin-Madison, in the summer of 2007 Dr. Schmiedt returned to UGA to join the faculty at the College of Veterinary Medicine as a soft tissue surgeon. Dr. Schmiedt is board-certified by the American College of Veterinary Surgeons and holds the Alison Bradbury endowed chair within the Department of Small Animal Medicine and Surgery. He is the section head of the small animal medicine and surgery section and also runs the feline renal transplantation program at UGA. Dr. Schmiedt commonly sees referral and emergency clinical cases on the soft tissue surgery service at the Veterinary Teaching Hospital and runs an active research program focusing on kidney disease in cats.

Diaphragmatic Hernia Repair in Dogs and Cats

Chad Schmiedt DVM, DACVS-SA
Professor, Small Animal Surgery
Alison Bradbury Chair of Feline Health
University of Georgia

Agenda

- Types of hernias
- Diaphragmatic anatomy
- Stabilization
- Anesthetic considerations
- Repair technique
- Post operative care

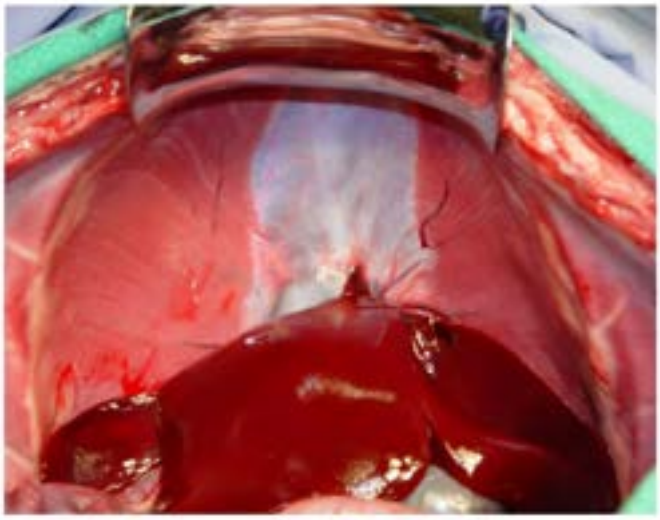
Diaphragmatic Hernia

- Traumatic
- Congenital –
  - Pleuroperitoneal -
  - Periteoneal pericardial diaphragmatic hernias (PPDH)
- Hiatal

Diaphragm Anatomy

- Central tendon
- Pars costalis, sternalis, lumbalis
- 3 holes:
  - Caval foramen
  - Esophageal hiatus
  - Aortic hiatus
- Local helpful muscles:
  - Transversus abdominus
  - Rectus abdominus

Diaphragm Anatomy



Traumatic Diaphragmatic Hernia

Physical Exam and Diagnosis

- Dyspnea of varying degrees (38% of patients)
- Tucked up abdomen – wasp waist
- Muffled heart or lung sounds
- Unilaterally increased heart sounds (opposite hernia)
- Borborygmi in the thorax
- Orthopnea
- Sitting up
- Gastrointestinal signs (vomiting, dysphagia, diarrhea, constipation)

- Asymptomatic

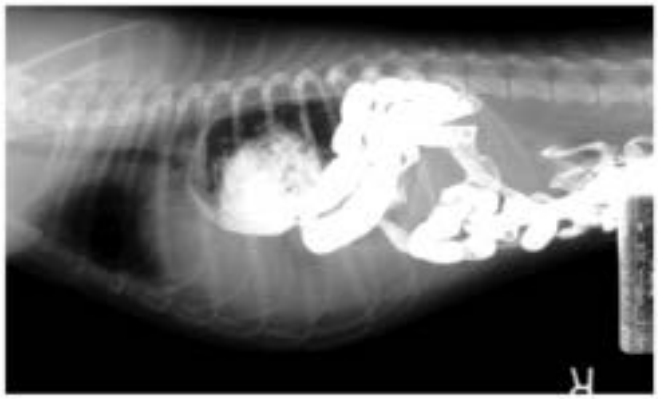
Radiographic Diagnosis

Thoracic radiographs are most useful

Loss of diaphragmatic line on lateral projection in 66 – 97%

Viscera in thorax, obscured cardiac shadow, pleural effusion

Oral contrast may aid in diagnosis



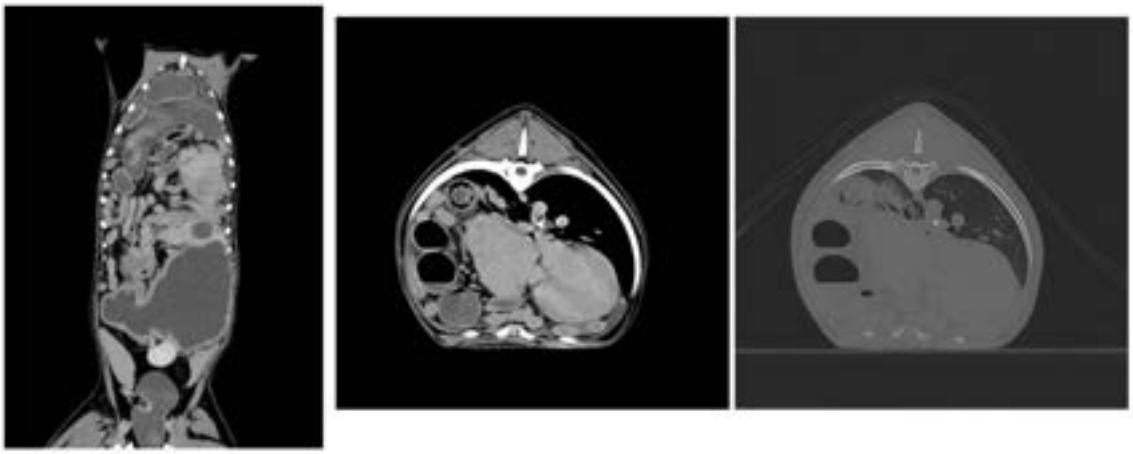
Opposite lateral may also help

Positive contrast peritoneography

Potential for false negatives (low sensitivity)

CT scan helpful for difficult cases

4 yr, FS, MBD
Chronic DH
History of corn cob ingestion



335941

Timing of Surgery: Acute vs. Chronic Hernias

- Acute hernias –
  - Traumatic injury may have other systemic consequences
  - Bullae, shock, pneumothorax, traumatic myocarditis, hemothorax

- Chronic hernias -
  - Pleural effusion
  - Adhesions
  - Loss of abdominal domain

Survival of Acute vs. Chronic Hernias

Pathophysiology of Traumatic Diaphragmatic Hernia in Dogs

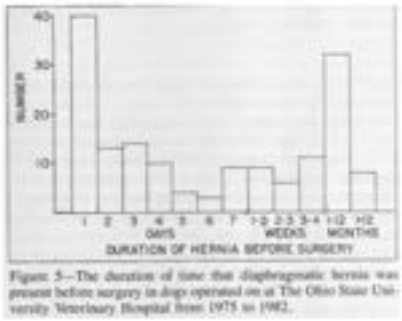


Figure 5—The duration of time that diaphragmatic hernia was present before surgery in dogs operated on at The Ohio State University Veterinary Hospital from 1975 to 1982.

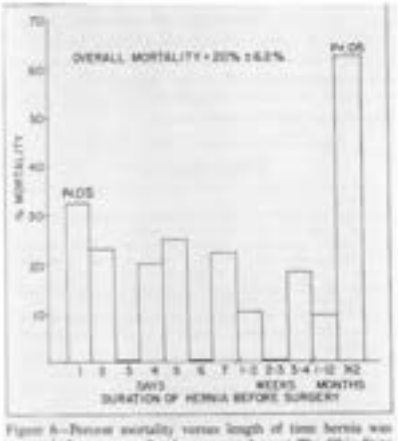


Figure 6—Percent mortality versus length of time hernia was present before surgery for dogs operated on at The Ohio State University Veterinary Hospital from 1975 to 1982.

Comp Small Animal, 1987

Survival of Acute vs. Chronic

Prognostic indicators for perioperative survival after diaphragmatic herniorrhaphy in cats and dogs: 96 cases (2001-2013)

- 79 dogs and 17 cats with DH
- Time between trauma and surgery, trauma and admission, admission and surgery – not associated with survival
- Duration of anesthesia, surgical procedure, concurrent soft tissue or orthopedic injury related to mortality

Perioperative survival rates after surgery for diaphragmatic hernia in dogs and cats: 92 cases (1990–2002)

- 63 dogs and 29 cats with DH
- 92% of cases with acute DH received intervention within 24 hours of admission – 94% discharged
- 43% of cases with acute DH received intervention within 24 hours of trauma – 90% survival

Timing of Surgery: Hernia Contents

- Liver may increase risk of pleural effusion
- Stomach may risk bloat and respiratory compromise
- More likely to take an animal to surgery more rapidly if stomach is herniated (tension gastrothorax)

5 week old Golden Retriever,
Acute respiratory distress

Pleuroperitoneal diaphragmatic hernia with tension gastrothorax

These findings are consistent with congenital pleuroperitoneal diaphragmatic hernia with gastric herniation, entrapment, and distention.

340921

Stomach is not in correct location in the abdomen

Timing: The Bottom Line

- Surgical intervention should take place when the patient has been adequately stabilized.
- Delay increases the risk of respiratory compromise

Acute stabilization

- Supplement oxygen
- Analgesia
- Address traumatic injuries
- IV access
- Drain pleural effusion if present
- Emergent surgery maybe indicated

Congenital Diaphragmatic Hernia

- Heritability is not clear
- Most commonly peritoneopericardial diaphragmatic hernia (PPDH)
- Occurs in cats and dogs
- May be incidental or present with vomiting, inappetance, lethargy, difficulty breathing, pleural or pericardial effusion

3 yr old, MN, DMH
Vomiting, 3 weeks duration

340972

Surgical vs. Conservative Therapy of PPDH

Surgical and nonsurgical treatment of peritoneopericardial diaphragmatic hernia in dogs and cats: 58 cases (1999–2008)

- 34 animals had surgical repair.
- Animals with clinical signs most commonly had surgery
- 9% mortality for surgical treatment
- No difference in long term survival with surgically treated vs. non-surgically treated
- Other congenital abnormalities were common (umbilical hernias, sternal defects, abdominal wall hernias)

Long-term outcome of cats treated conservatively or surgically for peritoneopericardial diaphragmatic hernia: 66 cases (1987–2002)

- 37 treated surgically, 29 treated conservatively
- Post op mortality 14%
- Post op complications in 29/37 cats
- 2 conservatively treated cats had progression of clinical signs which caused death or need for surgical treatment
- 88% owner satisfaction with surgery and 68% owner satisfaction with conservative.

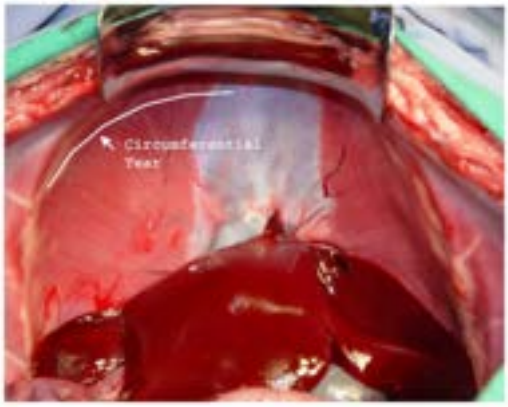
Anesthetic Considerations

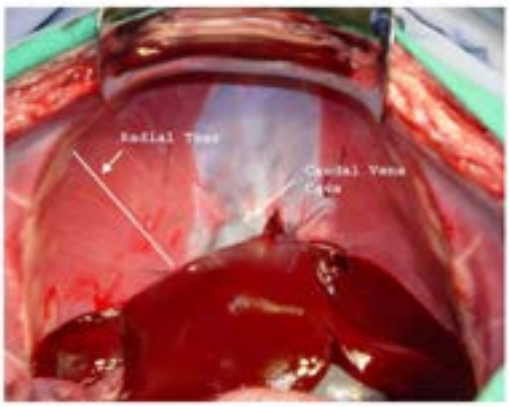
- Preoxygenate
- Elevate the head if possible
- Rapid induction, intubation, and ventilation – induction is a dangerous time
- Reexpansion Pulmonary Edema –Chronic Hernias
  - Avoid high ventilatory pressures,
  - Max around 10 mmHg

Operative Management: Diaphragmatic Hernia

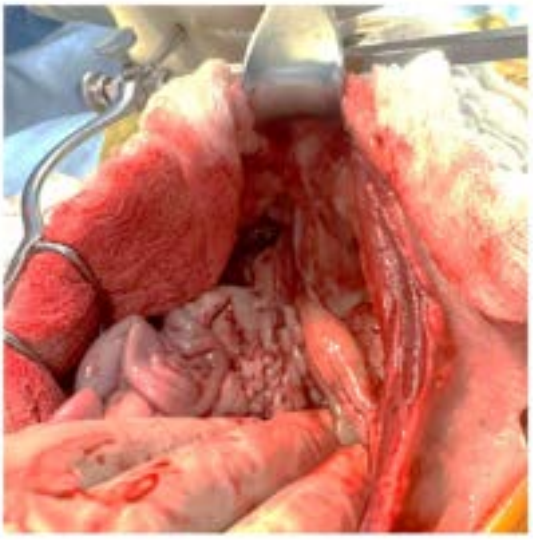
- Approach via the ventral midline
- Drape in extra space for chest tube and extending cranially
- Adhesions and necrosis may be evident
- Debride and close the diaphragm with a simple continuous suture line
- May require muscle flap or mesh is defect is large (rare)
- Drain chest – place a chest tube

Radial or Circumferential Tear



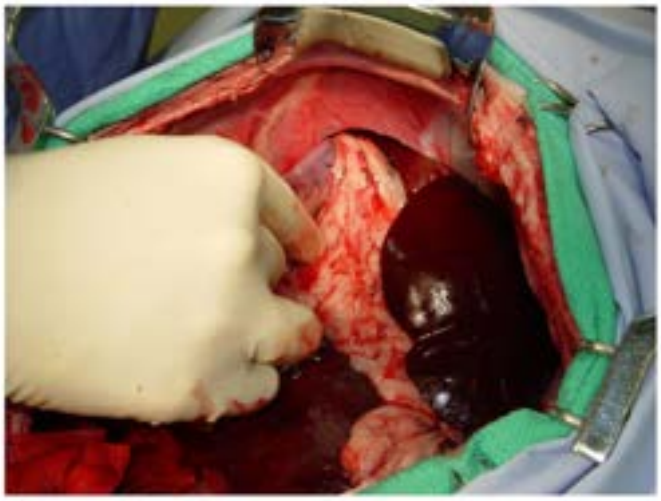


Traumatic hernias can have multiple tears – be sure to inspect the entire diaphragm. Particularly dorsally.



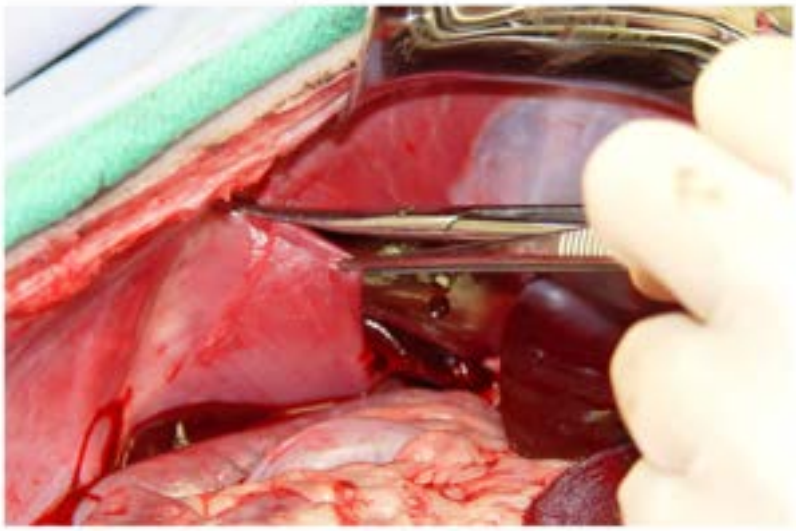
Retractors are important to be able to visualize and repair the defect

Gently Milk Hernia Contents back into Abdomen

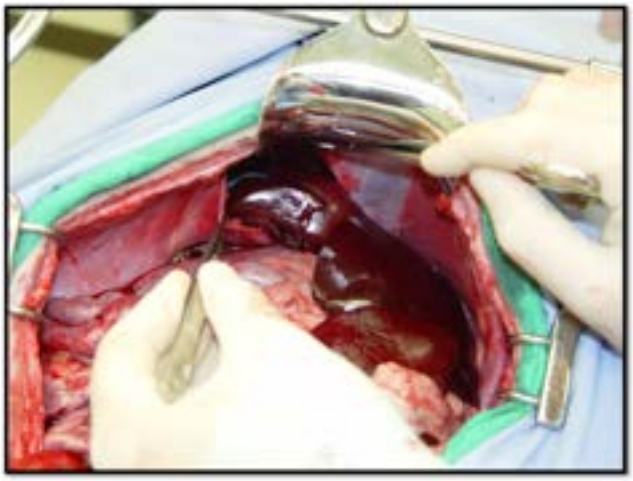


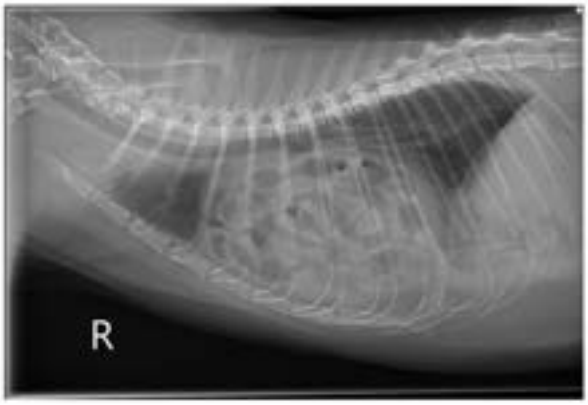
If reduction is difficult,

enlarge the hernia



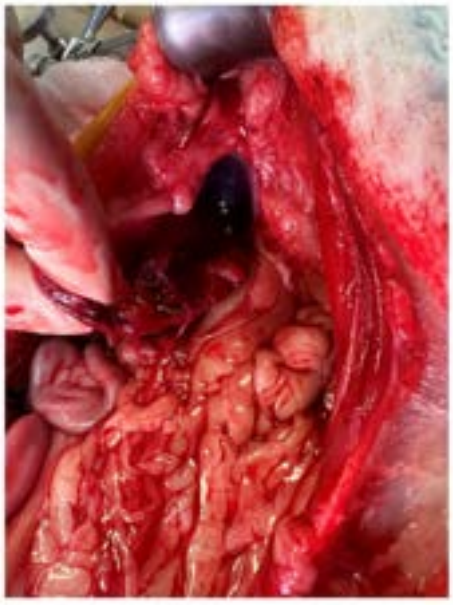
Now organs can be *nontraumatically* reduced



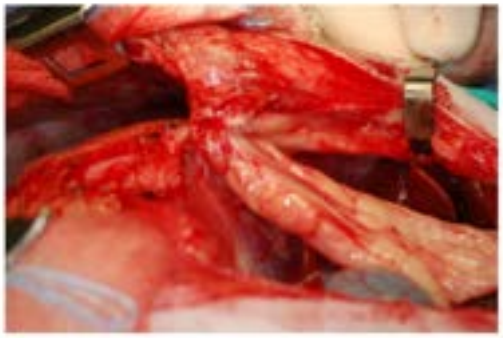


Hernia sac

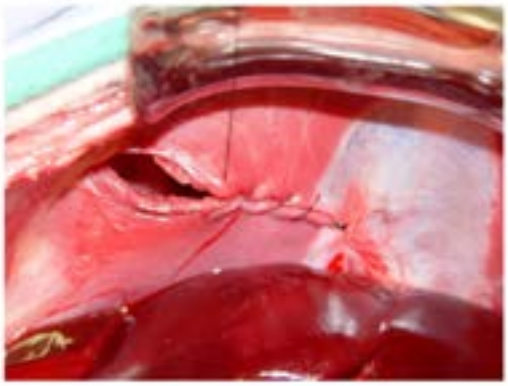
- Peritoneal mesothelial cells will create a pocket or sac around the hernia
- Can be debrided or left in place.



Extending ventral midline abdominal incision into caudal medial sternotomy is helpful if significant adhesions are present

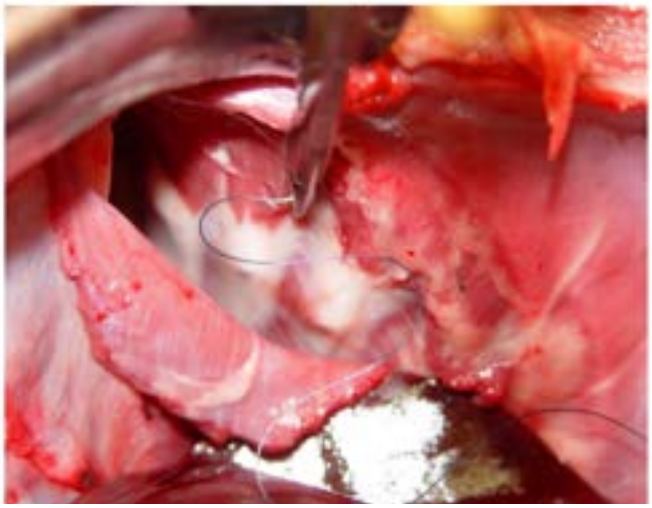


Hernia is closed from dorsal to ventral, medial to lateral (hardest to easiest)



Place and tighten sutures carefully around caudal vena cava hiatus

Circumferential Tears are Bolstered with Circumcostal Sutures, then Oversewn



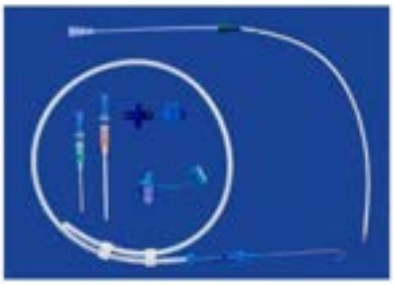
What if you can't close it?

- Transect rib and mobilize thoracic wall
- Rectus Abdominus flap
- Transversus abdominus flap
- Mesh
- Porcine submucosa (SIS)

Vet Comp Orthop Traumatol 2/2013

Chest tubes post op

- Can use a red rubber placed through the diaphragm
  - Incorporated into diaphragm closure or,
  - Stab incision and purse string
  - Typically exited through abdominal incision and pulled prior to recovery.
- Or…place a thoracostomy tube prior to closure of the chest.



Complications

- Pneumothorax
- Pneumopericardium
- Reexpansion pulmonary edema
- Sudden cardiac death
- Death from other traumatic injury
- Ascites
- Recurrence of hernia
- Hiatal hernia
- Transient megaesophagus/esophagitis

Prognosis

- **~15% mortality prior to presentation**
- **Guarded peri-operatively because of acute risks before, during, and just after surgery. Traumatic hernias survival 82 – 89%.**
- **Post operatively if animal is doing well prognosis becomes much better**
- **Risk of recurrence is low**

GASTRIC DILATATION VOLVULUS

Chad Schmiedt DVM, DACVS
Professor
Small Animal Surgery

OUTLINE

- Signalment, history, exam, diagnostics
- Pathophysiology
- Treatment
  - Pre-operative
  - Intra-operative
  - Post-operative
- Prognosis, prophylactic gastropexy
- Questions and discussion

SIGNALMENT

- **Deep-chested, large breed dogs**
  (Others: Shar Pei, Bassett, Cocker Spaniel)
- **Usually middle aged to older**

HISTORY

- Restlessness
- Retching
- Non-productive vomiting
- Hypersalivation
- Distended abdomen
- Weakness
- Collapse

PHYSICAL EXAM

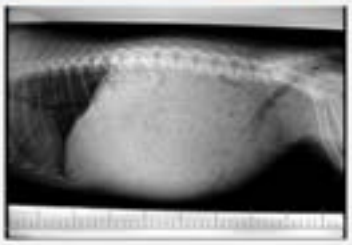
- May be nearly normal
  - Abdomen may not be *that* distended, femoral pulses may feel OK, may even be wagging tail

May be collapsed, in shock, or obtunded or dead

Or anywhere in between

VS. FOOD BLOAT?

- Typically a history of food thievery is known
- Gastric distention can be as severe as GDV
- Dogs with food engorgement frequently presented with acid-base and electrolyte derangements (including hyperlactatemia)
- Outcome with only supportive care is excellent

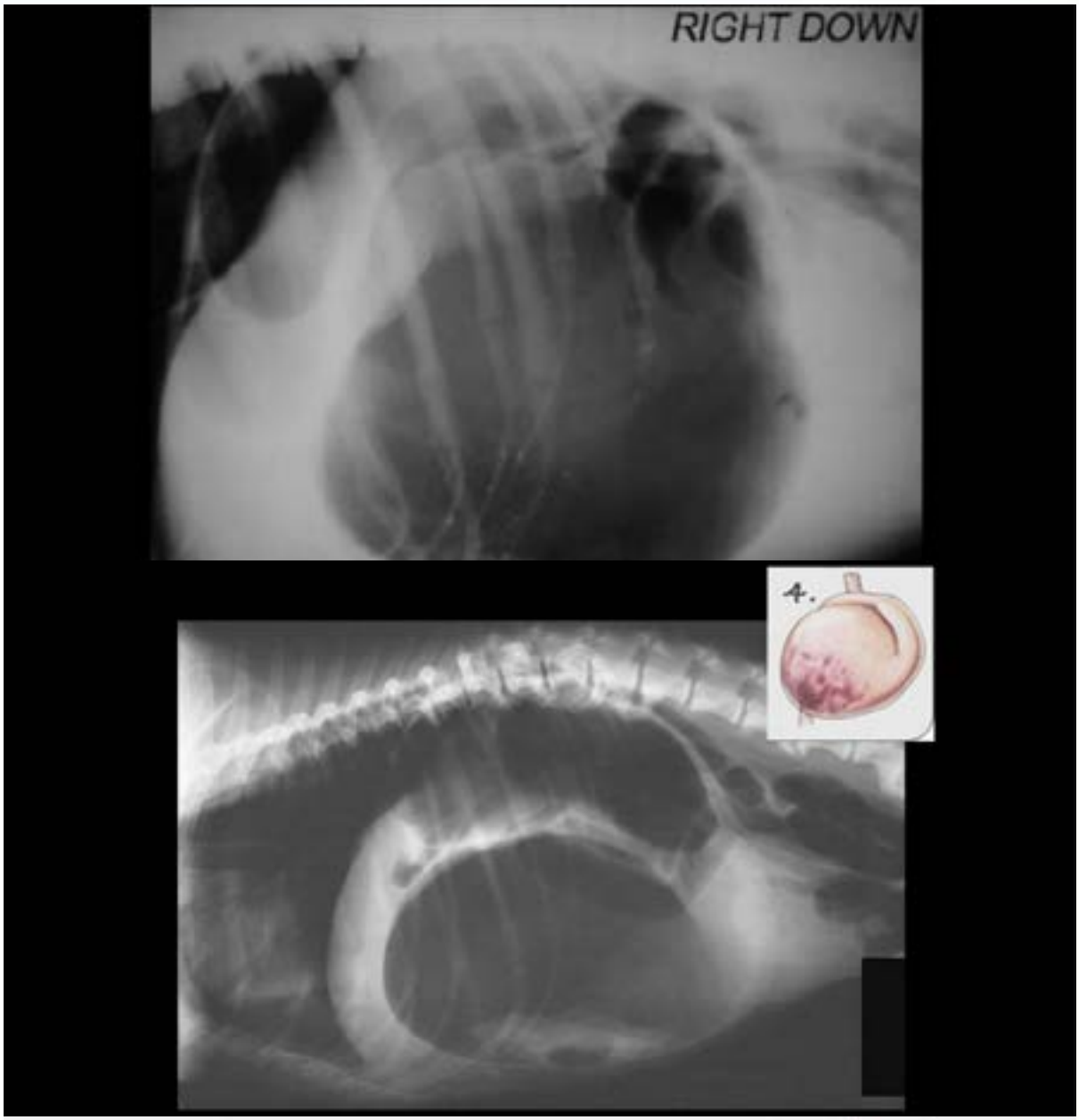


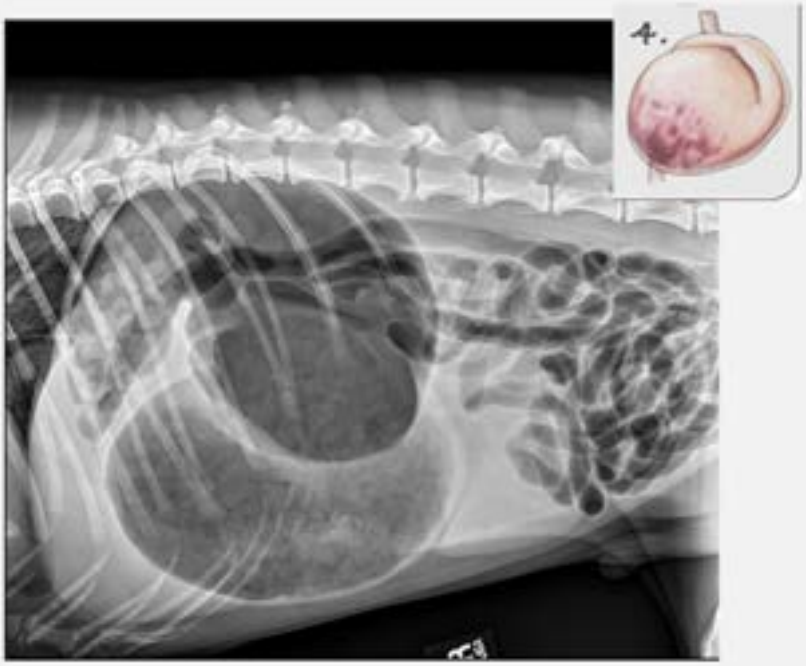
Smart, Reese, and Hosgood, VetRecord, 2017

CLINICOPATHOLOGIC DIAGNOSTICS FOR GDV

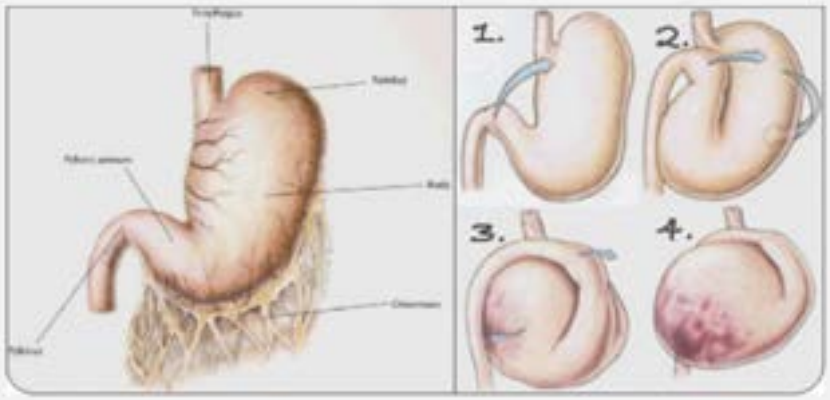
- Right lateral abdominal radiograph
  - Should also obtain an orthogonal view (VD)
- CBC, Chemistry, electrolytes
- ±Coagulation profile
- BP and EKG
- ±3 view thoracic radiographs (older dogs)

For the severely affected animal, stabilization must be performed in parallel with diagnostics


RIGHT DOWN
4.


4.

PATHOPHYSIOLOGY



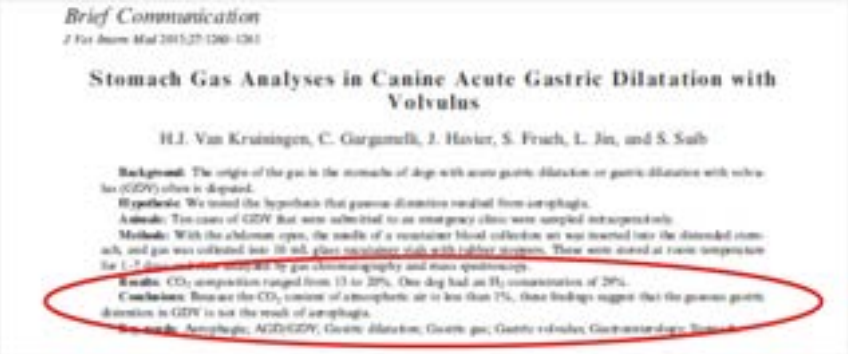
RISK FACTORS

Increased Risk

- Purebred or giant breed
- History of GD or GDV in a 1st degree relative
- Deep chested
- Fewer meals/day
- Fed dry kibble
- Smaller kibble size
- Anxiety/aggressive/fearful
- Spending 5 hours a day with owner
- Intact females
- Splenectomy
- Activity after eating
- Elevated food bowls

Reduced Risk

- Playing with other dogs
- Running the fence after meals
- Fish and egg supplements
- Equal time indoors and out



Brief Communication

Stomach Gas Analyses in Canine Acute Gastric Dilatation with Volvulus

H.J. Van Kruiningen, C. Gargazzelli, J. Havier, S. Frueh, L. Jin, and S. Saib

- Authors postulate gas is not from aerophagia but a result of bacterial fermentation

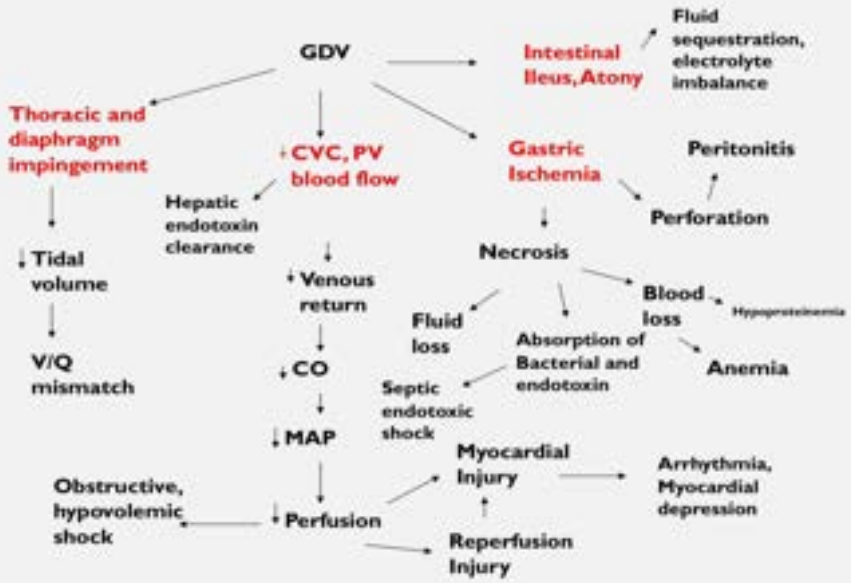
Association between previous splenectomy and gastric dilatation-volvulus in dogs: 453 cases (2004–2009)

Angela J. Sartor, DVM; Adrienne M. Bentley, DVM, DACVS; Dorothy C. Brown, DVM, MSCI, DACVS

- Previous studies showed no evidence that splenectomy was associated with an increased incidence of subsequent GDV
- Odds of GDV 5.3x with previous splenectomy vs. dogs without splenectomy

Results—6 (4%) dogs in the GDV group and 3 (1%) dogs in the control group had a history of previous splenectomy. The odds of GDV in dogs with a history of previous splenectomy in this population of dogs were 5.3 times those of dogs without a history of previous splenectomy (95% confidence interval, 1.1 to 26.8).

Conclusions and Clinical Relevance—For the patients in the present study, there was an increased odds of GDV in dogs with a history of splenectomy. Prophylactic gastropexy may be considered in dogs undergoing a splenectomy, particularly if other risk factors for GDV are present. *J Am Vet Med Assoc* 2013;242:1381–1384)



ETIOLOGY OF CARDIOVASCULAR COMPROMISE IN DOGS WITH GDV

Ventilation

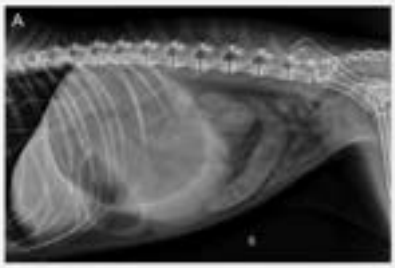
- Diaphragmatic pressure reduces ability to ventilate

Blood Flow

- Reduced cardiac return from abdomen via vena cava
- Reduced portal vein blood flow

Cardiac Dysfunction

- Reduced return means reduced stroke volume and cardiac output
- Electrocardiographic abnormalities in 40 – 70% of cases
  - Myocardial ischemia/necrosis
  - Other?



SECONDARY COMPLICATIONS

Gastric Wall Necrosis

- Secondary to high intragastric pressure
- Systemic hypotension

Bacterial Translocation

- Unknown significance. Actual occurrence hasn't been documented over control dogs.

Reperfusion Injury

Evaluation of plasma lactate concentration and base excess at the time of hospital admission as predictors of gastric necrosis and outcome and correlation between those variables in dogs with gastric dilatation-volvulus: 78 cases (2004–2009)

Kari A. Sarnoso Beer, DVM; Rebecca S. Syring, DVM, DACVECC; Kenneth J. Drobatz, DVM, MSCE, DACVECC, DACVIM

- Gastric Necrosis in 12 dogs (20%)
- 65 dogs (83%) survived to discharge
- Dogs with gastric necrosis
  - 8/65 survivors
  - 4/8 non-survivors
- Plasma lactate cutoff 7.4 mmol/liter
  - 82% accurate for predicting gastric necrosis
  - 88% accurate for predicting outcome

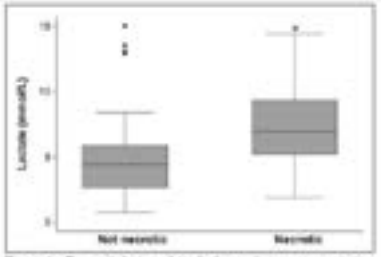


Figure 1—Boxand-whisker plot of plasma lactate concentration (mmol/L) at the time of admission to the hospital in dogs with GDV in which gastric necrosis was (n = 12) or was not (67) detected during surgery. For each box, the horizontal line represents the median value, and the upper and lower boundaries represent the 75th and 25th percentiles, respectively. Whiskers represent the minimum and maximum values, and black circles represent outlier values. *Median value for this group is significantly (P = 0.008) different from that for the other group.

Association between outcome and changes in plasma lactate concentration during presurgical treatment in dogs with gastric dilatation-volvulus: 64 cases (2002–2008)

Laurie A. Zacher, DVM, DACVS; John Berg, DVM, DACVS; Scott P. Shaw, DVM, DACVECC; Raymond K. Kudej, DVM, PhD, DACVS

- Dogs with initial lactate concentration below 9 mmol/L = 90% survival (36/40 dogs)
- Dogs with an initial lactate concentration over 9 mmol/L = 54% survival (13/24 dogs)
- Within the dogs with initial lactate over 9 mmol/L
  - Final lactate concentration (after fluid resuscitation) over 6.4 mmol/L = 23% survival
    (vs. 91% for final lactate concentration less than 6.4 mmol/L)
  - Absolute change in lactate concentration less than 4 mmol/L = 10% survival
    (vs. 86% for absolute change greater than 4 mmol/L)
  - Percentage change in lactate concentration less than 42.5% = 15% survival
    (vs. 100% for percentage change greater than 42.5%)
- So initial lactate is important, but better prognosis dogs with a high initial lactate that can be reduced with pre-surgical resuscitation

Zacher JAVMA 2010

TREATMENT

TREATMENT: PRE-OPERATIVE

- Stabilization → IV isotonic crystalloids, hypertonic saline, colloids
  - 16 or 18 Ga IV Cath
  - Front limb
- Antibiotics
- Anti-arrhythmics
- Analgesia / Premeds
- Other: oxygen?
  free radical scavengers?

GASTRIC DECOMPRESSION IS CRITICAL!

And/Or

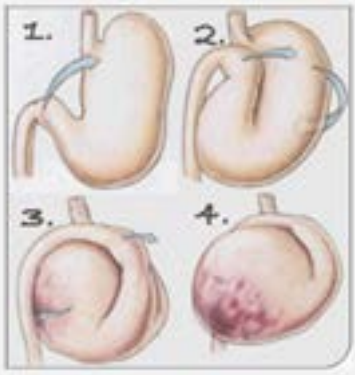
TREATMENT: INTRA-OPERATIVE

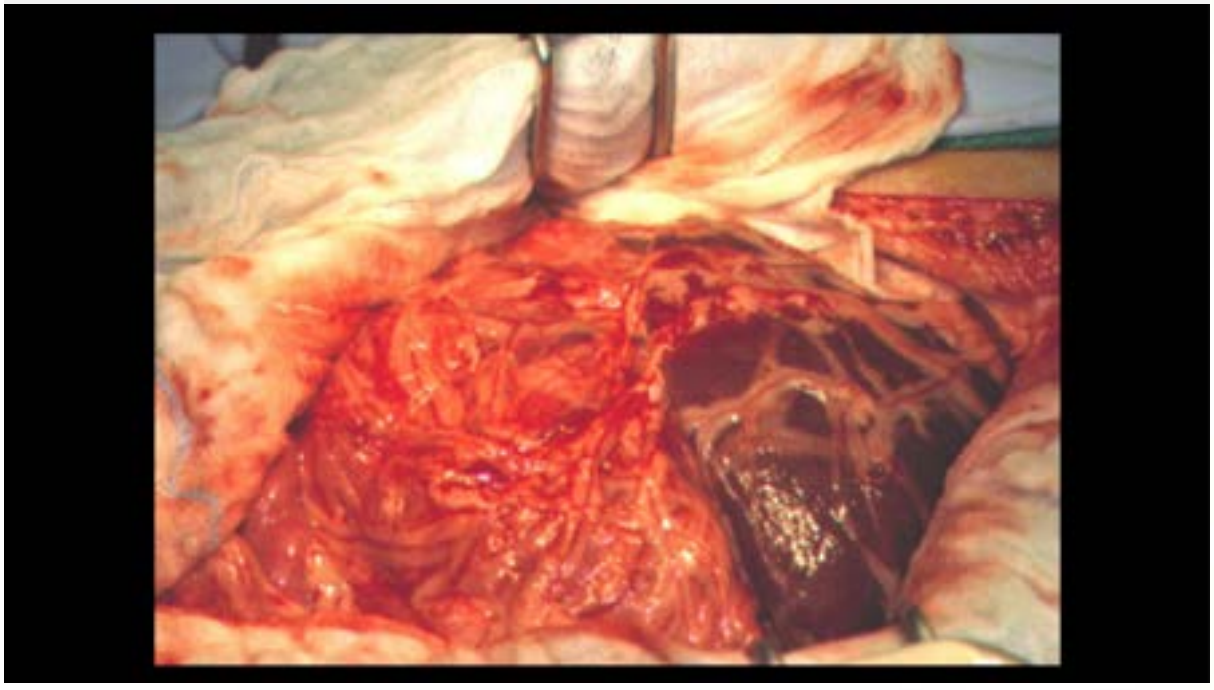
1. Gastric repositioning
2. Evaluate abdominal viscera
    1. If indicated, perform splenectomy
    2. If indicated, perform partial gastrectomy
3. Perform right sided gastropexy

*** *Maintain vigilant monitoring of response to treatment and adjust (fluid) therapy accordingly – BP and EKG monitoring are essential intraop*

TREATMENT: GASTRIC REPOSITIONING

- In most cases, derotation can be accomplished by standing on the dog's right side and:
    - Pushing the fundus (which is nearest to you) dorsally and to the dog's left
    - Pulling the pylorus (which is away from you, near the dog's left side) ventrally and towards you
    - Use a gentle but confident application of force
    - Often helpful if the stomach is decompressed
- Verify correct positioning afterwards by carefully palpating esophageal hiatus
    - Some may have experienced a counter-clockwise volvulus





NVF Hands-On Workshop

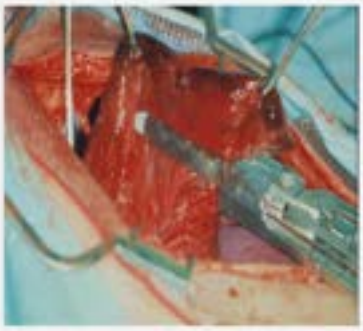
TREATMENT: ABDOMINAL EVALUATION

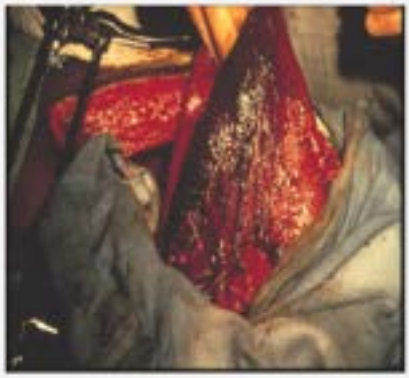
TREATMENT: +/- SPLENECTOMY +/- PARTIAL GASTRECTOMY

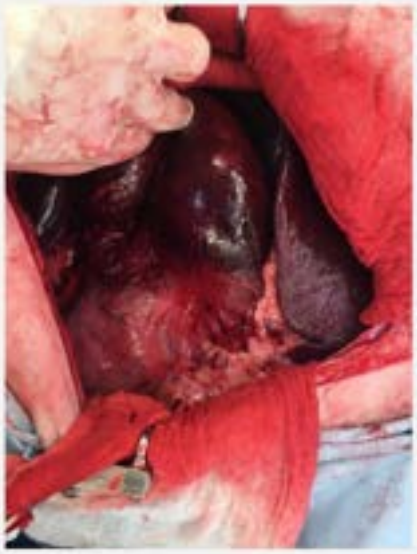
- Evaluate once completed remainder of abdominal explore
- If spleen is thrombosed or vascularly devitalized → splenectomy
- If stomach wall palpates thin, is excessively dark/black or white/grey → partial gastrectomy
- Gastric invagination? – has been associated with chronic recurrent bleeding gastric ulcers and clinical anemia

PARTIAL GASTRECTOMY

- Invagination
- Stapled – GIA stapler
- Hand sewn



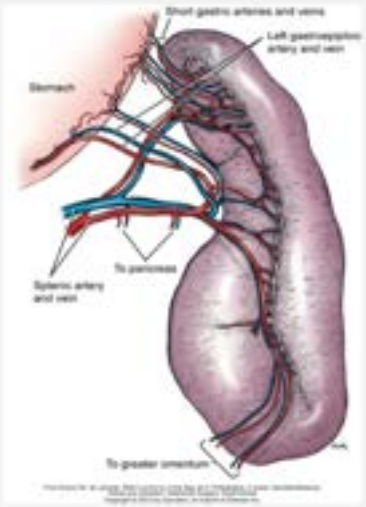




When do you say,
"I can't fix this."?

SPLEEN

- Hemoabdomen
  - Short gastric avulsion
- Splenic congestion
  - De-rotate stomach and see how it does!
  - Texture, color
  - Pulse



SPLENECTOMY?

- Evaluate once completed remainder of abdominal explore
- If spleen is thrombosed or vascularly devitalized → splenectomy

TREATMENT: RIGHT SIDED GASTROPEXY

Incisional
- Easiest; somewhat weaker but strength is still supra-physiologic

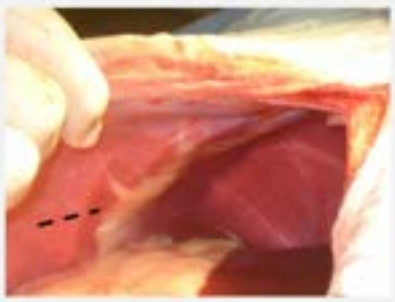
Belt-loop

Circumcostal

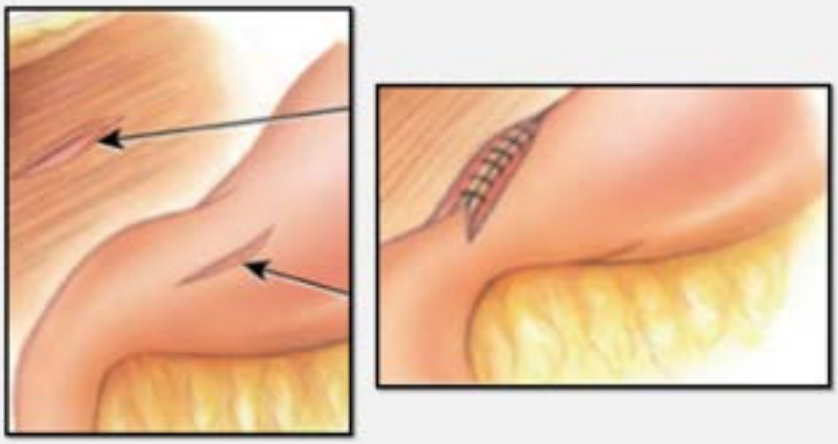
Ventral incision
- May lead to inadvertent gastrotomy during future abdominal surgeries

Tube
- Weakest, often stretches and may lead to recurrence

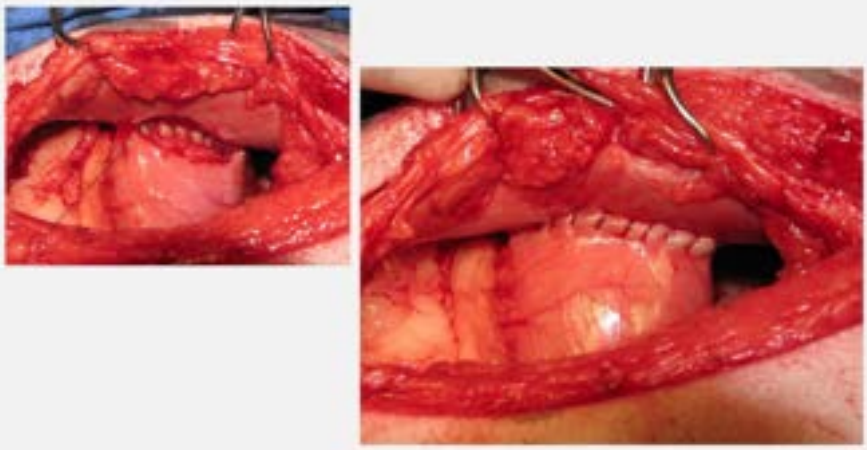
INCISIONAL GASTROPEXY



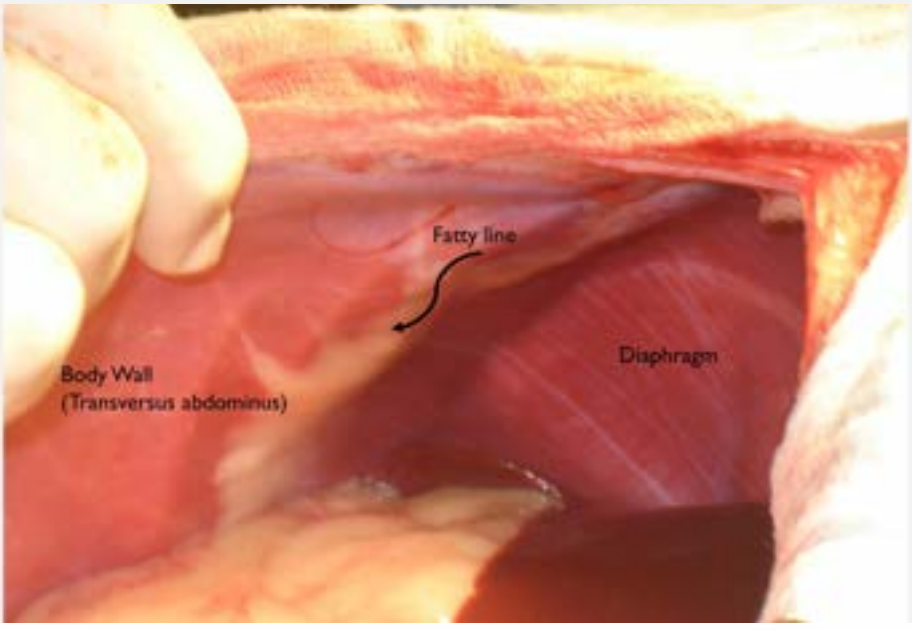
Incision in seromuscular layer of the stomach can be parallel or perpendicular to the long axis of the stomach

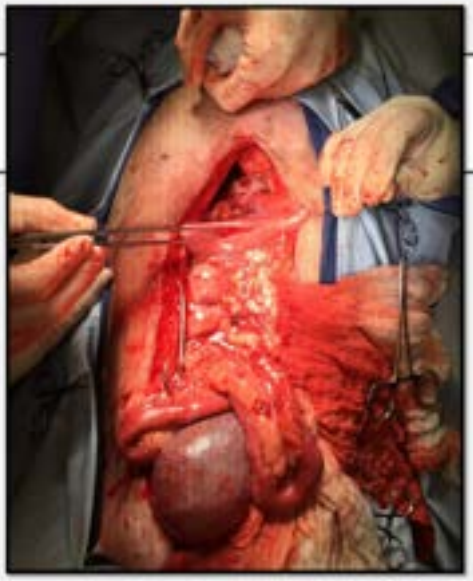


INCISIONAL GASTROPEXY

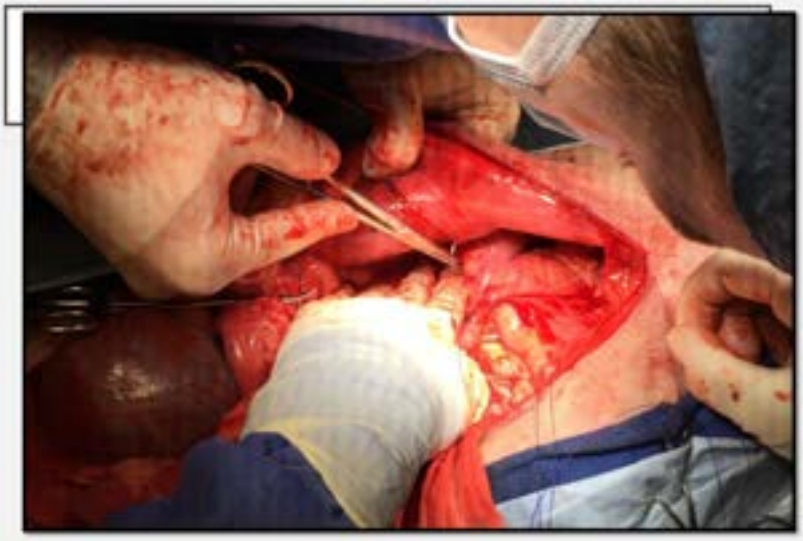


http://drstephenbirchard.blogspot.com/2013/09/normal.html





NVF Hands-On Workshop



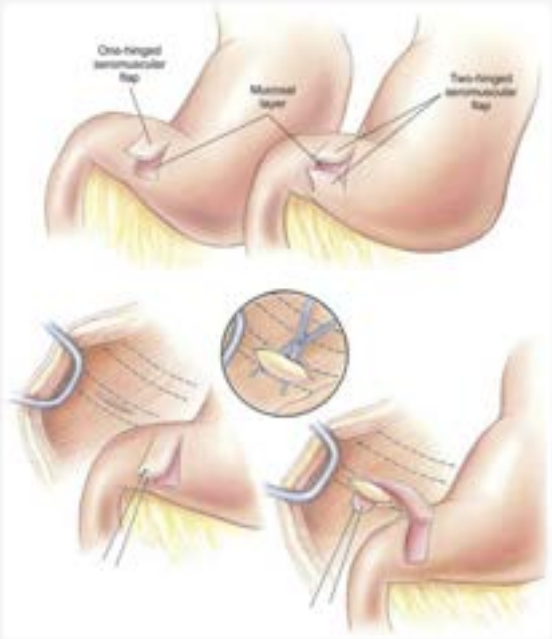
NVF Hands-On Workshop

Abdominal Wall
~5 cm long
~3 cm apart

Seromuscular flap
based on greater
curvature
~4 cm long
~3 cm apart

Circumcostal Gastropexy

- Similar to a belt loop but passes behind a rib instead of through a soft tissue tunnel
- Behind the 11th or 12th rib
- Rib fracture, hemorrhage, and pneumothorax are reported complications.



Efficacy of Incisional Gastropexy for Prevention of GDV in Dogs

Marian E. Benitez, DVM*, Chad W. Schmiedt, DVM, DACVS, MaryAnn G. Radlinsky, MS, DVM, DACVS, Karen K. Cornell, PhD, DVM, DACVS

- 61 dogs with incisional gastropexy
  - 34 had gastropexy at GDV surgery
  - 27 had prophylactic
- Median follow up was 700+ days
- Recurrence of GD alone in 3/34 patients (~9%) in the GDV group
- Occurrence of GD in 3/27 (~11%) in the prophylactic group

TREATMENT: POST-OPERATIVE

- Continuum of care from pre-op to intra-op to post-op
  - Aggressive volume expansion
    - Crystalloids 90-120 mL/kg/day
    - HES 10-30 mL/kg/day
    - +/- FFP or other blood products
- Monitoring
  - EKG, BP, emesis
  - Bloodwork and lytes

TREATMENT: POST-OPERATIVE

- **Analgesics (opiods; avoid NSAIDs)**
- **Consider gastroprotectants (sucralfate +/- famotidine and/or omeprazole)**
- **Antibiotics usually indicated for presumed risk of bacterial translocation**
- **Consider anti-emetics/prokinetics if vomiting**
- **Encourage small frequent meals as soon as will tolerate**

PROGNOSIS

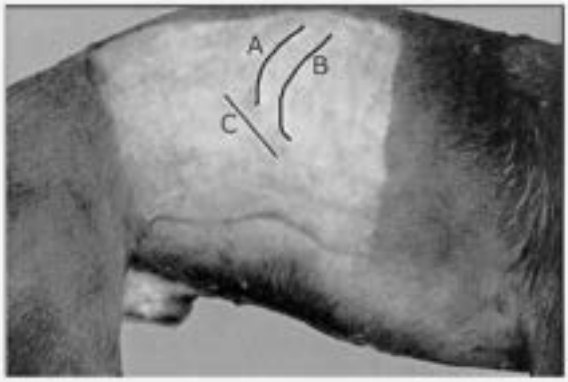
- Guarded to fair
  - Mortality ~10- 27%
- Prognostic Factors
  - Long (>6 hrs) clinical signs
  - Concurrent gastrectomy or splenectomy
  - Gastric necrosis
  - Cardiac arrthymias
  - Peritonitis
  - Plasma Lactate (<6 mmol/L has a 99% survival)
  - Changes in lactate (> 4 mmol/L after resuscitation)

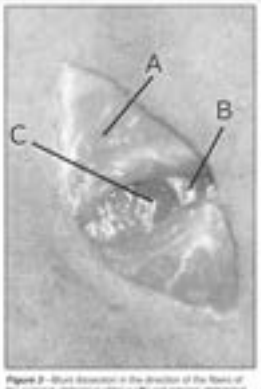
PROPHYLACTIC GASTROPEXY

- Previous episode of GD?
  - Likelihood of GDV after episode of GD is ~ 85%
- Familial history of GDV?
- At risk breed?
- Working/valuable dog?

GRID GASTROPEXY

Clinical Evaluation of a Right-Sided Prophylactic Gastropexy Via a Grid Approach





J Am Anim Hosp Assoc 2003;39:397–402.

Spontaneous gastric dilatation-volvulus in two cats

Meredith L. Leary, VMD and Virginia Sinnott-Stutzman, DVM, DACVECC

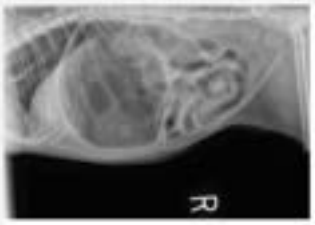
2 female Persian cats

Only 1 had compartmentalization evident on preop rads

Both confirmed intraop

No history of trauma

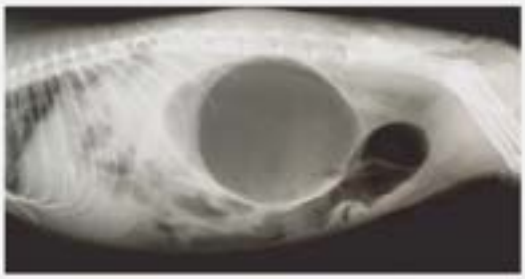
Others reported in association with diaphragmatic hernia



Acta Veterinaria Hungarica 65 (4), pp. 487–499 (2017)
DOI: 10.1556/004.2017.044

REVIEW OF GASTRIC TORSION IN EIGHT GUINEA PIGS *(CAVIA PORCELLUS)*

Anna Linda NOGRÁDI[1*], Iain COPE[2], Márton BALOGH[3] and János GAL[3]



Considerations in Gastrointestinal Surgery:

Focus on GI Foreign Body Obstruction

Chad W. Schmiedt, DVM

Diplomate, American College of Veterinary Surgeons
Professor, Small Animal Surgery
Alison Bradbury Chair of Feline Health
College of Veterinary Medicine
University of Georgia

College of Veterinary Medicine
UNIVERSITY OF GEORGIA

Objectives

- Understand **preoperative diagnostics** and **medical stabilization** in dogs and cats with gastrointestinal foreign bodies
- Review **basic anesthetic considerations** for emergency foreign body surgery
- Review **basic surgical principles** of gastric and intestinal surgery
- Review **postoperative considerations and complications** in dogs and cats following gastrointestinal surgery

Preoperative Considerations and Diagnostics

Is there a functional obstruction?

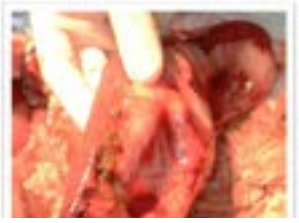
Functional obstructions can present a similar way to mechanical obstructions

- Inflammation (IBD, peritonitis, pancreatitis)
- Infection (parvoviral)
- Iatrogenic (hypokinetic drugs, surgical manipulation)
- Electrolyte or metabolic imbalance
- Idiopathic

Pyogranulomatous jejunitis in a cat

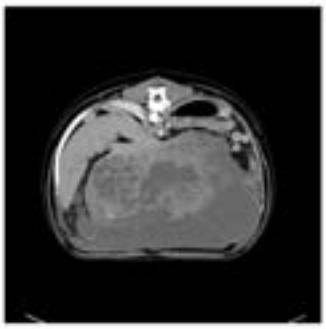
Could this be a mechanical obstruction other than a foreign body?

- Linear or Singular Foreign Body
- Intussusception
- Stricture
- Neoplasia
- Torsion



Other mental context for obstruction etiology

- Gastric vs. duodenal vs. jejunal
- Acute vs. chronic
- Partial vs. complete
- Intraluminal vs. intramural vs. extraluminal
- Strangulating vs. simple



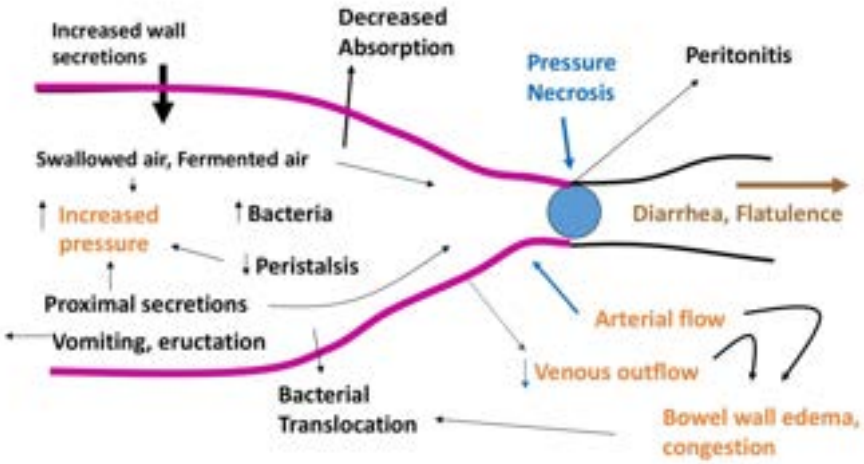
Pathophysiology

- Excessive fluid secretion
  - Increased parasympathetic tone from stretch receptors
  - Lack of aboral transport
- Malabsorption
- Fluid, electrolyte, and acid base disturbance
- Bacterial proliferation +/- translocation
  - More problematic in distal obstructions
- Devitalized bowel
- Perforation


Review Article

The Pathophysiology of Small Intestinal Foreign Body Obstruction and Intraoperative Assessment of Tissue Viability in Dogs: A Review

Pathophysiology



Preoperative Stabilization

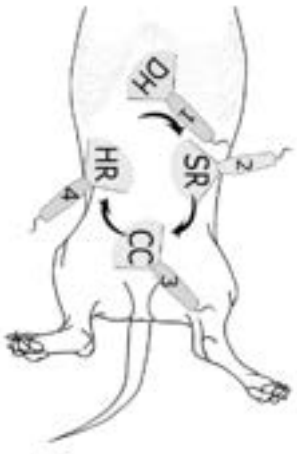
Based on abnormalities identified on physical and blood work

- Correct dehydration
- Correct electrolyte
- Reevaluate acid-base status

Other Diagnostics

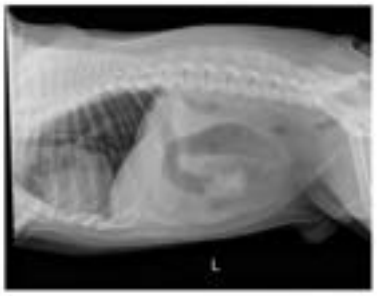
- aFAST (abdominal-**F**ocused **A**ssessment with **S**onography for **T**rauma)
  - Diaphragmaticohepatic
  - Splenorenal
  - Cystocolic
  - Hepatorenal

  - Useful for identification of free abdominal fluid
  - Free abdominal fluid will dramatically impact prognosis
  - *May not be apparent in a dehydrated animal (recheck after rehydration)*



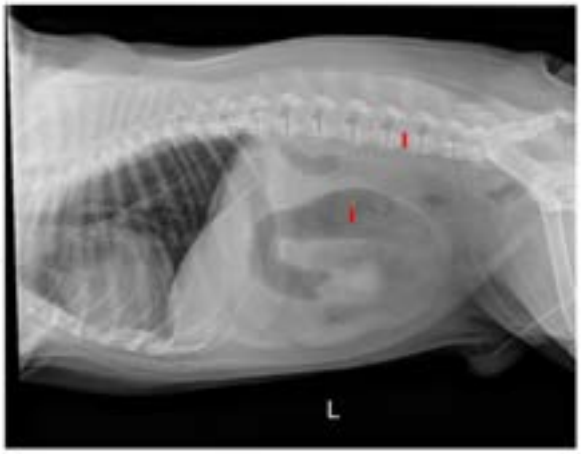
Lisciandro, J Vet Emerg Crit Care, 2011

Radiography



- 3 view abdominal films
- Classic signs:
  - 2 populations of bowel
  - Radio-opaque foreign object
  - Abnormal shapes – plication, stacking
- Its not always classic though…
  - Intestinal dilation alone present in 45-55%
  - Active vomiting, poor detail, poor body condition, peritonitis can all make that evaluation difficult

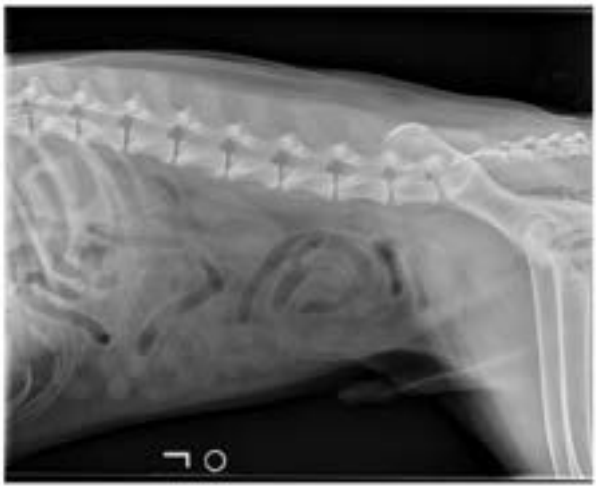
How big is too big?



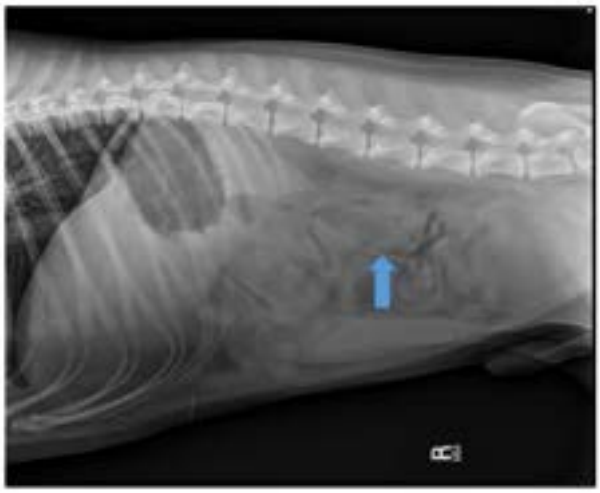
- Small intestine
  - Height of mid-body of L5 in dogs x 1.6 = 66% sensitive and specific
  - Greater than 2.4x = 74-92% sensitive, 74-84% specific
  - 1.6 -2.4x can be from nonobstructive causes – enteritis, nonobstructive ileus
  - Cats ~ 12 mm
- Large intestine
  - Length of body of L5

Radiographic findings need to pair with clinical signs

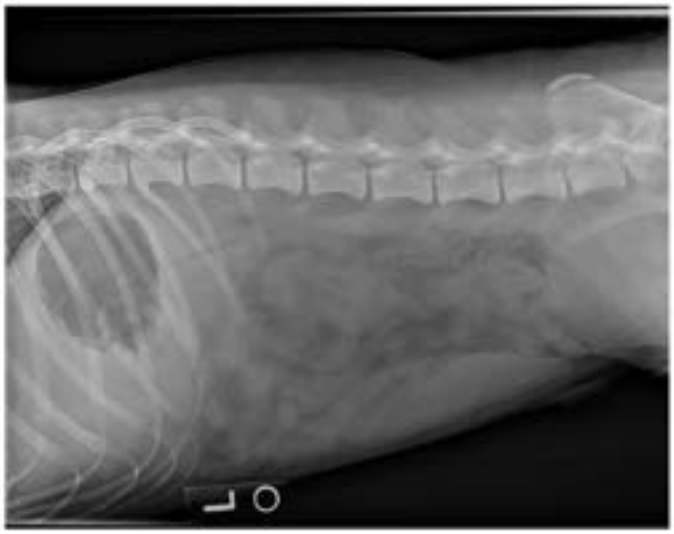
- 1 yr old, MN, Bernedoodle
- Previous history of eating foreign objects, previous gastrotomy ~ 6 months prior
- 1 week prior to presentation – ate toys, threw up in yard
- 3 days before presentation – threw up some boxer shorts, become progressively more lethargic and inappetent.
- At presentation dog appeared normal and had a nonpainful abdomen, NOVA was normal, lactate was 2.0 mmol/L, PCV -47%, TS – 6.6



Admission:
- Stomach, pylorus, duodenum are normal
- Right mid abdominal nonobstructive foreign body



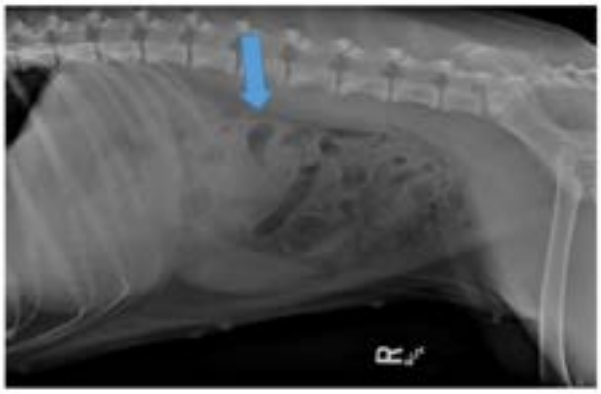
Day 2:
- Foreign material still present, still non obstructive
- Dog not vomiting, BAR, eating



Day 3
Foreign material in colon
Dog discharged

Radiographic appearance of linear foreign bodies

- Look at the stomach, duodenum, proximal jejunum
- Plication, comma shaped gas opacities
- Frequently no distention



Comma shaped gas opacities

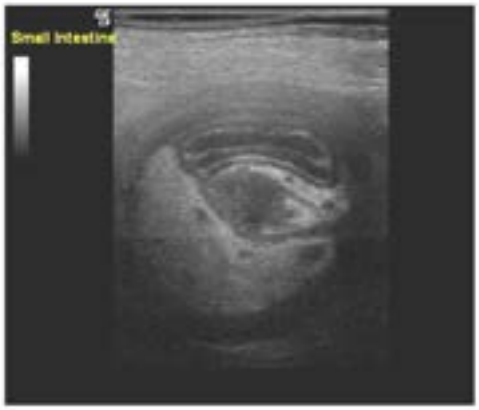
Bunched duodenum in the right cranial quadrant

What if you can't tell?

- Wait, treat symptomatically, and take another series
- Barium
  - 5-7 ml/lb PO
  - Dog: 0, 0.25 -0.5, 1, 2, 3, 6 hrs
  - Cat: 0, 5, 15, 30, 60, 120 min
  - Problematic if perforation
- Iodinated contrast
  - 1 ml/lb
  - Radiographs Q 15 minutes
  - Typically takes about an hour
  - If perforation suspected or likely

Ultrasound vs. Radiology

- 82 dogs, 27 with confirmed foreign body
- Radiology produced a definitive result - 70% of the time
- Ultrasound produced a definitive result – 97% of the time
- 30% of obstructed dogs did not have radiographic evidence of obstruction, of which 50% were linear foreign bodies
- Jejunum >1.5 cm was a useful discriminatory finding



Sharma, VRU, 2011

Perioperative preparations

Timing of surgery?
Can this wait for tomorrow?

- Surgery <6 hours vs. surgery > 6 hours after presentation in 855 dogs
- Overall outcomes did not differ in immediate (584) vs. delayed (210)
- *Intestinal necrosis and perforation more common* in delayed cases.
- *Enterectomies more common* and duration of surgery and anesthesia longer in delayed cases.
- *Early surgery had earlier return to feeding and discharge.*
- ~5% of dogs had negative explore in both groups.

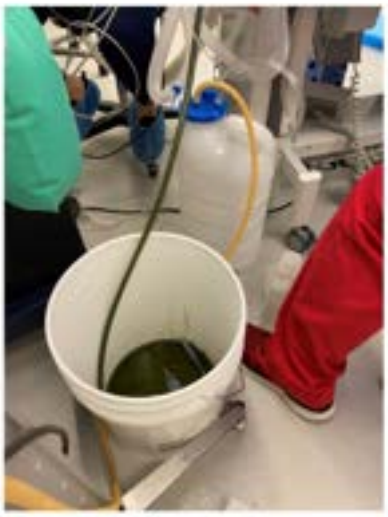
Maxwell, Vet Surgery, 2021

Anesthetic considerations

- Rehydrate prior to anesthesia
- Rapid induction
- Control and protect airway
- Ventilation maybe impaired if gastric distention
- Maropitant (Cerenia®) in the premeds (1 mg/kg)
- Regurgitation is common
- Consider an oro-gastric tube immediately after induction
- Perioperative antibiotics are indicated

Orogastric tubes

- Measure to the last rib
- Mark the tube
- Gently feed down esophagus
- Twist or insufflate to get past LES
- Remove mouth from tube



Before you cut

- Prep and drape more than you think you need
- Count your sponges
- Save clean instruments or have clean instruments for closure

Gossypiboma

Surgical exploration: incision length & retractors

- Do not cheat on exposure!
- Use Balfour retractors!
- Use Doyens!
- Complete abdominal explore!
  - ❖Satisfaction of search

Can you milk it?

Into the stomach –
A gastrotomy is better than a enterotomy

Into the colon –
No need for anything

If moving foreign body will cause additional injury- don't do it

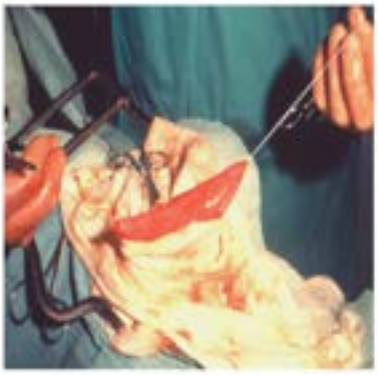
Specific surgical considerations: Stomach

Gastrotomy

- Extend incision to xyphoid
- Pack it off
- Unable to completely isolate stomach outside of the abdomen
- Have a landing pad

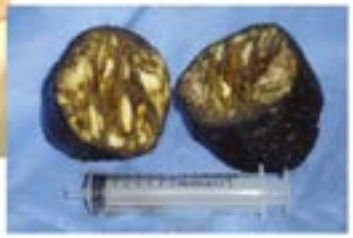
Gastrotomy

- Place stay sutures
- Stab incision into the body of the stomach
- Extend with scissors
- Between greater and lesser curvature

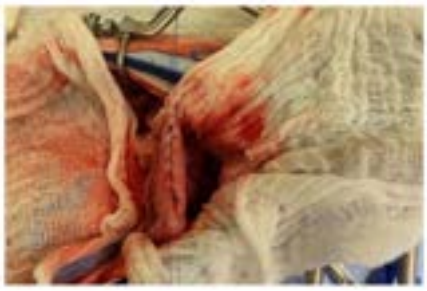


Make a big enough gastrotomy to do what you need to do.

Occasionally, gastric ulcers can form with chronic or caustic foreign bodies



Closure

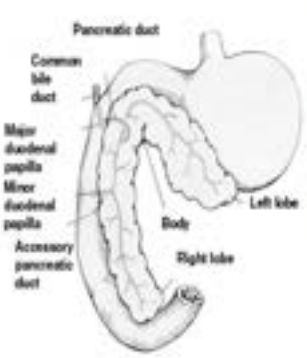


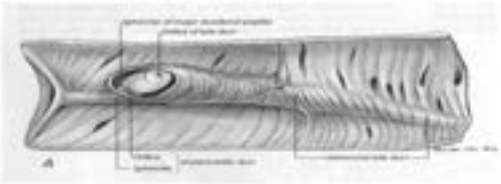
- 2 layers – appositional or inverting
- Hard to leak check
- Local/abdominal lavage

Specific surgical considerations: Duodenum

Problem Area

- Pylorus
- Common bile duct
- Pancreatic ducts
- Blood supply shared with pancreas
- Short mesentery
- Duodenal-colic ligament
- Potent secretions





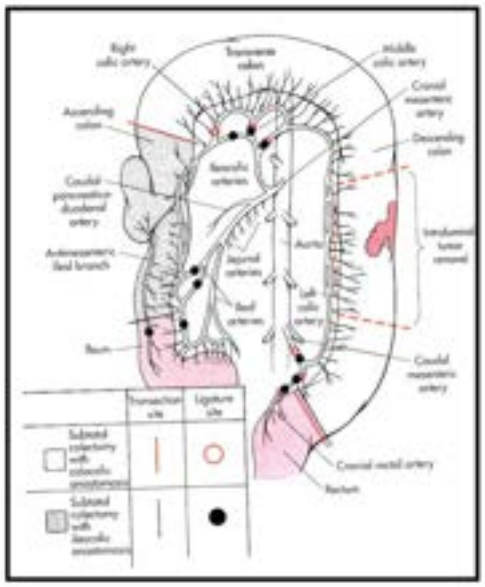
Strategies:

- Avoid if you can
- Milk into the stomach if possible
- Do not separate the pancreas from the duodenum
- Cannulate common bile duct
- Release the duodeno-colic ligament to improve exposure

Specific surgical considerations: Colon

Problem area

- Rarely indicated to resect except for tumors or idiopathic megacolon
- Foreign material can be 'milked' out
- High bacterial load = high collagenase activity = prolonged healing
- Cannot be any tension on closure
- Poor blood supply
- High intraluminal pressure during defecation



Preservation of the Ileo-cecal-colic valve

- 166 cats, ICJ removed in about 25%
  - Median survival not reached – good long term survival
  - 77% of cats had good to excellent outcomes
  - 14% of cats died as a result of complications or treatment of megacolon, major complications in 10% of cats
  - Constipation recurrence occurred in 32% of cats at a median of 344 days
  - Not associated with removal or retention of the ICJ
  - Long term diarrhea associated with removal of the ICJ
  - Fair to poor outcome associated with removal of ICJ

Grossman, JAVMA, 2022

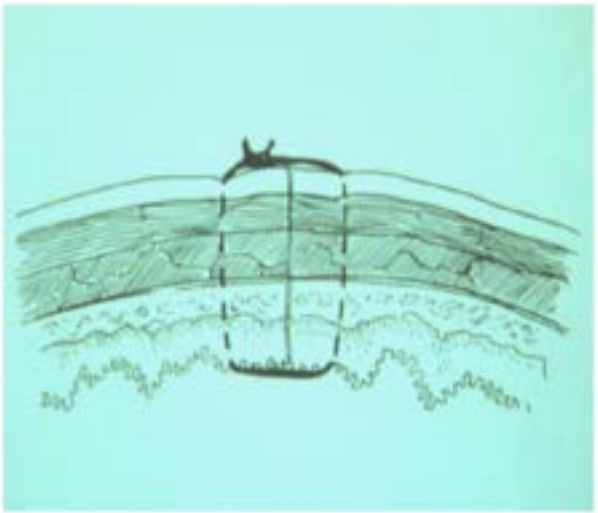
General Surgical Principles

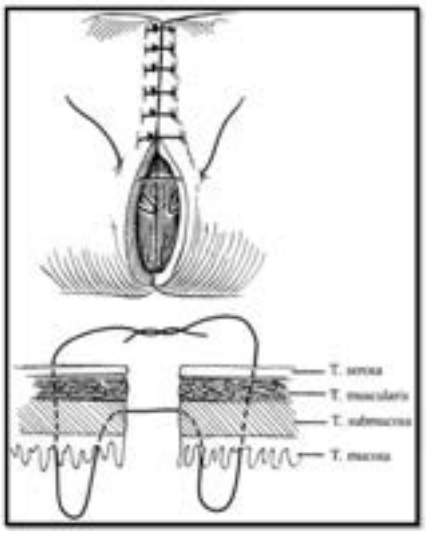
General Principles: Enterotomy

- Perform complete exploratory and palpate entire length of intestines
- Remove jejunum from abdomen
- Close Balfours to minimize contamination and preserve warmth
- Pack-off intestine with lap sponges
- Gently milk intestinal contents away from enterotomy site
- Handle gently with fingers or Doyen forceps

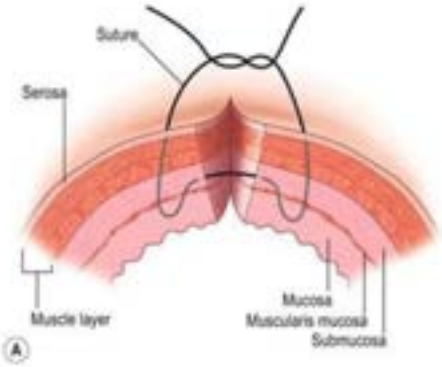
Closure

- Close with 3-0 or 4-0 monofilament, absorbable suture on taper needle
- Use SI or SC appositional pattern
- Avoid inverting or double layer closure
- Place sutures 4-5 mm away from edge and 3-4 mm apart

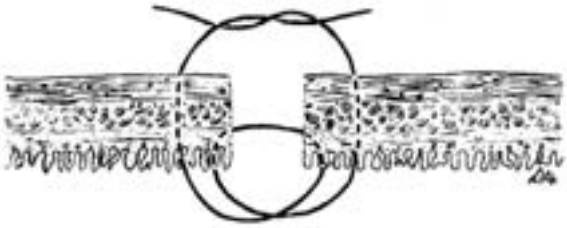




Gambee suture pattern helps to reduce mucosal eversion



Modified Gambee(s)



A Comparison of Ex Vivo Leak Pressures for Four Enterotomy Closures in a Canine Model

Nina R. Kieves, DVM, DACVS-SA, DACVSMR, CCRT*, Alexander I. Krebs, DVM, DACVS-SA†, Eric M. Zellner, DVM, DACVS-SA

Leak Pressure

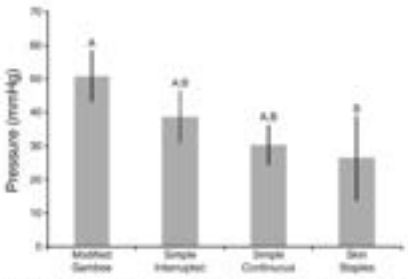


FIGURE 4 *Initial leak pressure (mm Hg) of the four enterotomy closures (mean ± SD). Means with common or shared letters indicate nonsignificant differences, whereas differing letters indicate significant differences (P < .05). SD, standard deviation.*

Time for placement

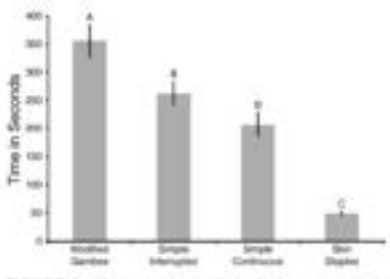


FIGURE 3 *Closure time in seconds for the four enterotomy closures (mean ± SD). Means with common or shared letters indicate nonsignificant differences, whereas differing letters indicate significant differences (P < .05). SD, standard deviation.*

J Am Anim Hosp Assoc 2018; 54:71–76. DOI 10.5326/JAAHA-MS-6459

Preservation of lumen diameter

Classic anti-mesenteric enterotomy

- Reduces lumen diameter in small and medium size animals

Transverse Closure of a longitudinal incision

- Maintains diameter
- Creates dog ears

Transverse incision: Maintains lumen diameter

Negative Explore? It happens. Biopsy.

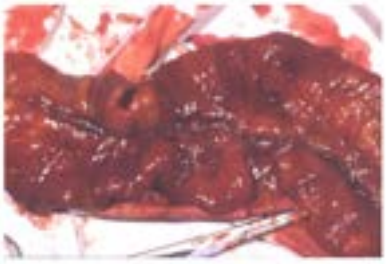
- Always biopsy on a 'negative' explore
- Biopsy multiple sites:
  - Gastric
  - Duodenal
  - Jejunal (proximal and distal)
  - Illeal
- Get full thickness samples
- Avoid crush artifact
- Don't forget lymph nodes

Intestinal Biopsy Technique

- Apply Doyen forceps or have an assistant hold off intestine
- Skin punch biopsy
- Stab incision with a 15 blade and scissors
- Suture technique

Linear Foreign Bodies

- Usually "anchor" under the tongue or at the pylorus
- Continued peristalsis causes sawing of the mesenteric border of the intestine
- Surgical treatment indicated



Linear vs. Non-linear Foreign Body

- 176 dogs linear vs. 323 non-linear
- LFB were more likely to have:
  - History of vomiting, anorexia, lethargy, pain on abdominal palpation
  - FB anchored in the stomach and extending into intestine
  - Intestinal necrosis, perforation, peritonitis
  - Require resection and anastomosis
  - Longer hospitalization
  - Increased cost of treatment
- Both groups have 96% survive to discharge

Journal of Small Animal Practice (2014) **55**, 560–565
DOI: 10.1111/jsap.12271

Linear Foreign Bodies

Strategy:

- Release anchor point with gastrotomy
- Remove remaining linear components through enterotomy (ies)

Linear Foreign Bodies

Alternate Strategy:

- Release anchor point with gastrotomy
- Tie foreign body to red rubber catheter and milk through intestines
- Better for cats than dogs with smaller, fine foreign bodies

Not good for thicker linear foreign bodies

Intestinal surgery in small animals: historical foundations, current thinking, and future horizons

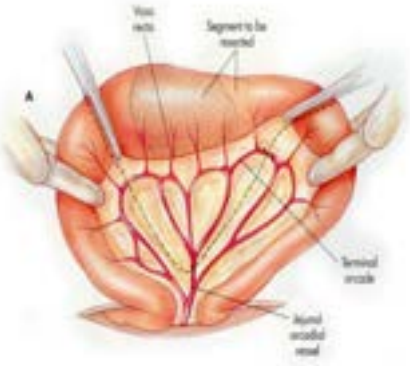
Veterinary Surgery. 2009;1–10.

Conservative Management of Linear Foreign Bodies in Cats?

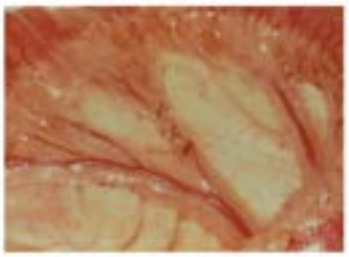
- About 50% will pass in 1 – 3 days if the anchor is released.
  - Study of 19 cats with LFB treated conservatively – 9 were successfully managed without surgery, 10 required surgery after conservative surgery failed. All cats survived.
- Those not passed will progress to septic peritonitis….
- Maybe an option for some owners

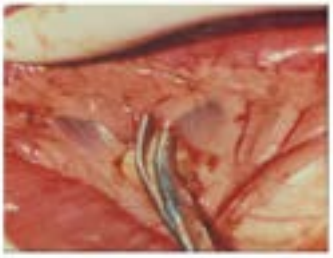
- Carefully inspect mesenteric border for pathology
- If perforation, culture, copious lavage, +/- open abdomen or abdominal drains

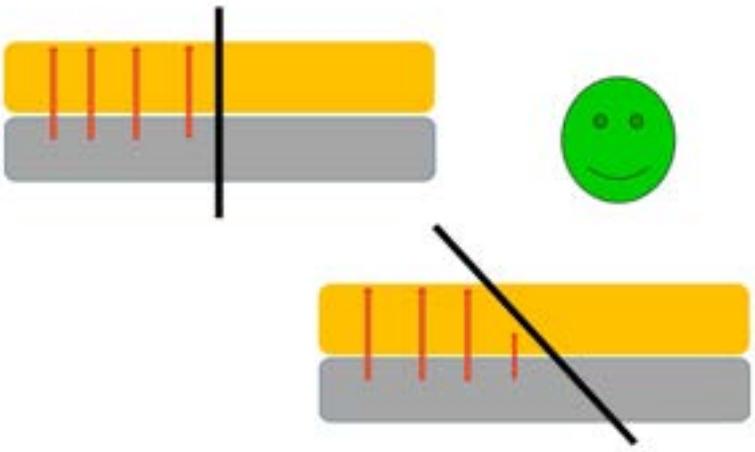
RESECTION-ANASTAMOSIS

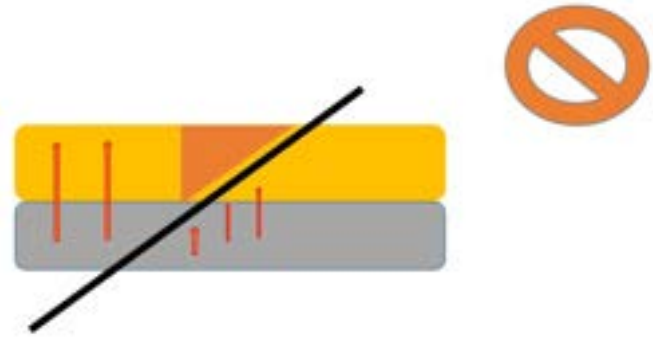


RESECTION-ANASTAMOSIS



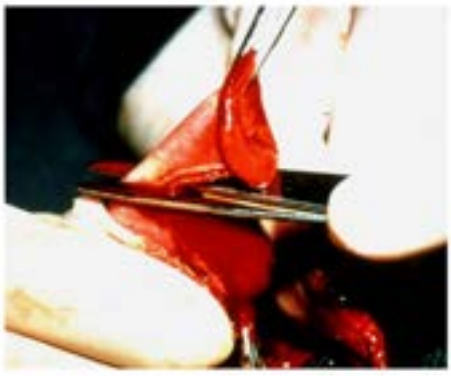






Management of Luminal Disparity

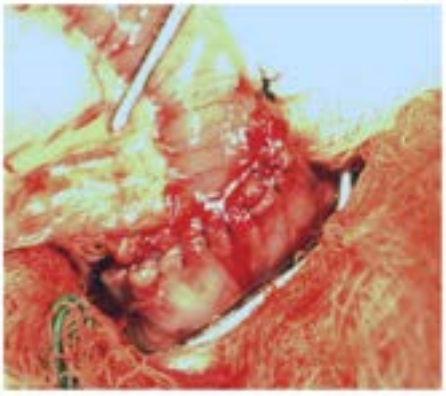
- Can be significant
- Chronic partial obstructions
- Can resect some oral intestine to a location with a more normal diameter
- Back cutting the antimesenteric surface
- Variable spacing of suture
- Partial over sew



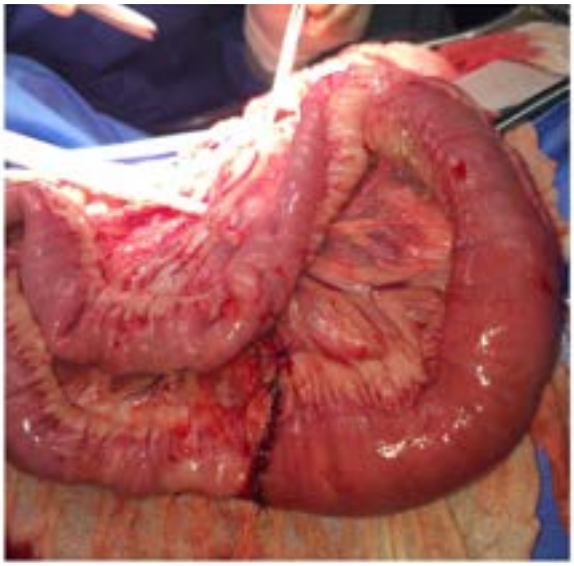
Disparity in luminal size can be accommodated by incising the smaller bowel at an oblique angle (left) or by placing sutures slightly further apart through the larger bowel (right).

Luminal Disparity:

Over sew



Danger!



Identification of risk factors for septic peritonitis and failure to survive following gastrointestinal surgery in dogs

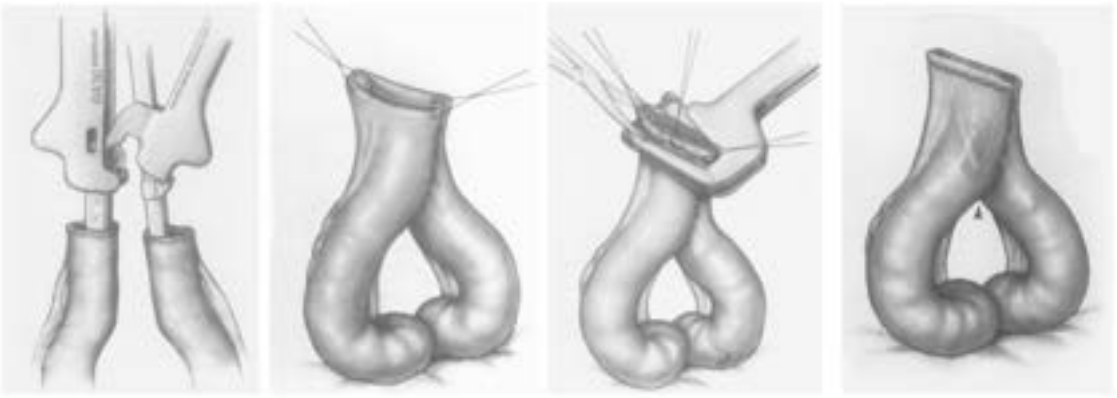
Janet A. Grimes, DVM; Chad W. Schmiedt, DVM, DACVS;
Karen K. Cornell, DVM, PhD, DACVS; MaryAnn G. Radlinsky, DVM, MS, DACVS

- 197 dogs with 225 surgeries
- 16% died prior to discharge
- 12% developed septic peritonitis
  - About 1/3 had continued peritonitis
  - About 1/3 of those dogs died
- 180 surgeries in dogs without septic peritonitis
  - 6% developed peritonitis

Risk factors for septic peritonitis

- Preoperative septic peritonitis
- Low serum albumin
- Low plasma proteins
- Intraoperative hypotension
- Foreign body was protective

Functional end to end stapled anastomosis (FEESA)



Why bother?

Frequency of Dehiscence in Hand-Sutured and Stapled Intestinal Anastomoses in Dogs

Jason R. Duell[1], Kelley M. Thaxton Mankin[2], Mark C. Rochat[3], Penny J. Regier[3], Ameet Singh[4], Jill K. Luther[5], Michael B. Mison[6], Jessica J. Leeman[6], and Christine M. Budke[6]

[1]Veterinary Clinical Sciences, Oklahoma State University, Stillwater, Oklahoma. [2]Small Animal Clinical Sciences, [3]Veterinary Integrative Biosciences, Texas A&M University, College Station, Texas. [4]Department of Clinical Studies, Ontario Veterinary College, University of Guelph, Guelph, Ontario. [5]Midwest Veterinary Referral Center, Chesterfield, Missouri and [6]Seattle Veterinary Specialists, Kirkland, Washington

Significantly reduced surgery time

Technique	N	Dehiscence	Surgery Time
Hand sutured	142	21/134 (16%)	140 minutes
FEESA	72	8/71 (11%)	108 minutes
		P=0.389	p<0.001

Intra-abdominal complications following intestinal anastomoses by suture and staple techniques in dogs

Significantly lower dehiscence rates in dogs with stapled anastomosis vs. hand sutured technique

Technique	N	Dehiscence
Hand sutured	93	13%
FEESA	87	5%
		p=0.04

JAVMA 2018

Influence of preoperative septic peritonitis and anastomotic technique on the dehiscence of enterectomy sites in dogs: A retrospective review of 210 anastomoses

Daniel J. Davis, DVM | Ryan M. Demianiuk, DVM, DACVS-SA | Jon Musser, DVM | Maria Podsiedlik, DVM | Joe Hauptman, DVM, DACVS-SA

Significantly less risk of dehiscence in the face of septic peritonitis

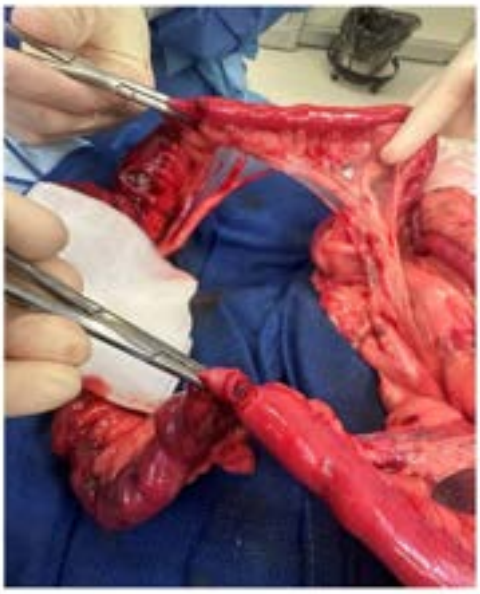
	WITHOUT Pre-op Septic Peritonitis		WITH Pre-op Septic Peritonitis	
	FEESA	Sutured	FEESA	Sutured
Dehiscence rate	4.2%	8.1%	9.7%	28.9%
	p = 0.38		P = 0.015	

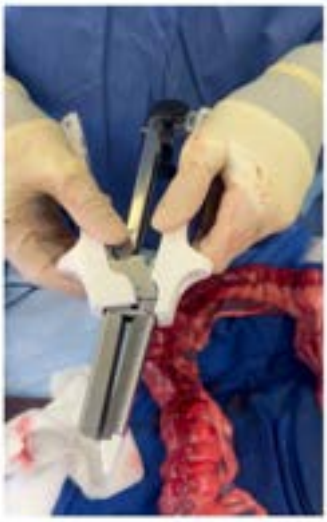
**** When all dogs are considered together (n = 198) risk factors for dehiscence were preoperative septic peritonitis and hand sewn technique**

Vet Surg 2018

FEESA Technique

Aftermath of a linear foreign body





Assemble stapler

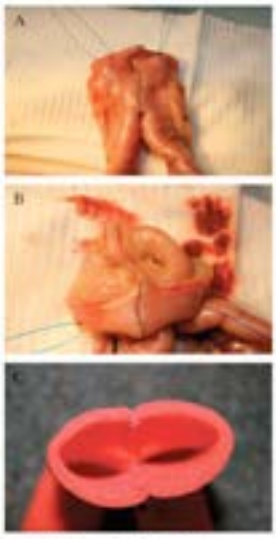
Antimesenteric surfaces are apposed
± Stay sutures can be useful

White, JSAP, 2008

Staple and blade control

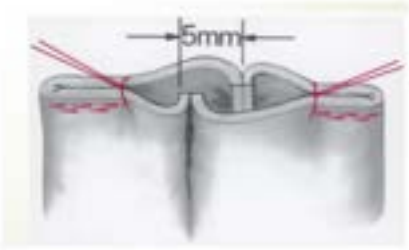
Stapler is closed

Blade is advanced



White, JSAP, 2008

GIA staple lines are offset prior to TA stapler



White, JSAP, 2008

Can also use another GIA cartridge

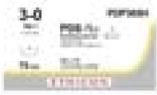
TA stapler line
is oversewn

"Crotch" suture
reinforces staple line

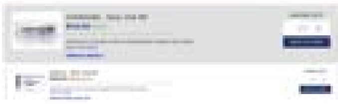
White, JSAP, 2008

Mesentery
is closed

Cost Comparison



	Stapler (Infinity)	Stapler (Synergy Surgical (formerly suture.com)	Suture
Materials	$348 (1 new stapler = $248, 1 reload = box of 5 for $500)	$310 (1 new stapler = $145, 1 reload = (box of 6 for $989)	$30 (2 packs)
Time	$540 1.8 x $300/hr	$540 1.8 x $300/hr	$690 2.3 x $300/hr
Total	$888	$850	$720



Endo-GIA staplers

- Linear staple cutters
- Made for laparoscopic use
- Useful in open surgery for smaller dogs or cats

Stapled functional end-to-end intestinal anastomosis with endovascular gastrointestinal anastomosis staplers in cats and small dogs

Small dogs (n = 10) and cats (n = 15)
Median bodyweight = 4.6 kg
No major complications reported

POSTOPERATIVE CARE

- Analgesia
- Feeding
- Antibiotics
- Prokinetics

Analgesia

- Local blocks can help (Nocita)
- NSAIDS contraindicated because of reduced GI mucosal blood flow
- Acetaminophen a good option for dogs
- Opiods are great, except…
  - Can cause nausea, ileus, reduced appetite
  - Methadone, Fentanyl
  - Switch to buprenorphine 1 day post operative
- Gabapentin
- Tramadol

Feeding post operative

- Enterocytes need the food in the gut to heal
- Feeding increases strength of anastomosis
- Feed when awake, typically that night or the next day
- Intraoperative NG tubes
- Perioperative esophagostomy tubes

Antibiotics

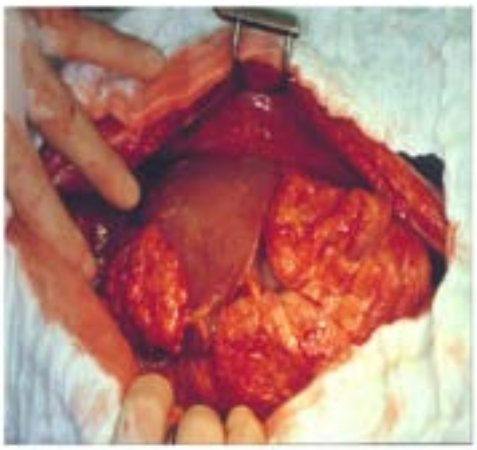
- Perioperative antibiotics are indicated
  - 30 minutes prior to incision
  - Q90 minutes after that
  - Cefazolin for most surgery (targeting G+ Staph and Strep)
  - Cefoxitin if colonic/rectal to increase anaerobic coverage
- Post operative antibiotics only indicated if contamination preop or intraop
  - Encourage resistance
  - Mask leakage

Prokinetics

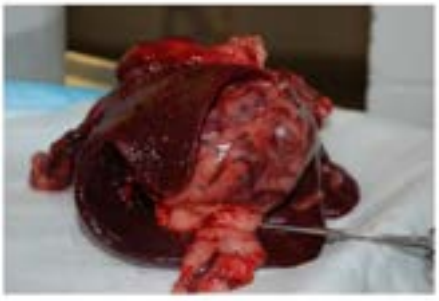
- Ileus can be a problem post op
- Worse in chronic obstructions, proximal (duodenal obstructions?), LFB
- NG Tube to reduce gastric residual volume
- Metoclopramide
- Lidocaine
- Ranitidine
- Erythromycin

COMPLICATIONS

- Vomiting
- Dehiscence- most likely in the first 2-5 days
- Stricture
- Short bowel syndrome- greater than 80% of SI removed



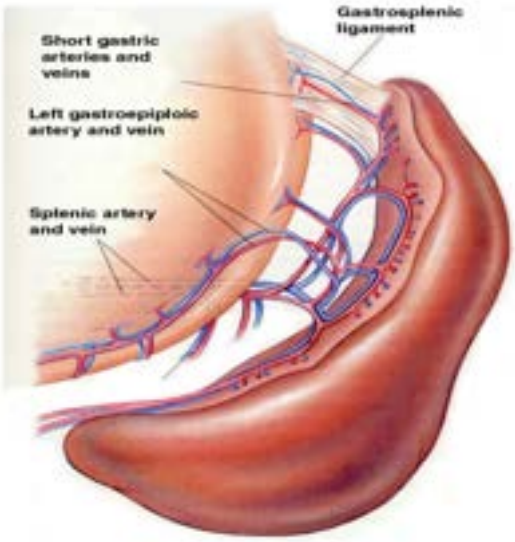
Management of Hemoperitoneum and Principles of Splenic Surgery

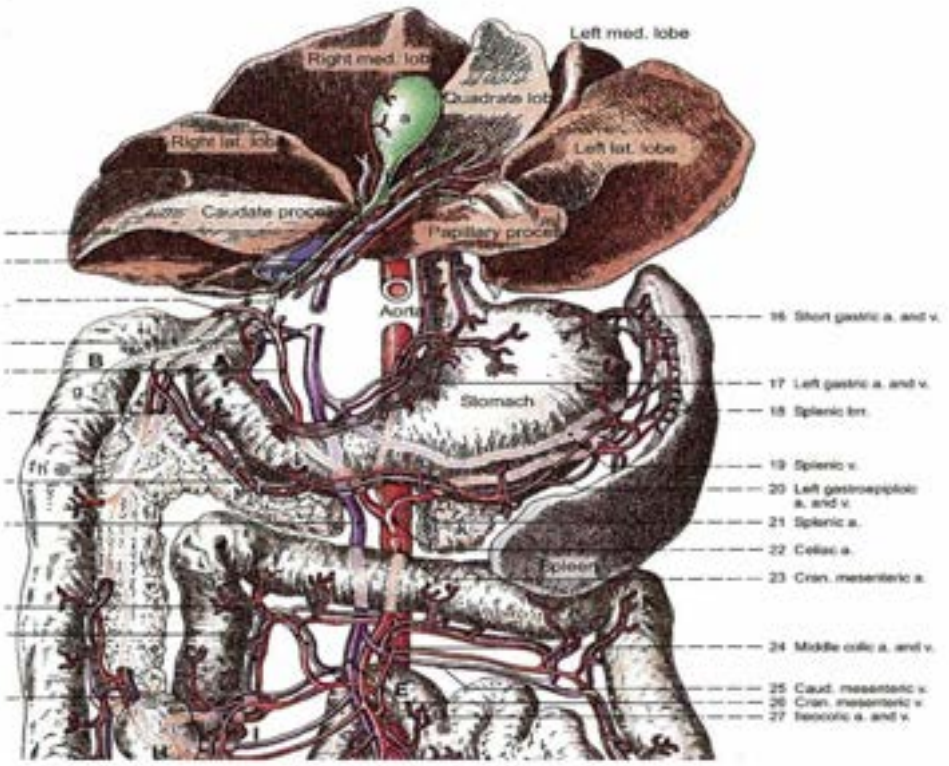


Chad Schmiedt DVM, DACVS
Professor, Small Animal Surgery
University of Georgia

SURGICAL ANATOMY

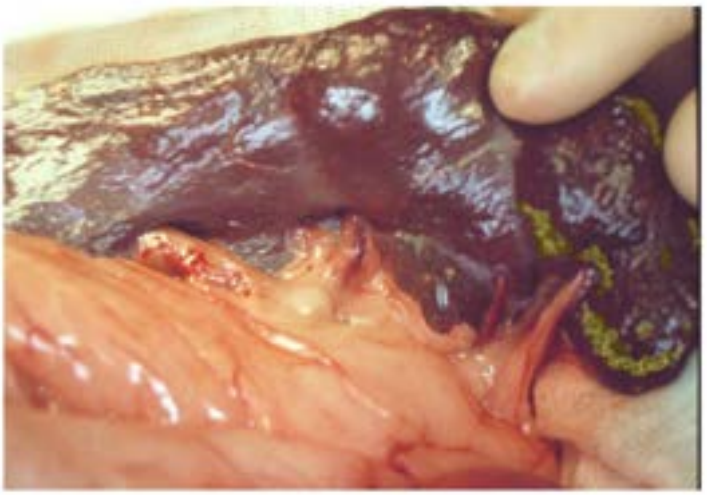
- Parenchymal organ
- Thin capsule of elastic fibers and smooth muscle
- Blood supply- splenic artery and vein
- Vagus and celiac nervous innervation





SURGICAL ANATOMY

- Splenosis, siderosis and hyperplastic nodules normal



FUNCTION

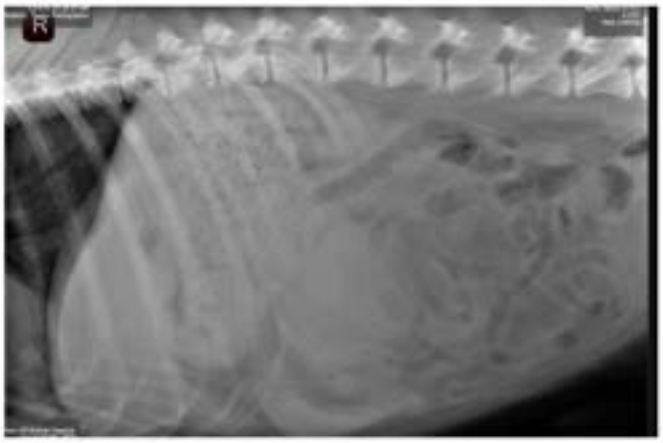
- Blood storage –
  - Red pulp and venous sinuses
- Blood filter –
  - Damaged red cells are removed
  - Recticuloendothelial function
- Hematopoesis
- Iron Metabolism
- Immunoglobulin production – white pulp

Physical Examination and Preoperative Work up

Clinical Signs of Splenic Disease

- Cranial abdominal mass
- Abdominal pain, distention
- Lethargy, weakness
- Hypotensive shock
- Anemia, thrombocytopenia, icterus
- Cardiac arrhythmias
- Coagulopathy
- GI - vomiting
- Nothing

SURVEY RADIOGRAPHS



Can provide valuable screening information

Frequently omitted in favor of more sensitive imaging, particularly with emergent cases or with hemoperitoneum

Maybe difficult to identify origin of large mass

Thoracic Imaging

- Thoracic radiographs/CT to look for pulmonary metastasis
- Cardiac ultrasound to look for heart base or right atrial tumors that might be a source of a primary tumor

Should an echocardiogram always be part of your staging?

Metastatic pattern in dogs with splenic haemangiosarcoma: Clinical implications

D. J. WATERS, D. D. CAYWOOD, D. W. HAYDEN, and J. S. KLAUSNER

- Necropsy study of 25 dogs presenting for hemoperitoneum/splenic mass
- 6 dogs (25%) had right atrial HAS
- Most common metastatic sites in dogs liver, omentum, mesentery

J. small Anim. Pract. (1988) **29**, 805–814

Concurrent Splenic and Right Atrial Mass at Presentation in Dogs with HSA: A Retrospective Study

Sarah E. Boston, DVM, DVSc, DACVS, Geraldine Higginson, BSc, MSc, Gabrielle Monteith, BSc

- Group 1: 23 dogs with splenic HSA
  - 2 dogs (8.7%) had concurrent cardiac masses (both Goldens), neither had pericardial effusion, 7 dogs (30%) had distant metastasis
- Group 2: 31 dogs with cardiac HAS
  - 9 dogs (29%) had concurrent splenic HAS and 13 (42%) had distant metastasis
- Dogs with splenic HAS staged with abdominal US had a low incidence of concurrent cardiac mass

J Am Anim Hosp Assoc 2011; 47:336-341. DOI 10.5326/JAAHA-MS-5603)

Concurrent Splenic and Right Atrial Mass at Presentation in Dogs with HSA: A Retrospective Study

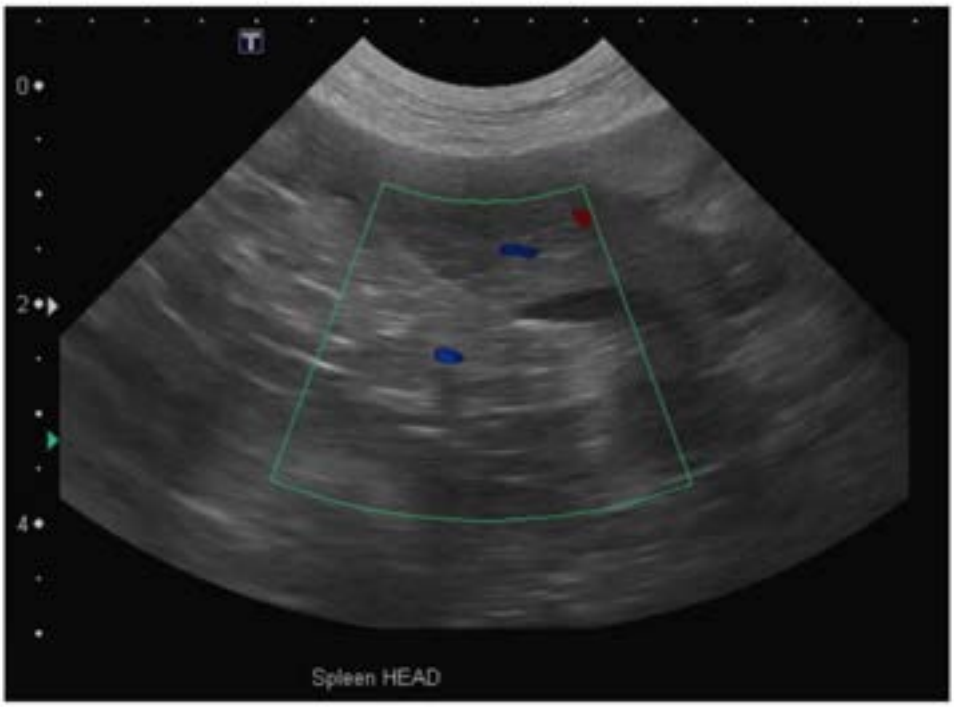
Sarah E. Boston, DVM, DVSc, DACVS, Geraldine Higginson, BSc, MSc, Gabrielle Monteith, BSc

- Group 1: 23 dogs with splenic HSA
  - 2 dogs (8.7%) had concurrent cardiac masses (both Goldens), neither had pericardial effusion, 7 dogs (30%) had distant metastasis
- Group 2: 31 dogs with cardiac HAS
  - 9 dogs (29%) had concurrent splenic HAS and 13 (42%) had distant metastasis
- Dogs with splenic HAS staged with abdominal US had a low incidence of concurrent cardiac mass

(*J Am Anim Hosp Assoc* 2011; 47:336-341. DOI 10.5326/JAAHA-MS-5603)

ULTRASOUND

- Blood flow?
- Evidence of lesions in other organs?
- Free abdominal fluid?
- Other abdominal concerns?



CT scan – greater sensitivity for metastatic lesions, can be easier in larger dogs

Abdominal US ~$350

Abdominal CT ~$600

Abx and Tx CT ~$1200

Abdominocentesis

- Frequently US guided aspirates of abdominal fluid if present
- Measure PCV/TS
- Evaluate microscopically
- Can track overtime (every 1-2 hr) and compare to blood to determine bleeding activity

Splenic Aspirate or Surgical Biopsy

Splenic aspirate or biopsy are rarely performed as part of work up procedures in dogs.

Preoperative Prognostication

Dogs with hemoabdomen go from normal to abnormal very quickly, owners have little time to digest

Your dog has cancer, I'm sorry. But wait...

- Roughly 1/3 of splenic masses are **benign**.
  - Anecdotally, the larger masses are more likely benign. A small bleeding mass is more like HAS
- Most dogs survive surgery and those that do have an good quality of life (if its HAS though it is probably short).

What is this ??

General Statistics

Evaluation of the validity of the double two-thirds rule for diagnosing hemangiosarcoma in dogs with nontraumatic hemoperitoneum due to a ruptured splenic mass: a systematic review

Ashley R. Schick, DVM, and Janet A. Grimes, DVM, MS, DACVS-SA*

Department of Small Animal Medicine and Surgery, College of Veterinary Medicine, University of Georgia, Athens, GA

*Corresponding author: Dr. Grimes (jgrimes@uga.edu)

doi.org/10.2460/javma.22.08.0389

- "Double 2/3^{rds}" rule is reasonably accurate but likely an underestimation
- About 73% of splenic masses are neoplastic.
- About 87% of the neoplastic masses are hemangiosarcoma
- If a dog has a non-traumatic hemoabdomen with a splenic mass – about risk of neoplasia increases

Perioperative outcome in dogs with hemoperitoneum: 83 cases (2005–2010)

Cassie N. Lux, DVM; William T. N. Culp, VMD, DACVS; Philipp D. Mayhew, DVMdrs, DACVS; Kim Tong, DVM; Robert B. Rebhun, DVM, DACVIM; Philip H. Kass, DVM, PhD, DACVMP

Objective—To characterize the clinical course of dogs with hemoperitoneum in the perioperative setting and to determine risk factors that may affect short-term outcome.

Design—Retrospective case series.

Animals—83 client-owned dogs.

Procedures—The medical records of dogs with hemoperitoneum that underwent surgery between 2005 and 2010 were reviewed. Data were analyzed to determine risk factors associated with perioperative outcome. The perioperative period was defined as the time from admission to the hospital for treatment of hemoperitoneum until the time of discharge or euthanasia (within the same visit).

Results—13 of 83 (16%) dogs died or were euthanized in the perioperative period. The median hospitalization time for surviving dogs was 2 days (range, 1 to 5 days). The requirement for a massive transfusion with blood products was a negative prognostic indicator for hospital discharge. The source of bleeding was isolated to the spleen in 75 of 83 (90%) dogs; a splenic source of hemorrhage was determined to be a positive predictor of survival to discharge from the hospital.

Conclusions and Clinical Relevance—In the present study, factors associated with death and failure to be discharged from the hospital included tachycardia, a requirement for massive transfusion with blood products, and the development of respiratory disease secondary to suspected pulmonary thromboembolism or acute respiratory distress syndrome. The presence of disease within the spleen was positively associated with survival to discharge. Surgical intervention for treatment of hemoperitoneum, regardless of etiology, resulted in discharge from the hospital for 70 of the 83 (84%) dogs in this series. (*J Am Vet Med Assoc* 2013;242:1385–1391)

Do the more abdominal lesions identified on ultrasound mean its more likely cancer? *Not really*

Prevalence of malignancy when solitary versus multiple lesions are detected during abdominal ultrasonographic examination of dogs with spontaneous hemoperitoneum: 31 cases (2003–2008)

Joshua G. Levinson, DVM; Jennifer L. Bouma, VMD, DACVR; Gary C. Althouse, DVM, MS, PhD, DACT and Teresa M. Rieser, VMD, DACVECC

Spontaneous hemoabdomen, US-detected lesions

- 1 lesion = 80% malignant
- More than 1 lesion = 81% malignant

Journal of Veterinary Emergency and Critical Care **19**(5) 2009, pp 496–500
doi: 10.1111/j.1476-4431.2009.00466.x

Owner assessment of dogs' quality of life following treatment of neoplastic haemoperitoneum

June 2, 2012 | Veterinary Record

A. H. Crawford, M. S. Tivers,
S. E. Adamantos

The study found that despite a significant perioperative mortality, dogs treated surgically for neoplastic haemoabdomen encountered minimal serious perioperative complications, a short duration of hospitalisation and a rapid recovery postoperatively. Although surgically treated dogs had a short survival time, this was associated with a significant improvement in QOL and good owner satisfaction. Thus, surgical management can achieve temporary remission and give the owner valuable time with their pet, with a good short-term outcome and high owner satisfaction, despite a poor long-term prognosis.

Spontaneous hemoperitoneum in cats: 65 cases (1994–2006)

William T. N. Culp, VMD, DACVS; Chick Weisse, VMD, DACVS; Melissa E. Kellogg, DVM; Ira K. Gordon, DVM, DACVR; Dana L. Clarke, VMD; Lauren R. May, VMD, DACVS; Kenneth J. Drobatz, DVM, MSCE, DACVECC, DACVIM

Objective—To describe the clinical signs, physical examination findings, clinical laboratory abnormalities, etiology, and outcome in cats with spontaneous hemoperitoneum.

Design—Retrospective case series.

Animals—65 client-owned cats with spontaneous hemoperitoneum.

Procedures—Medical records of cats with spontaneous hemoperitoneum at 7 large referral clinics were reviewed. Cats were included if a definitive diagnosis of spontaneous hemoperitoneum could be obtained from review of the medical records.

Results—65 cats met inclusion criteria. The most common historical findings were lethargy, anorexia, and vomiting. Common findings on physical examination included inadequate hydration status and hypothermia. The most common clinicopathologic abnormalities were high serum AST activity, anemia, prolonged prothrombin time, and prolonged partial thromboplastin time. Forty-six percent (30/65) of cats had abdominal neoplasia, and 54% (35/65) had nonneoplastic conditions. Hemangiosarcoma was the most often diagnosed neoplasm (18/30; 60%), and the spleen was the most common location for neoplasia (11/30; 37%). Eight cats survived to be discharged from the hospital. Cats with neoplasia were significantly older and had significantly lower PCVs than cats with nonneoplastic disease.

Conclusions and Clinical Relevance—Spontaneous hemoperitoneum in cats often results in debilitating clinical consequences. In contrast to dogs with hemoperitoneum, the cause of hemoperitoneum in cats is approximately evenly distributed between neoplastic and nonneoplastic diseases. Although only a few cats were treated in this study, the prognosis appears poor. (*J Am Vet Med Assoc* 2010;236:978–982)

When to do surgery?
Is it elective, urgent, emergent?

- Just a mass?
- Actively bleeding mass?
- Had a bleed, but now stable?
- Actively bleeding, temporarily responsive to fluid resuscitation?
- Your schedule?
- Comfort level (Could it be a liver met bleeding)?
- No mass? Traumatic?

Preoperative Stabilization

Fluid resuscitation

Blood replacement

Fibrinolysis inhibitors

Monitoring

IV Fluid Resuscitation

- Shock Dose = 90 ml/kg,
  give 1/3 to 1/2 and reassess
- Limited volume resuscitation?
  - Hypertonic saline, hyperoncotic fluids (hetastarch)

A Pilot Comparison of Limited Versus Large Fluid Volume Resuscitation in Canine Spontaneous Hemoperitoneum

Tara N. Hammond, DVM, DACVECC, Jennifer L. Holm, DVM, DACVECC, Claire R. Sharp, BVMS, DACVECC

ABSTRACT

Treatment for hemorrhagic shock secondary to a spontaneous hemoperitoneum includes restoration of IV volume and surgical control of hemorrhage. This study was designed to determine if limited fluid volume resuscitation (LFVR) with hypertonic saline (HS) and hyperoncotic fluids (hydroxyethylstarch [HES]) results in more rapid cardiovascular stabilization in dogs with spontaneous hemoperitoneum versus conventional resuscitation (CR) with large volume resuscitation. Eighteen client-owned dogs presenting in hemorrhagic shock with a spontaneous hemoperitoneum were enrolled. Dogs were randomized to be fluid resuscitated with up to 90 mL/kg of an isotonic crystalloid (CR group) or up to 8 mL/kg of 7.2% Na chloride (i.e., HS) combined with up to 10 mL/kg of 6% HES. Measurements of vital signs, lactate, packed cell volume (PCV), total solids (TS), and blood pressure were made at standard time points. The primary end point was time to stabilization of hemodynamic parameters (measured in min). Dogs in the LFVR group achieved hemodynamic stabilization significantly faster (20 min; range, 10–25 min) than those in the CR group (35 min; range, 15–50 min; $P = .027$). Future studies are warranted to further investigate potential benefits associated with LFVR in dogs with spontaneous hemoperitoneum. *J Am Anim Hosp Assoc* 2014; 50:159–166. DOI 10.5326/JAAHA-MS-6085)

Autotransfusion?

- Perfectly fine for dogs with traumatic hemoperitoneum, hemothorax
- Be sure there is no possibility of sepsis
- Cancer?
  - Is there other blood available?
  - Will they die without it?
  - Not really any evidence that it reduces long term survival
  - Tumor has likely already spread

Autologous blood transfusion in dogs with thoracic or abdominal hemorrhage: 25 cases (2007–2012)

Veronica A. Higgs, DVM; Elke Rudloff, DVM, DACVECC; Rebecca Kirby, DVM, DACVIM, DACVECC and Andrew K.J. Linklater, DVM, DACVECC

Abstract

Objective – To describe the use and outcome following autologous blood transfusion (ABT) in dogs.
Design – Retrospective study (January 2007–July 2012).
Setting – Private veterinary referral center.
Animals – Twenty-five dogs that underwent ABT secondary to thoracic or abdominal hemorrhage.
Interventions – None.
Measurements and Main Results – The hospital transaction database was searched using the keyword "autotransfusion" from January 2007 to July 2012. Data collected included signalment, body weight, etiology of hemorrhage, source and method of collection, volumes and method of ABT administration, use of anticoagulant, reported complications, and outcome. Twenty-five dogs were included for a total of 27 ABTs. Causes of hemorrhage included vascular trauma (14/25-dogs, 56%), ruptured tumor (8/25, 32%), and coagulopathy attributed to brodifacoum toxicosis (3/25, 12%). Autologous blood was collected from the abdominal (19/25, 76%), thoracic (5/25, 20%), or abdominal and thoracic cavities (1/25, 4%). Anticoagulant was added to the ABT blood in 13 of 25 (52%) cases. A median ABT volume of 20.3 mL/kg (range 2.9–406.9 mL/kg) was infused through either a 210 μm blood administration filter (21/27, 78%) or an 18 μm hemostatic filter (6/27, 22%). Reported complications that may have been associated with ABT included hypocalcemia (4/17, 24%), hemolyzed serum (5/19, 26%), and prolonged coagulation times (4/5, 80%). These complications were considered of minimal clinical significance. Additional blood products were administered in 17 of 25 (68%) dogs. Seventeen (68%) dogs survived to discharge. Cause of death in the remaining cases was euthanasia or cardiac arrest secondary to uncontrollable hemorrhage.
Conclusions – ABT is an adjunct to volume replacement in dogs with thoracic or abdominal hemorrhage secondary to vascular trauma, ruptured tumor, or anticoagulant rodenticide toxicosis. ABT may be used as a bridge to definitive hemorrhage control, particularly when other blood products are not available or affordable. Complications may include hypocalcemia, prolonged coagulation times, and hemolysis.

(J Vet Emerg Crit Care 2015; 25(6): 731–738) doi: 10.1111/vec.12338

Autologous Blood Collection/Administration

Collection:

1. Into syringe by butterfly catheter
2. Into catheter tip syringe
3. Pool suction tip into sterile container
4. ± anticoagulant

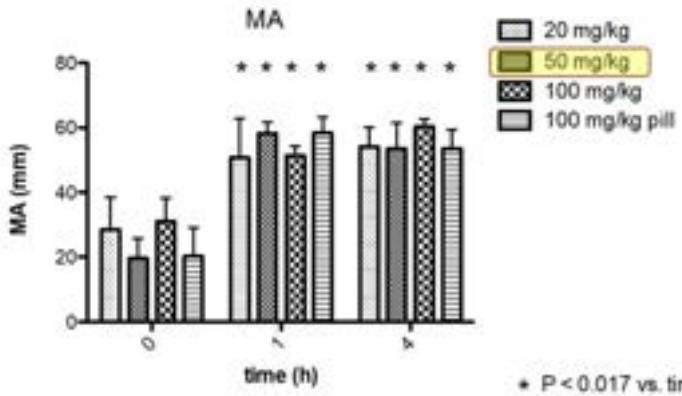
Transfer into separate sterile syringe for administration through blood administration filter

(J Vet Emerg Crit Care 2016; 26(6): 766–774) doi: 10.1111/vec.12476

(J Vet Emerg Crit Care 2009; 19(5): 496–500) doi: 10.1111/j.1476-4431.2009.00466.x

Fibrinolysis Inhibitors

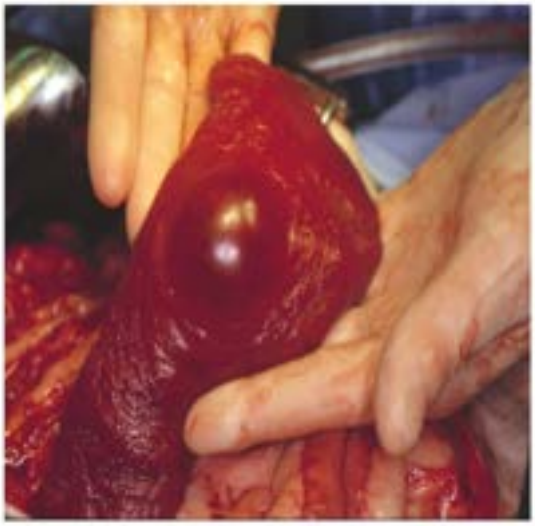
- Aminocaproic acid, Tranexamic acid
- Stabilizes clot formation



MA is "maximum amplitude" and is a measure of overall clot strength on a TEG

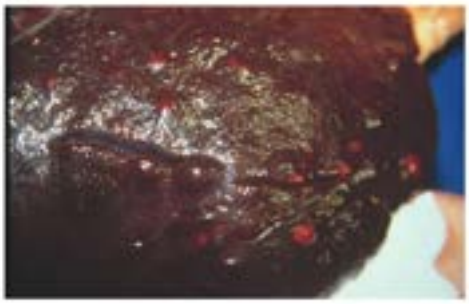
SURGICAL DISEASES

- Neoplasia
- Hematoma
- Traumatic rupture
- Torsion
- Abscess



NEOPLASIA

- Hemangiosarcoma
- Hemangioma
- Mast cell tumor
- Lymphosarcoma
- Histiocytoma
- Sarcoma

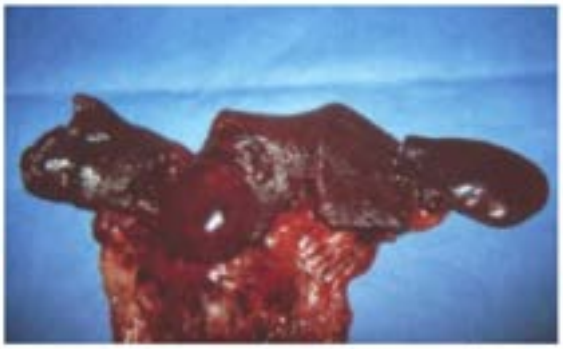


HEMATOMA

- **May cause very similar clinical signs as a neoplastic mass**
- **Gross appearance may be the *same* as a neoplastic mass**
- **Histopathology necessary to determine the difference**
- **Provide pathology with large tissue sample**

TRAUMATIC RUPTURE

- **Usually secondary to severe blunt trauma**
- **Hemorrhage can be significant but usually stops without surgical intervention**
- **Evaluate spleen**
- **Suture lacerations or remove all or portions that are devitalized**



TORSION

- May be spontaneous or secondary to GDV
- Occlusion of vessels leading to ischemia and necrosis
- Generally requires splenectomy unless diagnosed early and spleen still viable and can be de-rotated

Vascular Pedicle

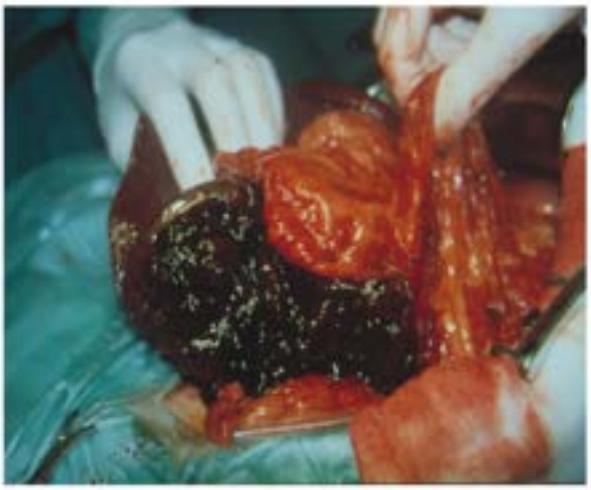
ABSCESS

- Vague clinical signs
- Hematogenous or direct spread of bacteria
- Diagnose with US and FNA
- Splenectomy
- Culture and continue systemic antibiotics

Splenic Surgery

SURGICAL PRINCIPLES

- Handle spleen carefully to avoid rupture
- Have plenty of hemostats available – use them on the spleen side or both sides if active bleeding
- Perform a gastropexy
- Provide multiple tissue samples for biopsy

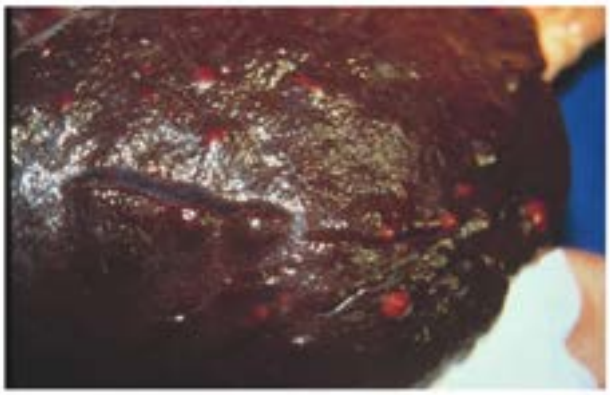


SURGICAL PRINCIPLES

- Make adequate size laparotomy for thorough exploratory
- Have suction to remove hemorrhage
- Pedicle-ize and remove omental adhesions
- Stay close to the spleen

SURGICAL PROCEDURES

- Partial splenectomy
- Total splenectomy



PARTIAL SPLENECTOMY

- Double ligate vessels that supply portion of spleen to be removed
- Gently compress spleen before clamping
- Transect spleen and and oversew cut edge with two continuous rows
- Use 3-0 or 4-0 absorbable suture on taper needle
- Monitor suture line for bleeding

PARTIAL SPLENECTOMY

- Automatic stapling devices can be used for partial splenectomy
- Two staggered row of staples are placed
- Must ensure that the tissue is not too thick and staples are secure

SPLENECTOMY

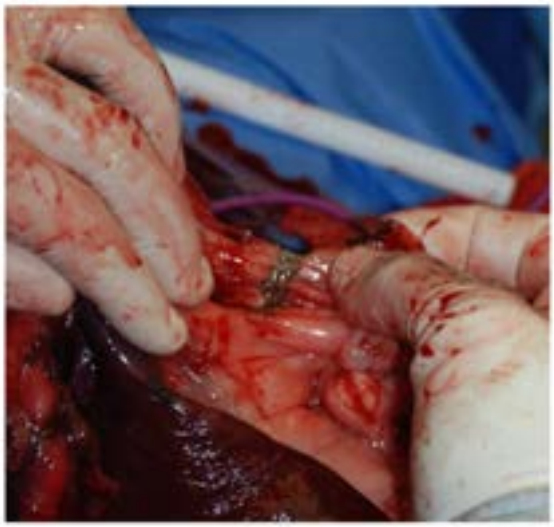
- Isolate spleen and identify vascular pedicle
- Pack-off spleen with moist lap sponges
- Double ligate vessels with absorbable or nonabsorbable material

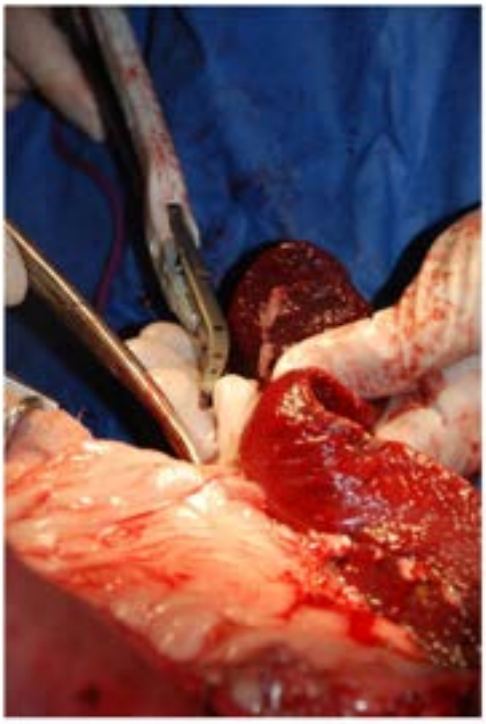
SPLENECTOMY

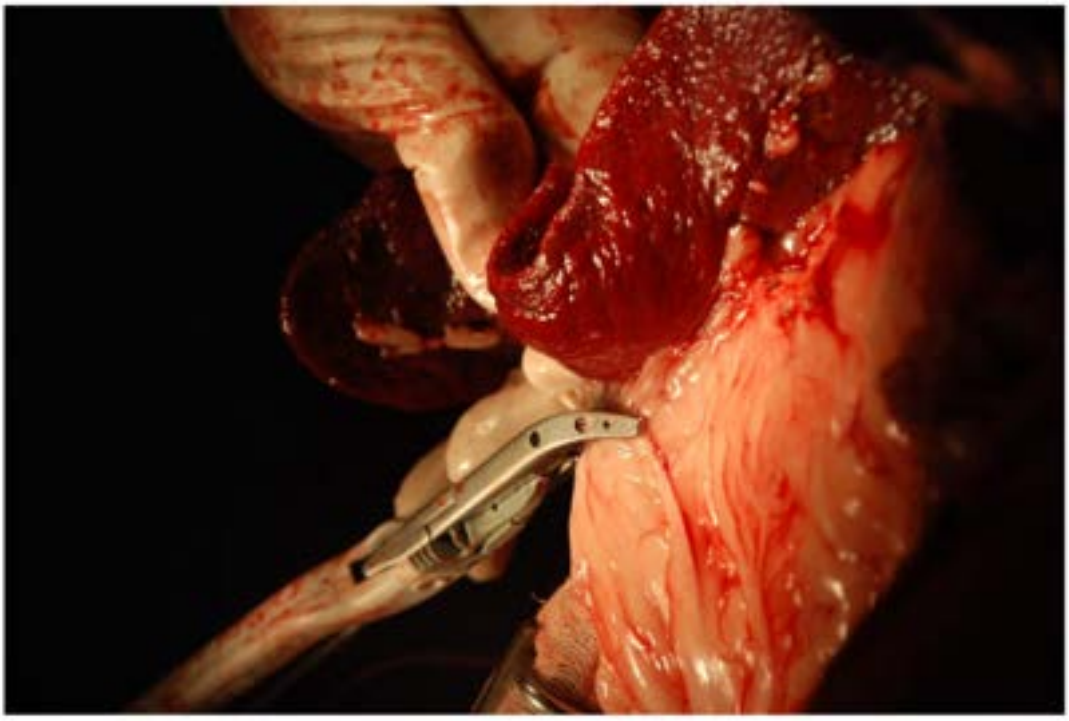
- **Hemoclips may be used to save time but must be secure**
- **LDS stapling device (Ligate – Divide – Staple)**
- **LigaSure or Harmonic Scalpel**

Harmonic Scalpel

Ligasure







Or... you can just ligate....

- Hand ties or instrument ties
- Ligature with the dog, hemostats with the spleen
- Suture type?

The one exception...

- Splenic torsions should be removed at the twist.
- Suture or staple

Association between previous splenectomy and gastric dilatation-volvulus in dogs: 453 cases (2004–2009)

Angela J. Sartor, DVM; Adrienne M. Bentley, DVM, DACVS; Dorothy C. Brown, DVM, MSCE, DACVS

- Odds of GDV 5.3x higher in dogs with previous splenectomy vs. those without splenectomy

Results—6 (4%) dogs in the GDV group and 3 (1%) dogs in the control group had a history of previous splenectomy. The odds of GDV in dogs with a history of previous splenectomy in this population of dogs were 5.3 times those of dogs without a history of previous splenectomy (95% confidence interval, 1.1 to 26.8).

Conclusions and Clinical Relevance—For the patients in the present study, there was an increased odds of GDV in dogs with a history of splenectomy. Prophylactic gastropexy may be considered in dogs undergoing a splenectomy, particularly if other risk factors for GDV are present. *J Am Vet Med Assoc* 2013;242:1381–1384)

POSTOPERATIVE CARE

- Analgesia and supportive care
- Monitor closely for signs of hemorrhage
- Repeat PCV/TS as necessary
- Provide blood products if necessary to replace losses
- Continue ECG if arrhythmias persistent
- Continue IV fluids until eating and drinking

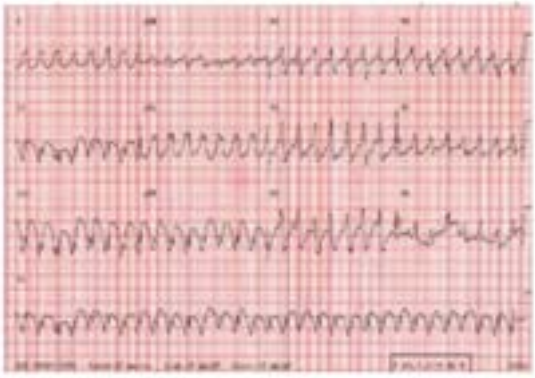
Complications

Hemorrhage

- Mostly commonly – its your fault – bad ligature, missed pedicle, etc.
- Coagulopathy
- Another mass – check the liver!

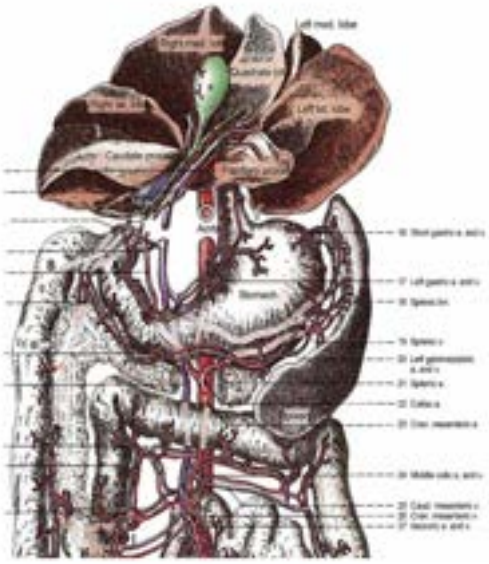
Arrythmias

- Most common post operative complication
- Usually not pathologic and usually doesn't require treatment
- Treat if: tachycardic, R on T, multiform, reducing cardiac output
- Lidocaine (2 mg/kg bolus then 50 µg/kg/min) or Sotalol (1 – 2 mg/kg BID)



Pancreatitis or Gastric Necrosis

- Stay close to the spleen!!



Babesiosis in Pit Bulls

- Pit Bull Terriers and related may develop Babesiosis when immunosuppressed and potentially after removal of the spleen
- Vertical or horizontal transmission
- Discuss risk with owners
- Consider a partial splenectomy

CHYLOTHORAX IN DOGS AND CATS

Chad Schmiedt DVM, DACVS
Professor, Soft Tissue Surgery
College of Veterinary Medicine
University of Georgia

Outline

- Overview of chylothorax
  - *Pathophysiology*
  - *Diagnosis*
  - *Treatment*
  - *Prognosis*

PATHOPHYSIOLOGY

Signalment

- Oriental cats
- Dogs
  - *Afghan hound*
  - *Mastiff*
  - *Shetland sheepdog*
  - *Shiba Inu (young)*
- Any age possible
- No sex predisposition

Current Techniques in SA Surgery 2014.
Singh, et al. Compendium 2012.

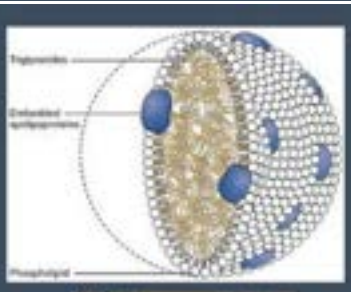
Prevalence

Characterization of and factors associated with causes of pleural effusion in cats

Ruiz, et al. JAVMA 2018.

What is Chyle?

- Modified transudate composed of lymph and chylomicrons
- Proteins between 2.5 – 4 g/dL
- Lymphocytes, chronically more nondegenerate neutrophils
- Normally returned to systemic circulation by the thoracic duct

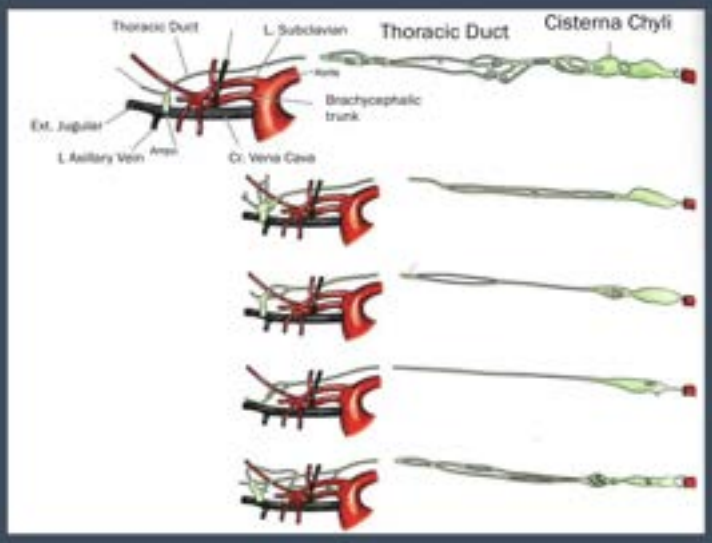


Current Techniques in SA Surgery 2014.
Singh, et al. Compendium 2012.

The Lymphatic System

- Cisterna chyli (CC)
  - *Abdominal lymphatic reservoir*
  - *Fat from SI absorbed as chylomicrons → collected by villous lacteals → empties in CC → TD*
- Thoracic duct (TD)
  - *Largest lymphatic vessel in the body*
  - *Dorsal to the aorta*
  - *Lymphaticovenous junction*

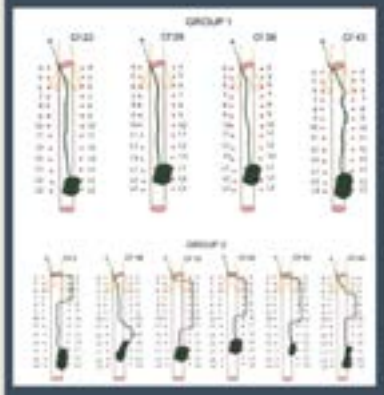
ery 2014.
Singh, et al. Compendium 2012.



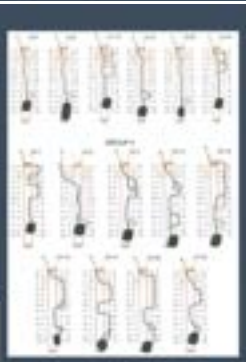
From Evans HE, DeLahunta A. Millers Anatomy of the Dog, 4th ed.

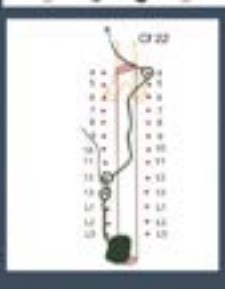
Anatomical variations of the thoracic duct in the dog

Kim Korpes | Magdalena Kolenc | Tijana Trbojević Vukičević | Martina Duras



- Variations in 39/43 dogs
- Originates as 1 vessel in 83.7% of dogs, 2 vessels in 14%, and 1 vessel in 2.3%





NVF Hands-On Workshop

How Does Chylothorax Occur?

- Anything that impedes TD flow or obstructs its lymphaticovenous junction
- Differentials
  - ***Idiopathic *****
  - *Cardiac disease – restrictive pericarditis, RCHF, Heartworm*
  - *Mediastinal mass – neoplasia (lymphosarcoma, thymoma) or fungal (blastomycosis)*
  - *Diaphragmatic hernia*
  - *Lung lobe torsion*
  - *Thoracic trauma – tear or rupture of the TD*

Current Techniques in SA Surgery 2014.
Singh, et al. Compendium 2012.

Idiopathic Chylothorax

- Theories
  - *Lymphangectasia leading to leakage of lymph*
  - *Functional obstruction of the lymphaticovenous junction*
  - *Lymphatic hypertension*
- Fibrosis pleuritis develops
  - *Especially problematic in cats*

Small Animal Soft Tissue Surgery 2013.
Singh, et al. Compendium 2012.

DIAGNOSIS

History and Physical Exam

- History
  - *Coughing*
  - *Difficulty breathing*
  - *Exercise intolerance*
  - *Weight loss*
- Physical Exam
  - *Tachypnea or dyspnea*
  - *Quiet lung sounds*
  - *+/- murmur, arrhythmia, caval syndrome*

Singh, et al. Compendium 2012.

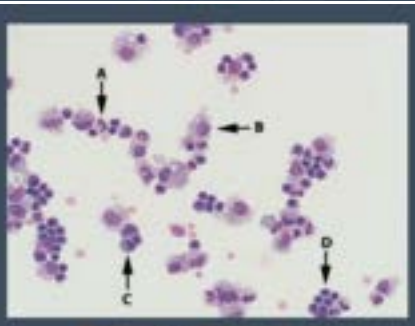
Thoracocentesis

- Both diagnostic and therapeutic
  - *Sedation as needed*
  - *Get as much as you can*
  - *Save some for cytology, biochemical analysis, and culture*
- Chyle
  - *Milky appearance*
  - *May be clear in anorexic patients*
  - *No odor*

Singh, et al. Compendium 2012.

Fluid Analysis

- *Lots of lymphocytes*
- *Some macrophages*
- *Some non-degenerate neutrophils*
  - Especially if chronic – intrapleural inflammation and lymphocyte depletion
- *Lipid droplets may also be present*



Current Techniques in SA Surgery 2014.
Singh, et al. Compendium 2012.

Fluid Analysis

- Triglycerides
  - *Higher in pleural fluid than serum*
  - *Can be pronounced*
- Cholesterol
  - *Lower in pleural fluid than serum*

Table 43-2. Characterization of Chylous Pleural Fluid in Dogs and Cats

	Dogs	Cats
Specific gravity	1.022-1.037	1.019-1.038
Total Protein (g/dl)	2.5-6.2	3.5-7.8
Average nucleated cells/µL	6,127	11,919

Triglycerides	
Serum	189 mg/dl
Effusion	250 mg/dl

Current Techniques in SA Surgery 2014.

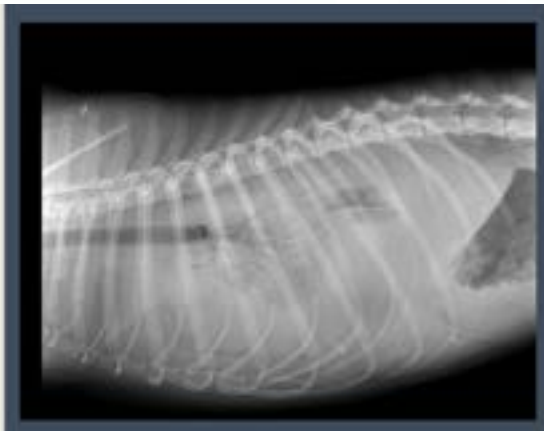
Bloodwork

- Chemistry Panel
  - *May see hyponatremia and hyperkalemia*
- CBC
  - *May see lymphopenia*
- Heartworm,
- FeLV, FIV testing

Singh, et al. Compendium 2012.

Imaging: Radiographs

- Thoracic radiographs
  - *Pleural effusion?*
  - *Cardiomegaly?*
  - *Mass?*
  - *Rounding of the lungs?*
  - *Lung lobe torsion?*
- Thoracocentesis first, or repeat films afterwards



Fibrosing Pleuritis

- Chronic exposure of the pleura to chyle → altered fibrin production and degradation
  - *Fibrosis of the visceral pleura can result*
  - *Restricts pulmonary expansion*
- More common in cats
  - *Poorer prognosis*

Small Animal Soft Tissue Surgery. 2013.
Singh, et al. Compendium 2012.

Imaging: Echocardiogram

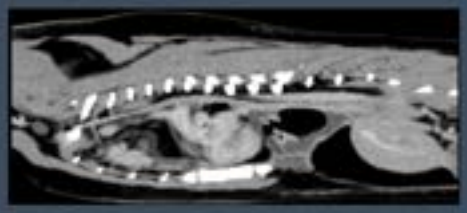
- Recommended in all patients with chylothorax
  - *Regardless of auscultation*
- Rule out cardiac causes of chylothorax
  - *Impacts treatment!*

Thoracic CT scan

Definitively rule out mediastinal mass lesions, other pathology

Further evaluate lungs

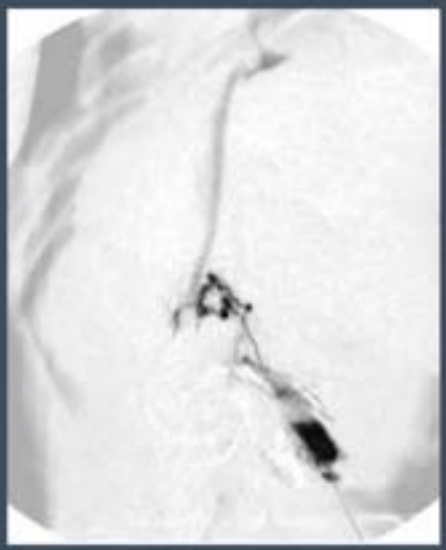
Lymphangiography can be performed to assess thoracic duct anatomy



Imaging: Lymphography

- Many methods described
  - *CT*
  - *Fluoroscopy*
  - *Fluorescent imaging*
  - *Catheterization and direct injection*
  - *Intranodal – popliteal, ileocelcal colic*
  - *SQ rectal, metatarsal*
- Surgical planning
  - *Can also help diagnose lymphangectasia*
- Confirmation of ligation
- Investigation of recurrence or failure to resolve
- As part of embolization procedures

Lee, et al. VRU 2011.



Lymphangiogram 1 month after CCA and TDL

Contrast shunting directly into caudal vena cava

MEDICAL TREATMENT AND PROGNOSIS

Etiology is Important

- Treat any underlying cause if identified
- Will not guarantee complete resolution of chylothorax
  - *May consider concurrent chylothorax surgery if already performing thoracic surgery*

General Medical Treatment

- Periodic thoracocentesis
  - *As needed to prevent dyspnea*
  - *Risk of introducing bacteria – sterile technique!*

- Low fat diet
  - *Reduce lipid concentration in chyle to improve absorption of effusion*

Singh, et al. Compendium 2012.

Medical Treatment: Rutin

- OTC Benzopyrene
- Possible Mechanism of Action:
  - *Stimulation of macrophage function to remove protein and promote fluid reabsorption*
  - *Decreased vascular leakage*
- Case reports in cats show possible efficacy
  - *Minimal information on its utility in dogs*

Small Animal Soft Tissue Surgery 2013.
Singh, et al. Compendium 2012.

Medical Treatment: Miscellaneous

- Octreotide
  - *Somatostatin analogue*
  - *May reduce TD flow and aid in healing*
  - *Little information in the veterinary literature*
  - *Injectable only, $$$*
- Steroids?
- Furosemide?

Small Animal Soft Tissue Surgery 2013.
Singh, et al. Compendium 2012.

Pleuroport as part of medical management

Reduce risk and discomfort of regular thoracocentesis

Prognosis with Medical Treatment

- Spontaneous resolution of chylothorax is possible
  - *May take weeks to months*
- Exposure to chyle likely increases risk of fibrosing pleuritis
- Other sequela
  - *Electrolyte imbalances*
  - *Hypoproteinemia*
  - *Dehydration*
  - *Immunodeficiency?*

Small Animal Soft Tissue Surgery 2013.
Singh, et al. Compendium 2012.

SURGICAL TREATMENT AND PROGNOSIS

Surgical Treatment

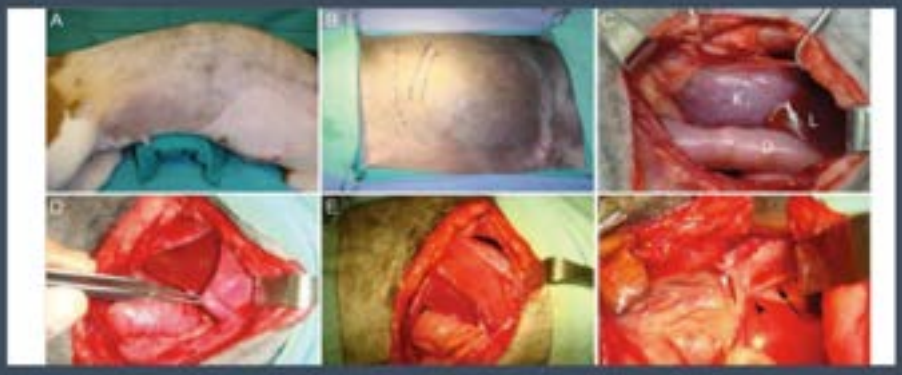
- When?
  - *Persistent effusion despite treatment of a predisposing condition*
  - *Idiopathic etiology*
  - *Persistence for >4 weeks (?)*
  - *Consider patient*
- Several techniques described

Small Animal Soft Tissue Surgery 2013.
Singh, et al. Compendium 2012.

Open surgical strategy

- Approach the thoracic duct by a paracostal incision at the 12th intercostal space
- Inject abdominal LN with methylene blue
- Identify and ligate thoracic duct
- Ablate the cisterna chyli
- Remove the pericardium through a separate incision

Single Paracostal Approach

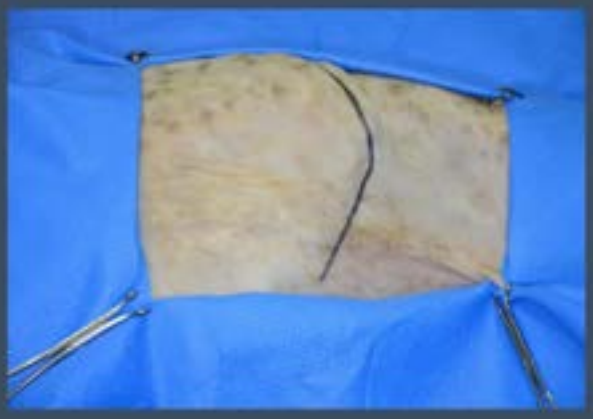


Single Paracostal Approach

TDL + CCA +/- subtotal pericardiectomy
Mean Surgical Time= 136 minutes
7/8 survived; 6/7 resolved (median follow up time 7 months)

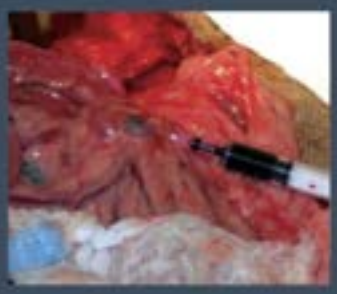
Small Variation:

Use of 12th intercostal space allows for easier access to caudal thorax



Intraoperative Identification of Lymphatics

- **Methylene blue**
  - *Diluted with 10 – 20x saline*
  - *Injected into mesenteric LN typically the Ileocecocolic*
  - *One shot at good injection, 25 gauge needle, slow injection*
  - *Visible within 10 min, lasts ~5 – 60min*
- **Tripan Blue** can also be used – less visible
- **Heavy cream** administered PO before surgery



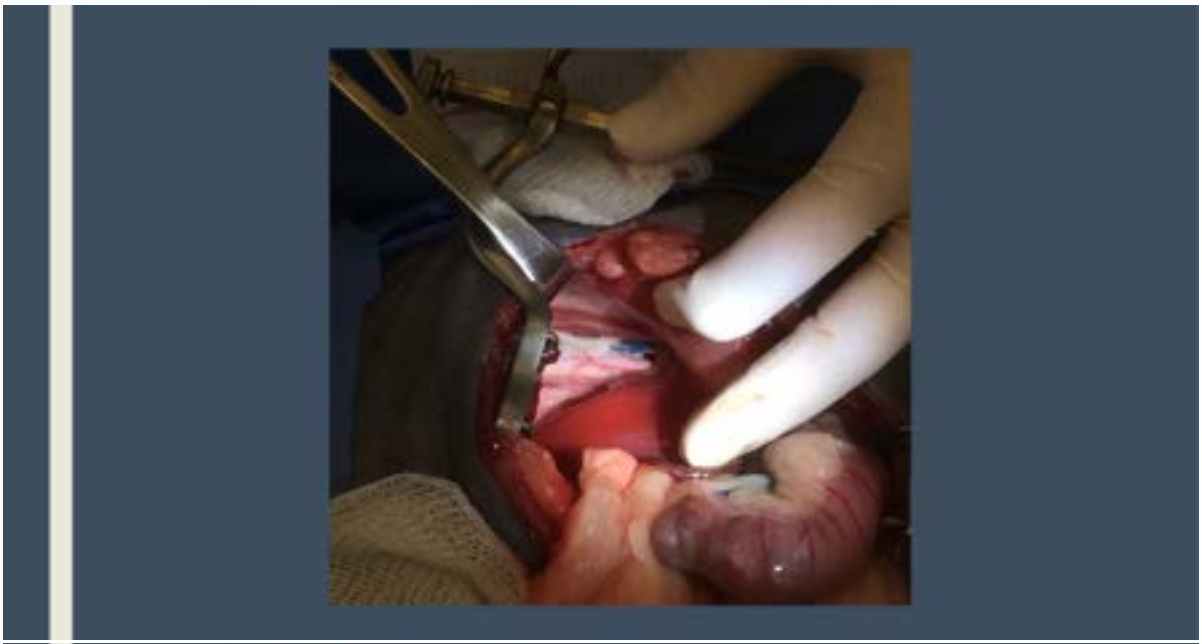
Small Animal Soft Tissue Surgery 2013.
Singh, et al. Compendium 2012.

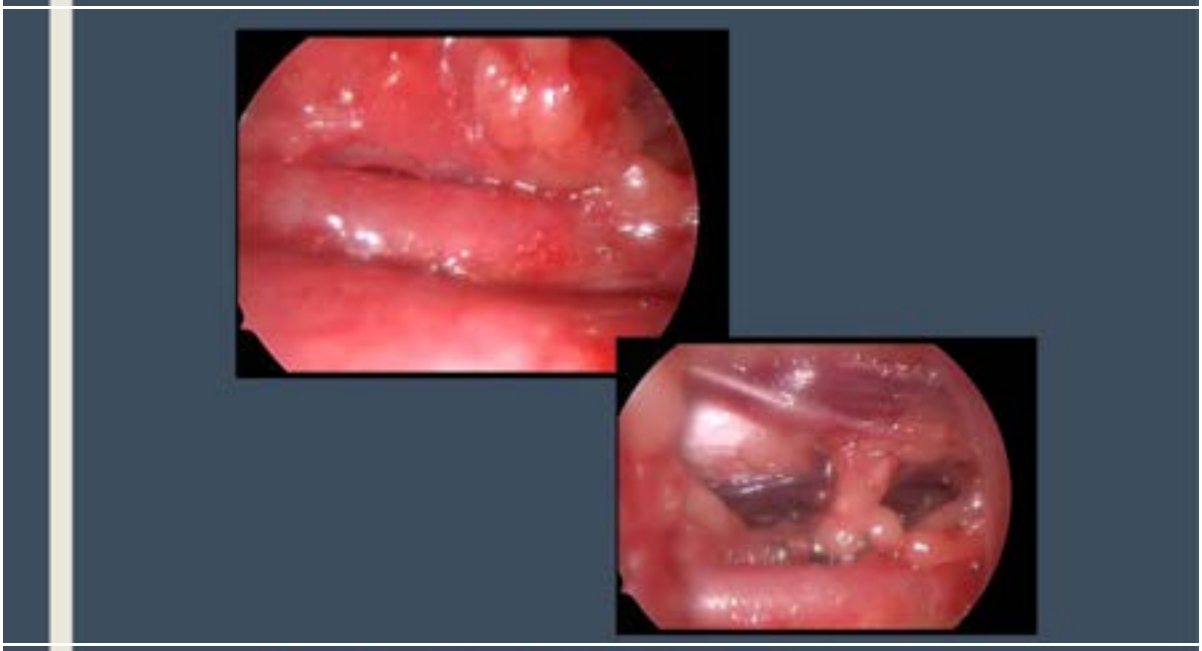
Thoracic Duct Ligation

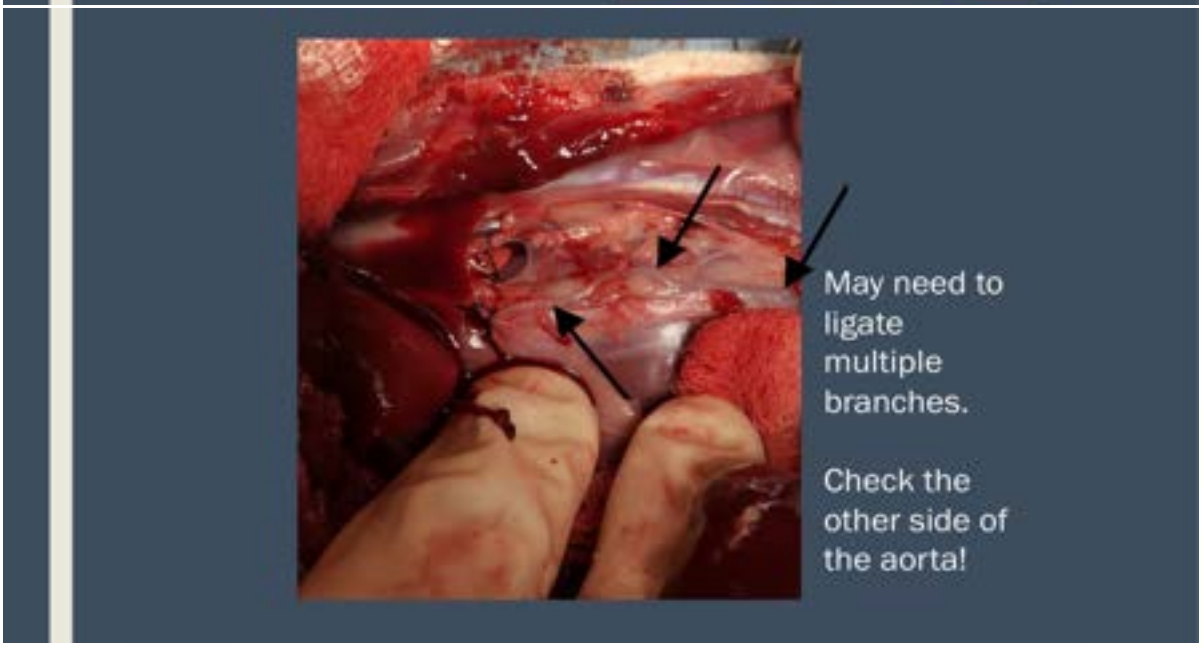
- TD occluded at its entry point in the thorax just past the cisterna chyli
- Typically double ligated with non-absorbable suture or clips
  - *Thoracoscopic or open*
  - *Branches common!*
  - *Dog – right sided*
  - *Cat – left sided*
- Ligasure can be used to seal and divide

The thoracic duct can be difficult to see under the thickened pleura

Prior to injection of the LN, the pleura should be gently removed from the aorta and dorsal

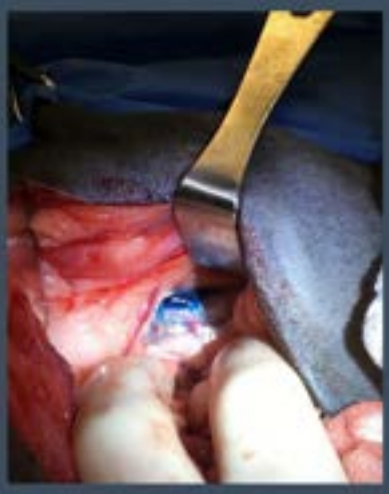





May need to ligate multiple branches.
Check the other side of the aorta!

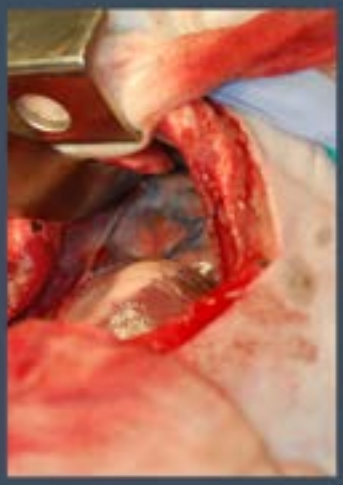
Cisterna Chyli Ablation

- Cisterna chyli identified and broken open
  - *Must be after TDL*
  - *Dorsal to aorta at the level of the renal arteries*
  - *Walls are grasped and debrided*
- Relieves increased lymphatic pressure caudal to TD ligation site
  - *Encourages intra-abdominal lymphaticovenous anastomosis formation*

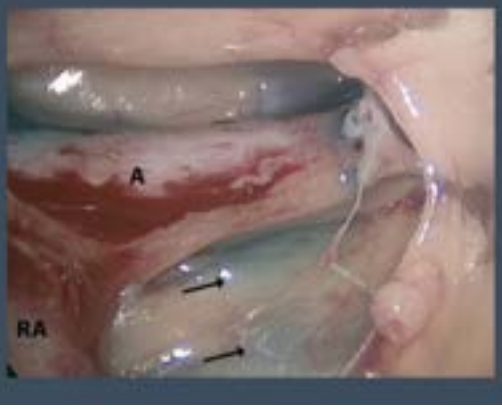


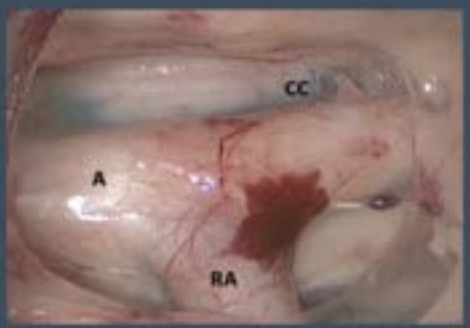
Small Animal Soft Tissue Surgery 2013.
Singh, et al. Compendium 2012.

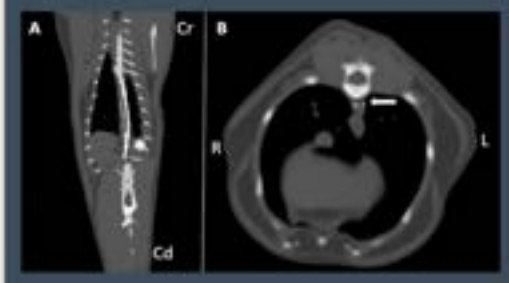
Feline cisterna chyli before and after ablation.



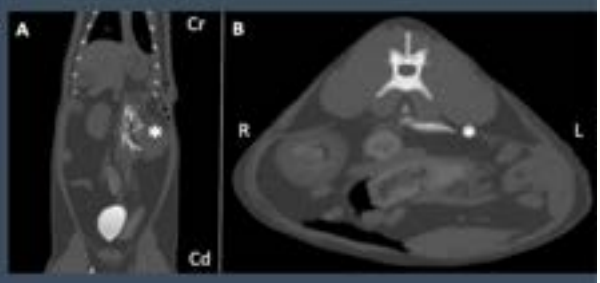
Cisterna can be accessed by open approach or by transdiaphragmatic laparoscopy





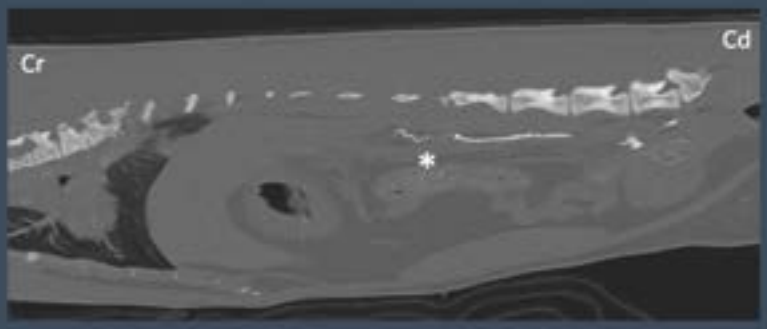


Lymphangiogram in a cat immediately prior to TDL and CCA; popliteal injection



Lymphangiogram in a cat immediately after to TDL and CCA; popliteal injection

Dickerson, AJVR, 2019



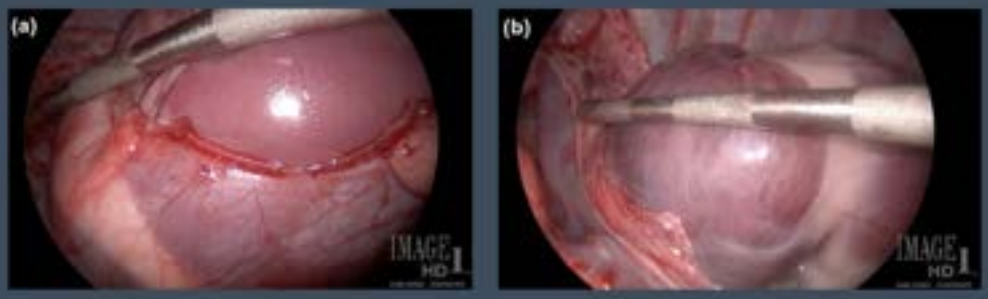
Lymphangiogram in a cat 30 days after TDL and CCA; popliteal injection; * = new lymphatic anastomosis

Dickerson, AJVR, 2019

Subtotal Pericardectomy

- Pericardium removed, preserving the phrenic nerve
- Thickened pericardium secondary to chyle irritation vs primary condition
- If thickened, may be restrictive
  - *Increased right-sided venous pressure*
  - *May impede chyle drainage*
- Could evaluate intracardiac pressures to determine need for pericardectomy

Need to fully release the pericardium – this is not a "window"



Epicardial exposure provided by a novel thoracoscopic pericardectomy technique compared to standard pericardial window

Omentalization

- Omentum pulled through a slit in the diaphragm
- Proposed benefits
  - *May function as a physiologic lymphatic drain*
  - *May promote healing of the TD through neovascularization and fibroplasia*

Stewart, et al. JAHA 2010.
Singh, et al. Compendium 2012.

Pleural Port

- May be placed at time of original surgery, or in the event of persistent effusion
- Long term chest tube with silicone subcutaneous port
- Potential risks:
  - *Port obstruction*
  - *Infection*
  - *Suboptimal positioning*

Singh, et al. Compendium 2012.

Normal immediately post placement

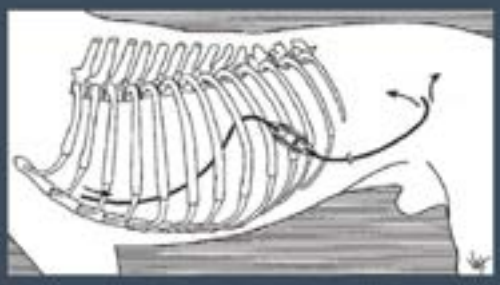
Painful, swollen, purulent = infected Pluralport

Indications of Pleural Port

- Prior to surgery
- At the time of surgery
- After surgery if the chylothorax does not resolve

Pleuroperitoneal Shunt

- Fenestrated catheters shunt fluid from the pleural to the peritoneal cavity
  - *One-way valve under the skin is pumped daily*
- Potential risks:
  - *Obstruction*
  - *Dislodgement*
  - *Infection*
  - *Pain at pump site*
- Complication in over 50% of dogs
- Median disease free interval – 27 months



Smeak 2001 JAVMA

Postoperative Strategies

General expectations

- Give at least 30 days for response to allow for lymphaticovenous anastomoses formation
- In dogs – 70 – 80% response rate for surgery
- In cats – 50% response rate to surgery
  - *More likely to get restrictive pleuritis*
- Dogs or cats may have persistent non-chylous (serosanguinous) effusion
  - *Lymphatic drainage from the head/cranial thorax?*
  - *Secondary to chronic inflammation?*

Outcome After Surgery in Cats

- TDL alone
  - *Fossum 1991 - 15 cats - **20%** resolution*
  - *Kerpsack 1994 - 19 cats - **68%** resolution, 9 died early post-op*
- TDL + CCA
  - *Not reported in cats*
- TDL + SP
  - *Stockdale 2018 - 15 cats - **73%** resolution, 1 died early post-op*
- TDL + CCA + SP
  - *Stockdale 2018 - 7 cats - **14%** resolution, 3 died early post-op*
  - *UGA records review - 8 cats - **38%** resolution, 4 died early post-op*

Reported outcomes in dogs

- TDL and PC
  - *McAnulty 2011 – 11 dogs – 60%*
- CCA and TDL –
  - *Hayashi 2005 – 8 dogs – 88%*
  - *McAnulty 2011 – 12 dogs - 83%*
  - *Staiger 2011 – 8 dogs (4 with pericardiectomy) – 75%*
- Video assisted TDL and pericardiectomy
  - *Mayhew 2018 – 39 dogs – 89%*
  - *Mayhew 2012 – 6 cases – 85%*

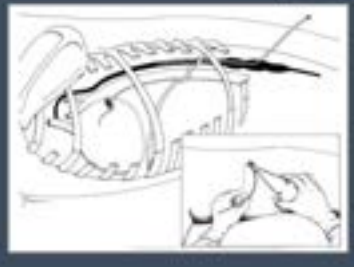
Outcome After Surgery

- Options if not successful
  - *Try steroids*
  - *Lymphangography +/- repeat surgery*
  - *Pleural port*
  - *Continued medical management*
  - *Euthanasia*

Small Animal Soft Tissue Surgery 2013.
Singh, et al. Compendium 2012.

Lymphatic embolization

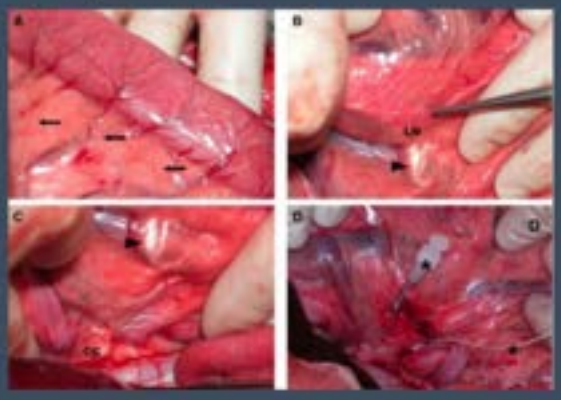
- Used as a first-line treatment or as a salvage procedure
- Open approach recommended, percutaneous approach is technically difficult
- Advantages:
  - *reduces chyle flow into the chest,*
  - *occludes branches which maybe missed in surgery or "silent or sleeping" branches*
  - *may reduce the likelihood of collateralization*
- Sternal position
- 3:1 mixture of Lipiodol® and N-butyl cyanoacrylate glue
  - *Starting volume of 0.1 ml/kg*
  - *Catheterized efferent abdominal lymphatic*



Singh, AJVR, 2011; Clendaniel JVIM, 2014, Pardo Vet Surg, 1989

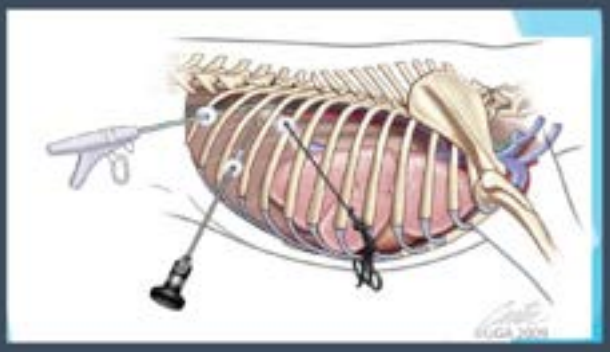
Salvage Cisterna Chyli and Thoracic Duct Glue Embolization in 2 Dogs with Recurrent Idiopathic Chylothorax

D.C. Clendaniel, C. Weisse, W.T.N. Culp, A. Berent, and J.A. Solomon



Thoracoscopic approach

- Sternal recumbancy
- Camera – mid 10th intercostal space
- Instruments –
  - Dorsal 9th or 10th intercostal space
  - Dorsal 11th or 12th



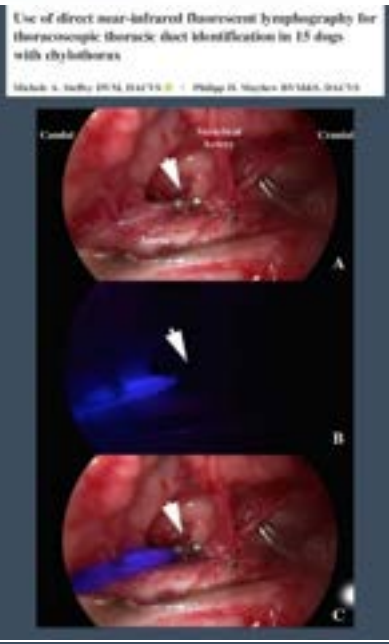
Allman, Vet Surg 2010

Laparoscopic cisterna chyli ablation

- Transdiaphragmatic
  - *Long threaded port*
  - *Use camera portal from thoracoscopic TDL*
  - *Establish new abdominal instrument portals*
- Transabdominal
  - *Establish 3 new portals in abdominal wall*

Direct near-infrared fluorescent lyphography using indocyanine green (ICG)

- ICG is the fluorophore
- Given intranodal in the popliteal or intrahepatic
- Requires special light and filter
- Used for intraoperative identification of the thoracic duct and cisterna chyli


Use of direct near-infrared fluorescent lymphography for thoracoscopic thoracic duct identification in 15 dogs with chylothorax

Leo – UGA MR 247381

- 4 year old, castrated male, domestic shorthair cat
- Presented for respiratory distress
- Bloodwork – mild thrombocytopenia, all serum chemistry was within normal limits
- Heartworm, FIV, FeLV negative
- Up to date on vaccines, indoor only, 1 other cat in the house

Bloodwork and Initial Diagnostics

- Blood pressure - 150- mmHg
- PCV – 36%, Total solids – 6.8 g/dL
- Mild hyperlactatemia, mild azotemia
- Fluid cytology:
  - *No infectious organisms*
  - *Non-degenerate, neutrophil rich exudate*
  - *Lightly eosinophilic proteinacious background*
- Cardiology consultation:
  - *Ventricular rhythm rate of 160 – 180 during exam, consider electrolyte changes*
  - *No cardiac cause of chylothorax*

Abdominal Ultrasound

- Normal abdomen
- Left caudal lung lobe mass
- Non-diagnostic aspirate – mixed inflammation

Thoracic CT scan:

- Left caudal lung lobe mass
- Pleural effusion
- Sternal Lymphadenopathy

Surgical procedure

- 5th intercostal thoracotomy
  - *Left caudal lung lobectomy with a TA-30 vascular stapler*
  - *Pericardectomy*
- 12th intercostal thoracotomy
  - *Trypan Blue used to identify thoracic duct, injection in ileocecocolic lymph nodes, 0.5 ml*
  - *Thoracic duct ligated*
  - *Cisterna chyli ablated*
  - *Chest tube placed*

Recovery

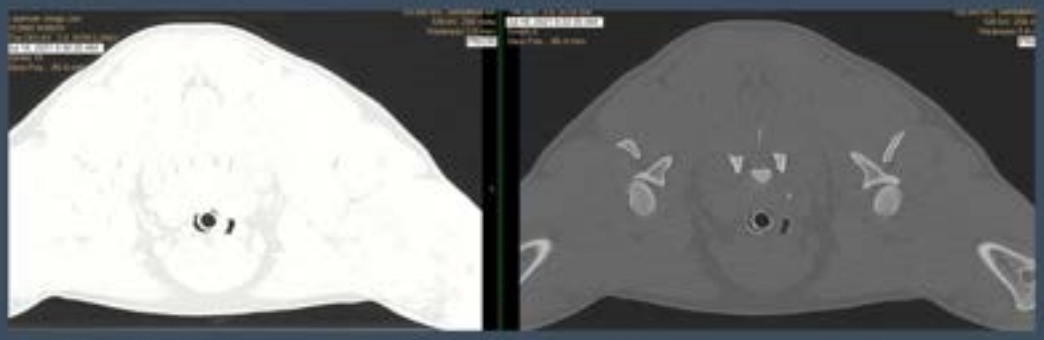
- Uneventful except developed ventricular tachycardia post op
- Oral Sotalol (20 mg Q12 hours) resolved ventricular rhythm
- Discharged 4 days post op
- No neoplasia noted – lung 'mass' was fibrosing restrictive pleuritis.
- Chylothorax resolved

Jengo – UGA MR 312092

- 3 yr old male neutered Pit Bull Terrier
- Thoracic effusion noticed incidentally on radiographs
- 600 mL of milky pink fluid was aspirated from the thorax
- Bloodwork prior to referral was unremarkable
- Started Rutin 500 mg Q 8 hours

At presentation

- Normal physical examination
- BP – 200 mmHg
- Pleural effusion on thoracic ultrasound (TFAST)
- Paired triglycerides – Blood 44 mg/dL, Thoracic Fluid – 1556 mg/dL
- Thoracic fluid cytology – pinkish white, opaque, nucleated cells 3.3 $x10^3/\mu L$, lymphocyte rich
- Echocardiograph – No cardiac abnormalities
- CBC – mild lymphopenia
- Serum Chemistry – no remarkable abnormalities



Thoracic CT scan: pleural effusion,
no other significant abnormalities

Surgical treatment

- Right sided, 12th intercostal thoracotomy
- Trypan Blue used for direct visualization of the thoracic duct and cisterna chyli
- Thoracic duct ligation
- Cisterna chyli ablation
- Pericardectomy

Post-operative

- Hydromorphone for 24 hours, then a NSAID and gabapentin
- IV fluids
- Management of chest tube – fluid amount significantly reduced after 48 hours, removed after 72 hours
- Discharged about 5 days after surgery
- No recurrence of chylothorax

Approaches to the Thorax

Chad Schmiedt DVM, DACVS
Professor, Small Animal Surgery
University of Georgia

Summary

- Thoracic anesthetic considerations
- Intercostal thoracotomy
- Median Sternotomy
- Recovery and post operative care

Anesthetic Considerations

Thoracic Surgery

Anesthetic Considerations

- Ventilation
- Capnography
- Painful procedures
  - Systemic opoids
  - Local blocks
- Preoperative thoracocentesis
- Preoxygenate prior to induction

Additional anesthetic considerations

- Pressure for ventilation will be less once thorax is open
- Lung lobes may be packed off – gently re-expanded prior to closure
- Be wary of tension pneumothorax, especially during closure – keep chest tube open until thorax is closed
- Consider small bore chest tubes whenever possible
- Be sure any post operative wraps are not too tight

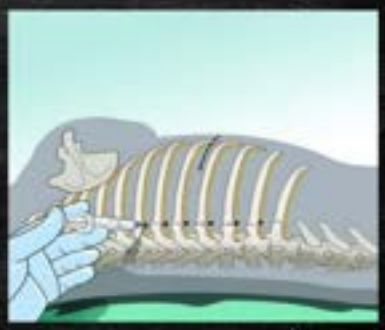
Local Blocks – Intercostal Blocks

Can be done preoperative or intraoperative

Just off caudal border of the rib

Bupivicaine has best duration of action

Up to 2 mg/kg



https://todaysveterinarynurse.com/articles/locoregional-anesthesia-for-small-animal-patients/

Preoperative considerations

- Surgery guided by preoperative imaging and goals
- **Lateral intercostal thoracotomy** exposure of about 1/3 of ipsilateral thorax
- **Median Sternotomy** – Explore the most of the thorax, poor exposure to the dorsal vessels, pulmonary hilus, thoracic duct

Intercostal Thoracotomy

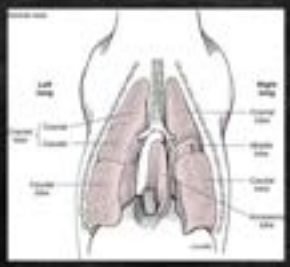
Considerations and Technique

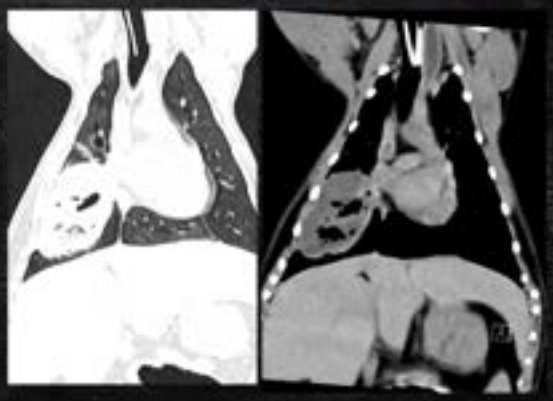
Intercostal Thoracotomy

Rib space can by guided by imagining

Additional exposure can be gained by rib resection

Target is the hilus of the lobe – not where the tumor is located





https://veteriankey.com/surgery-of-the-lower-respiratory-system-lungs-and-thoracic-wall/

Recommended sites

Target	Left	Right
Heart/pericardium	4, 5	4, 5
PDA, PRAA	4	
Cranial lung lobe	5, 4	5, 4
Middle lung lobe		5
Caudal lung lobe	5,6	5,6
Cranial esophagus	3, 4	3, 4, 5
Caudal esophagus	7, 8, 9	7, 8, 9
Thoracic duct (dog)		10
Thoracic duct (cat)	10	

Preparation and Positioning

- Lateral recumbency
- Consider towel underneath the patient
- Shave entire thorax

Skin and SQ are incised

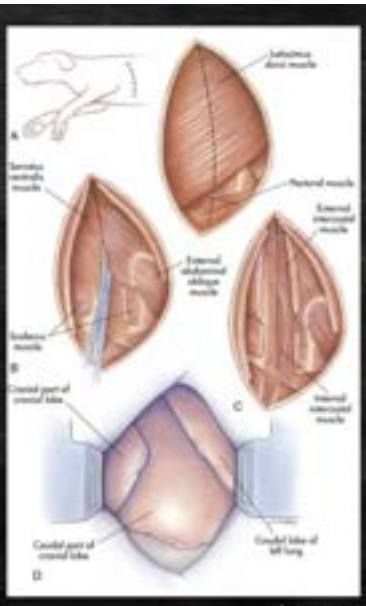
Hypaxial muscles to sternum

Latissimus dorsi is undermined and divided or preserved

Scalenus identified and transected

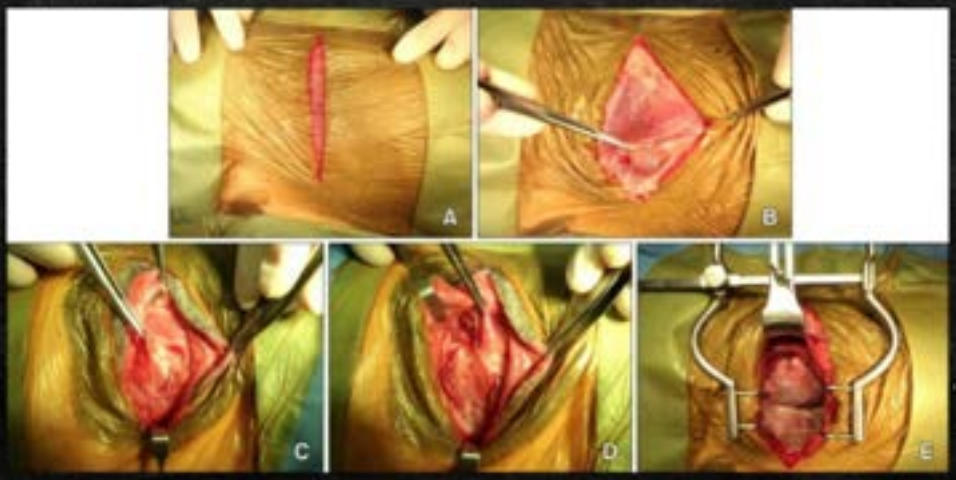
External and Internal intercostals are divided

Pleura is incised – sharp or blunt



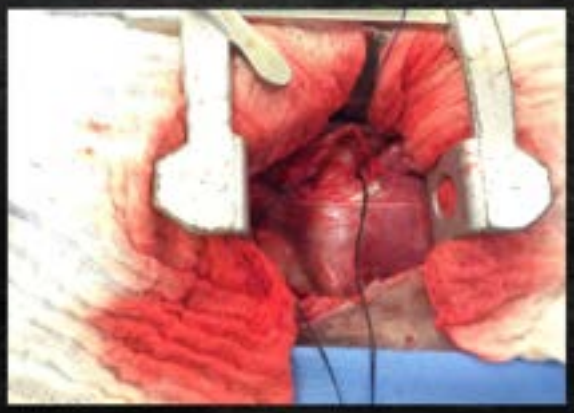
https://veteriankey.com/surgery-of-the-lower-respiratory-system-lungs-and-thoracic-wall/

Muscle Sparing Approach – Latissimus dorsi preserved



Yoon, J Vet Sci, 2015

Laparotomy pads and Finocchieto retractors are placed

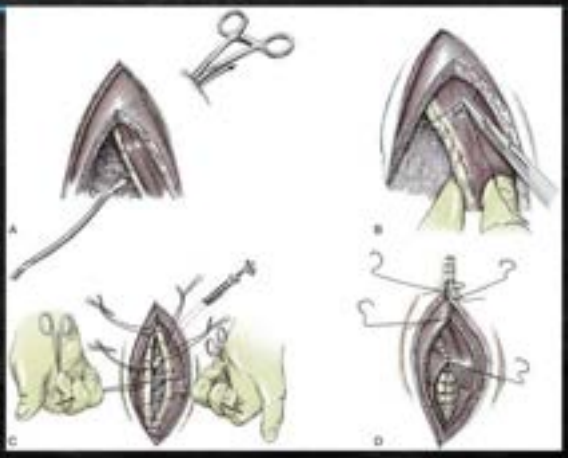


Closure of Intercostal Thoracotomy

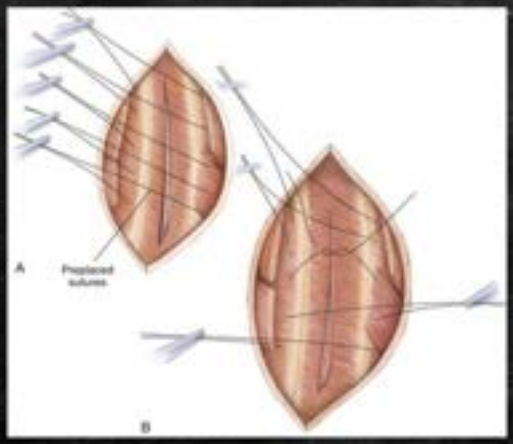
Flush with warm saline

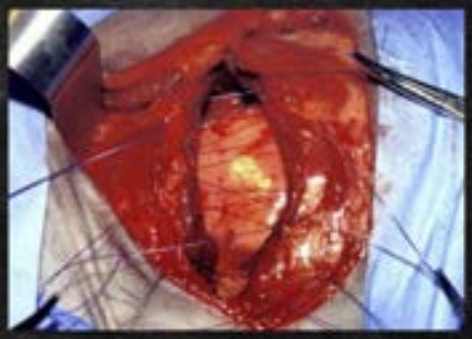
Place chest tube prior to closing

Circumcostal sutures



https://veteriankey.com/thoracic-wall/

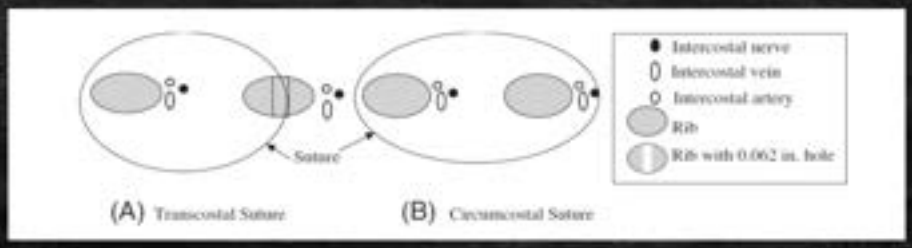




https://www.vetsmall.theclinics.com/article/S0195-5616(15)00019-4/references

NVF Hands-On Workshop

Transcostal suture technique



Rooney, Vet Surg, 2004

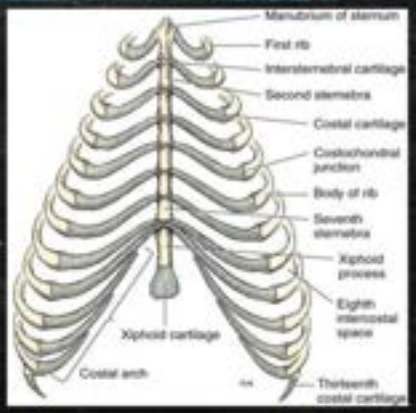
Median Sternotomy

Technique and considerations

Positioning and Preparation

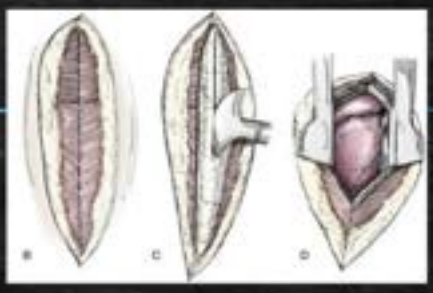
- Dorsal recumbency
- Shave and prepare entire thorax and cranial abdomen
  - Mid cervical area
  - Umbilicus
- Shave and drape laterally for thoracostomy tube

Cranial or Caudal approach?



Technique

- Skin and SQ incised on midline
- Sternum is exposed and scalpel is used to create a groove for oscillating saw
- Freer elevator is used to help define the sternum
- An oscillating saw is used to split sternum on midline – leaving cranial or caudal sternebrae intact
- Can be challenging to stay on midline in small patients

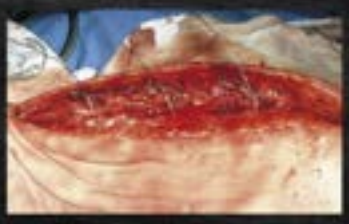


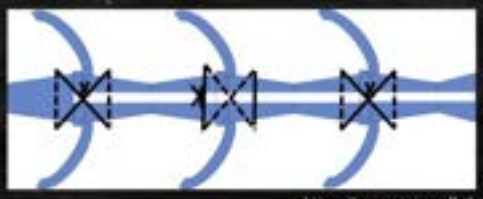
https://veterankey.com/thoracic-wall/

NVF Hands-On Workshop

Closure of Median Sternotomy

- Flush thorax, place chest tube
- Paracostal figure of 8 pattern
- Orthopedic wire recommended 18 – 22 g
- Can use suture in smaller animals





https://www.vetsmall.theclinics.com/article/S01
95-5616(15)00019-4/references

NVF Hands-On Workshop

Closure – Median Sternotomy

- Robust closure of muscle and SQ
- Padded bandage

Post operative management

- Hypoventilation – support with oxygen
- Pain control
  - Continue treatment with NSAIDs and Opioids
  - Consider intrathoracic bupivacaine lavage - 1.5 mg/kg Q 8 hours
  - Remove thoracic drain when appropriate
- Keep wound covered

Median Sternotomy Complications

- Seroma
- Infection
- Hypoventilation

Select Procedures: Lung lobectomy

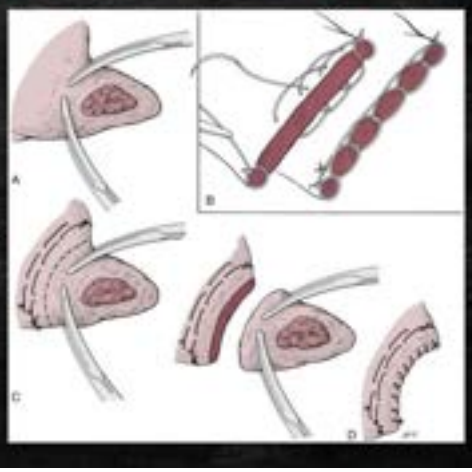
Lung Lobectomy

- Common indications
  - Lung tumor
  - Abscess
  - Torsion
- Hand Sutured vs. Stapled

Hand Sutured Lung Lobectomy - Partial

Overlapping continuous mattress pattern

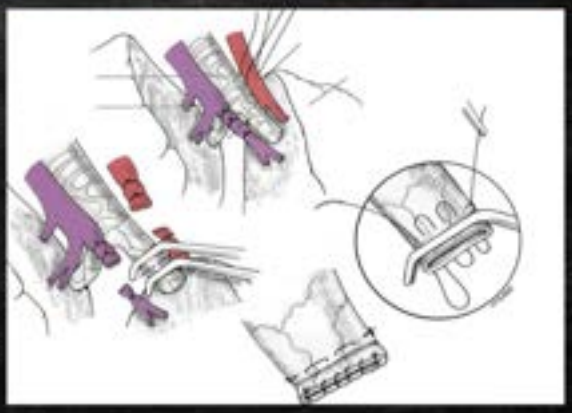
Oversew cut end



Hand Sutured Lung Lobectomy - complete

Individual ligation of

1. Pulmonary artery
2. Pulmonary vein
3. Bronchus



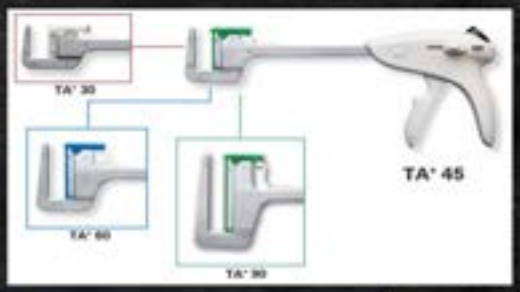
Small Animal Veterinary Surgery, 2nd ed

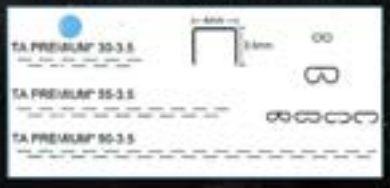
Stapled Lung Lobectomy

- One staple line ± oversew bronchus
- Typically with TA (thoraco-abdominal) linear stapler or GIA (gastrointestinal anastomosis)
- White or blue staples

General technique

- Prepare stapler if needed
- Isolate smallest pedicle possible
- Apply stapler across pedicle
- Fire stapler
- Cut the tissue off with stapler in place
- Remove stapler
- ± Oversew (bronchi, lung parenchyma, intestinal wall, liver parenchyma)





Right middle lung lobe torsion
V3 cartridge – 'Snow White'

Prior to closure

- Consider lymph node biopsy
- Leak check with saline
- Count sponges

Select procedures: Pericariectomy

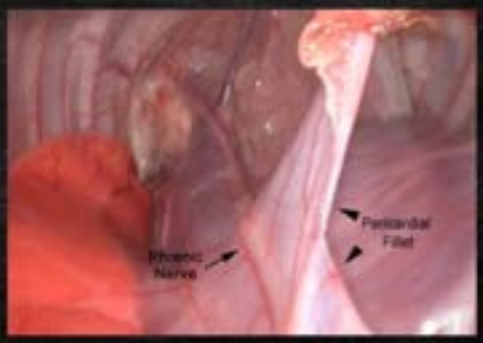
Indications for pericardiectomy

- Pericardial effusion
- Chylothorax/restrictive pericarditis
- Pericardial neoplasia
- Pericardiectomy vs. pericardial window?

Pericardial mesothelioma

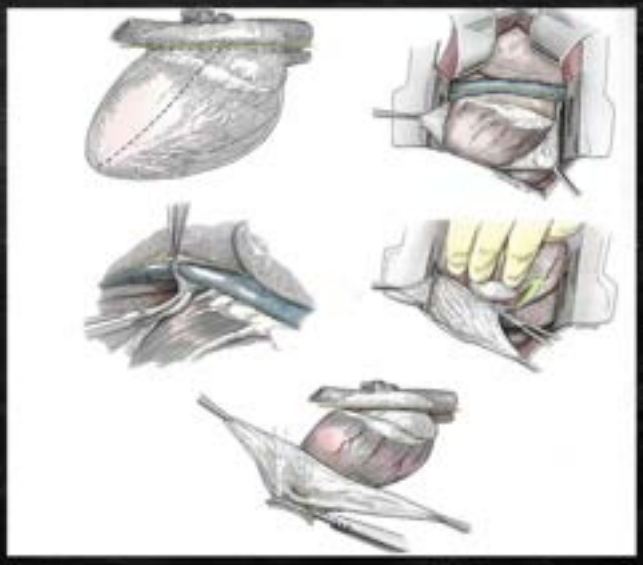
Pericardectomy technique

- Approach through right sided ICT or median sternotomy
- Subtotal vs. complete
- Fillet
- Window

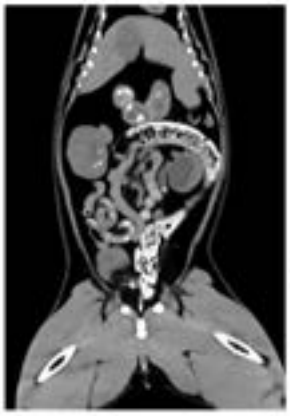


Subtotal Pericardiectomy

- Sharp dissection
- Bipolar cautery
- Caution with monopolar cautery!
- Pericardium is removed to the level of the phrenic nerve



Small Animal Veterinary Surgery, 2nd ed



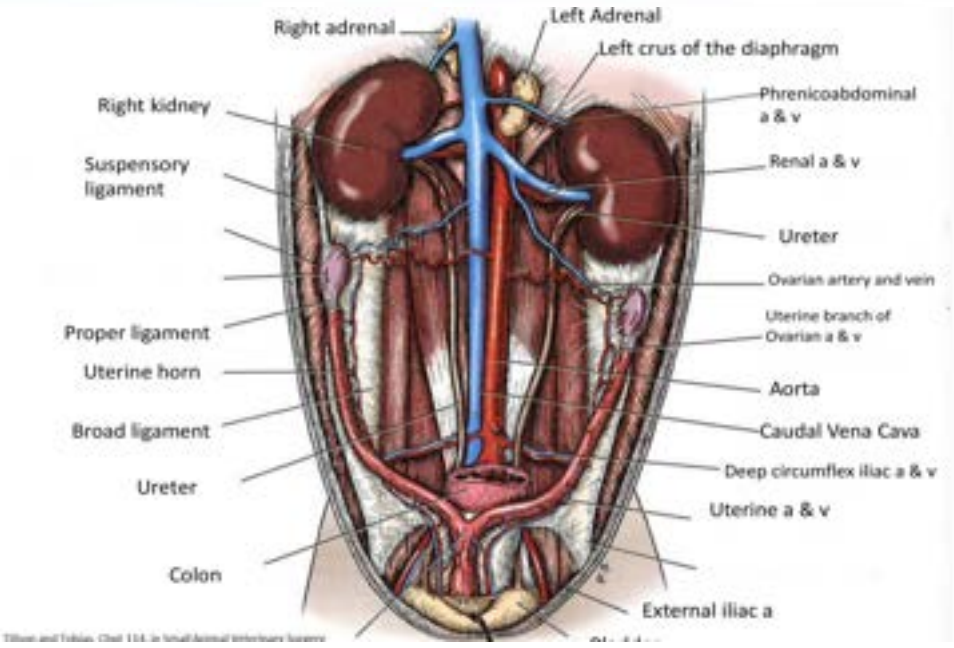
Surgery of the Urinary Track

Chad Schmiedt DVM, DACVS-SA
Professor, Small Animal Surgery
Alison Bradbury Chair of Feline Health
University of Georgia, College of Veterinary Medicine

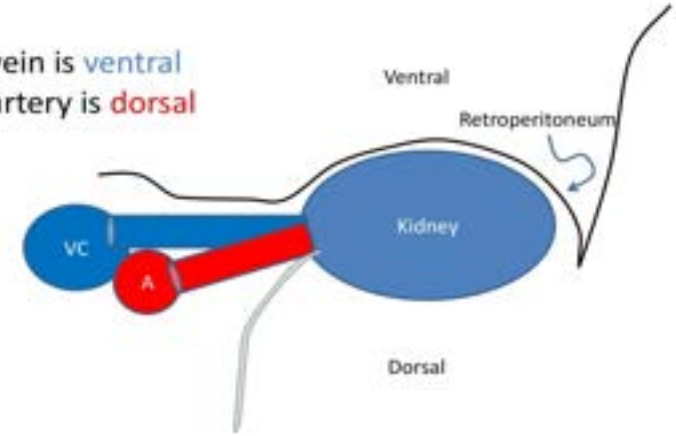
Lecture Outline

- Surgery of the kidney
  - Uretero-nephrectomy
  - Renal biopsy
  - Nephrotomy
- Surgery of the ureter
  - Ureterotomy
  - Ureteral reimplantation
- Surgery of the bladder
  - Cystotomy

SURGERY OF THE KIDNEY



The renal vein is ventral
The renal artery is dorsal

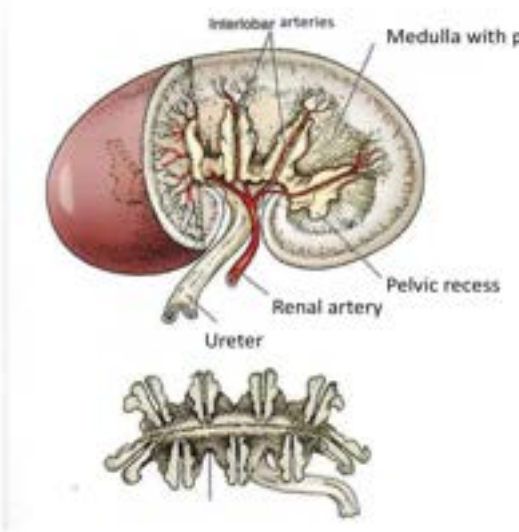


Exposure: Right Kidney

Exposure of the kidneys requires

1. Long incision
2. Use of retractors

Exposure: Left Kidney



Opportunities for bleeding and urine leakage

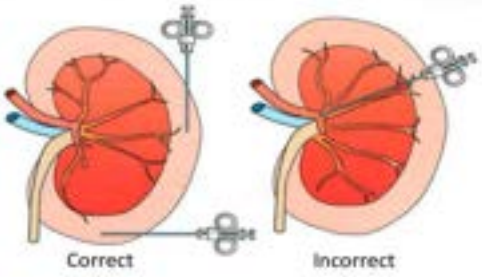
Renal Biopsy

- Indications:
  - Renal neoplasia
  - Nephrotic syndrome
  - Renal cortical disease – protein losing glomerulopathy
  - Acute renal failure of unknown cause
- Contraindications:
  - Coagulopathy
  - Pyelonephritis
  - Ureteral obstruction
  - Hydronephrosis

Do the benefits outweigh the risks?

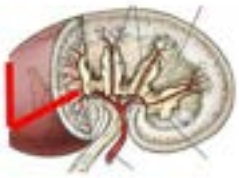
Will is change what you recommend?

Ultrasound or laparoscopic guided renal biopsy



Open Renal Wedge Biopsy

1) Occlude the vasculature
    1) Fingers
    2) Vascular clamps
2) Small superficial sample
3) Close with a horizontal mattress
4) Sutures pulls through very easily
5) Apply pressure for hemostasis



Types of Renal Biopsy

- Open wedge biopsy – best sample, ability to treat hemorrhage, most invasive
- Laparoscopic – good sample (14 g), insufflation reduced hemorrhage, specialized equipment
- Ultrasound guided – small sample (18g), unable to treat hemorrhage, least invasive

Complications of Renal Biopsy

- Bleeding!
  - Stay in cortex
- Small sample size – may not represent focal or multifocal lesion
- Crush artifact
- Urine leakage
  - Stay in cortex
- Results may not influence therapy

Ureteronephrectomy

- Preoperative considerations
  - Will the patient survive on 1 kidney?
  - Difficult to determine single kidney function
    - Nuclear scintigraphy
  - Remove ureter and kidney
  - Need excellent exposure
  - Need retraction

Ureteronephrectomy

- Indications
  - Severe infection (pyelonephritis)
  - Traumatic injury
  - Hydronephrosis

- Partial Nephrectomy (nephron sparing) an option in patients with reduced renal function

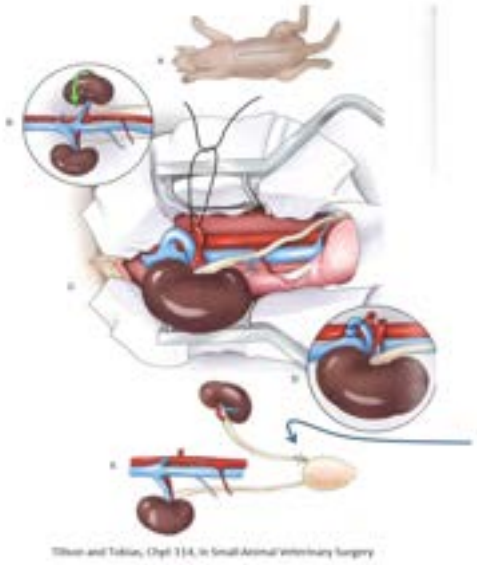
End-stage
Hydronephrosis

Hydronephrosis

Pyelonephritis and pyoureter

Renal papillary adenocarcinoma

Ureteronephrectomy: Technique



1) Ventral midline incision
2) Free retroperitoneal attachments and flip kidney medially to expose artery
3) Ligate artery
4) Ligate vein
5) Ligate ureter near UVJ

Why take the whole ureter?

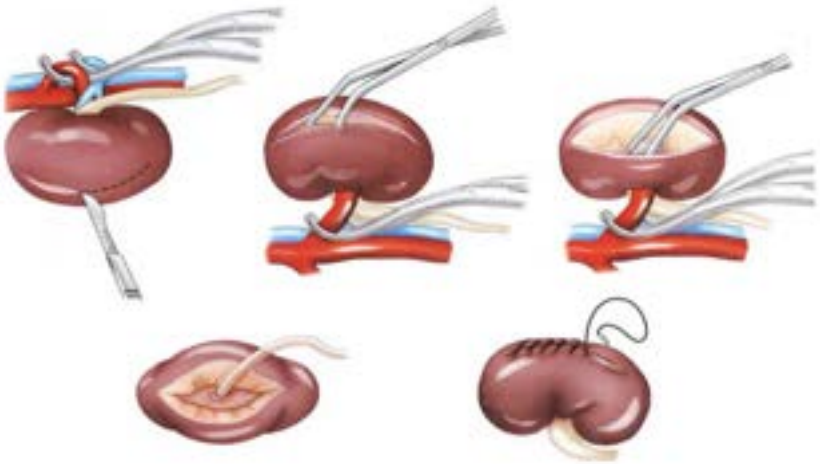
Complications of Ureteronephrectomy

- Bleeding!
  - Large vessels need good ligatures
  - Exposure!
- Leakage of urine
- Chronic infection
  - Remove all of ureter
- Renal failure

Nephrotomy

- Midline incision through the kidney to the renal pelvis
- Nephrotomy vs. nephrostomy?
- Indication: Removal of nephrolith that one cannot get through the renal pelvis
- Nephrolith removal indicated when:
  - Obstructive
  - Chronic/recurrent infection
  - Causing other clinical signs (hematuria)

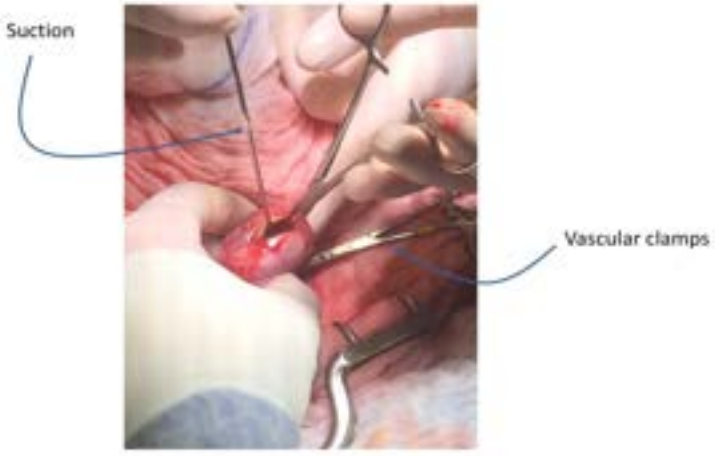
When would that be?



Tilson and Tobias, Chpt 114, in Small Animal Veterinary Surgery

Consider pretreatment with Mannitol (0.5 g/kg) IV over 15 minutes just prior to placing vascular clamp.

Limit clamp time to – 15 – 20 minutes



Remove stone

Flush pelvis

Close just the capsule

Release the vascular clamps

Complications of Nephrotomy

- Acute kidney failure
  - Ischemic injury
  - Parenchymal injury
  - Bilateral?
- Acute kidney injury
  - GFR is effected temporarily, may be minimal
    - Technique
    - Ischemia time
    - Hemorrhage
    - Anesthetic protocols
- Bleeding
- Urine leakage
- Ureteral obstruction
  - Debris from the stone flushed into ureter

What could go wrong?

Ureteral Surgery

Ureteral Blood Supply

In people, blood supply is segmental with branches from renal, gonadal, vesical, vaginal, and uterine

In cats and dogs?
- Renal artery
- Prostatic or vaginal
- Cranial vesical

Circumcaval/Retrocaval Ureters

Present in 106/301 (35%) cadaver cats evaluated

Right side most common
- Right side = 30.6%
- Left 1.3%
- Bilateral 3.3%

Double caudal vena cava = 7%

No sex predilection

In cats with right circumcaval ureter, right kidney was longer (4.39 vs. 4.16 cm), but no evidence of hydronephrosis

Strictures more common cause of ureteral obstruction in cats with circumcaval ureters

Rarely reported in dogs

Ureters are Small

Surgical microscope

Variable magnification up to about 10x

Surgical loupes

2.5-4.5 x magnification

Ureterotomy

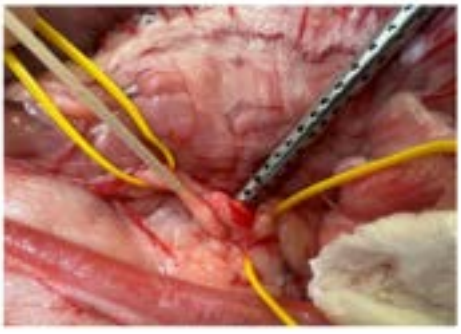
Good for-

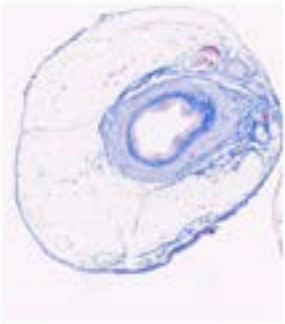
- Proximal obstruction
- Bilateral obstruction
- Dilated ureter
- Patent ureter

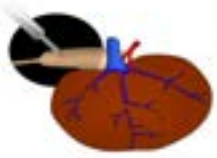
Isolate the ureter

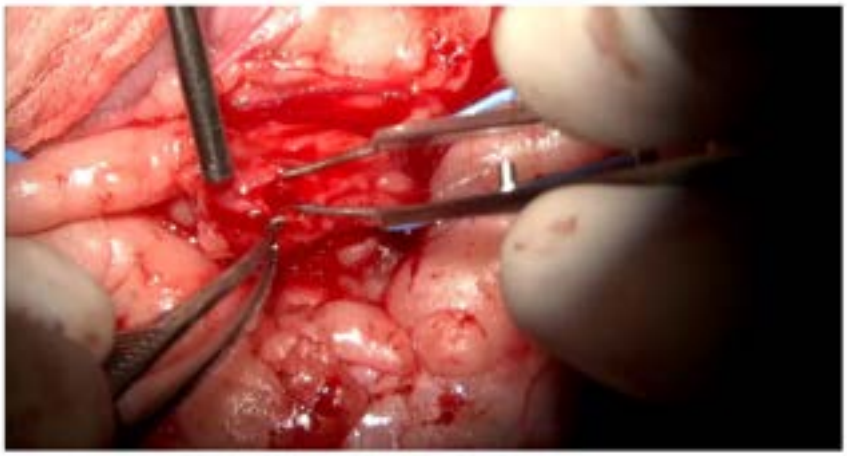
- Palpate the stone
- Careful dissection and preservation of the ureteral blood supply
- Isolate area with vessel loops

Incise through the fat to the ureter just proximal to the obstruction



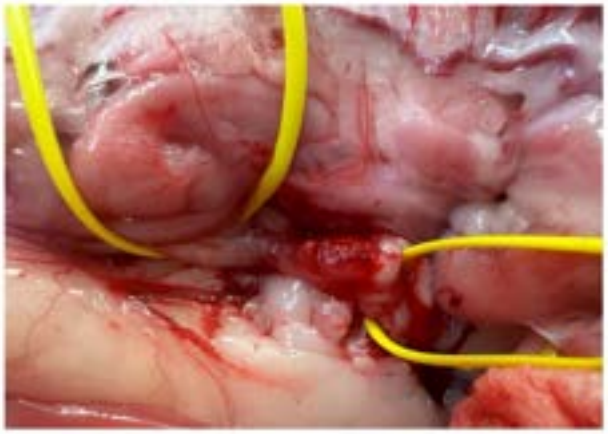






NVF Hands-On Workshop

Closure, SI or SC over a stent or suture.

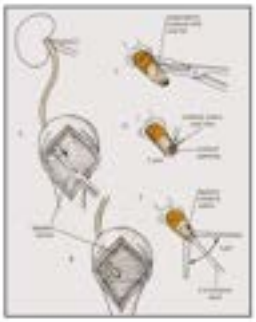


Complications of a ureterotomy

- Underlying kidney disease almost always present
- Urine leakage
- Ureteral stricture
- Re-obstruction
- Much better outcomes in dogs vs. cats.

Ureteral reimplantation

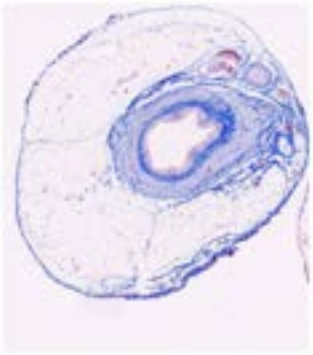
- Intravesicular
  - Smaller ureters
- Extravesicular
  - Larger ureters
- Extravesicular side-to-side
  - Proximal ureters
- Tension relieving techniques
  - All ureters
    - Renal decensus
    - Psoas hitch
    - Nephropexy
    - Nephrocystopexy



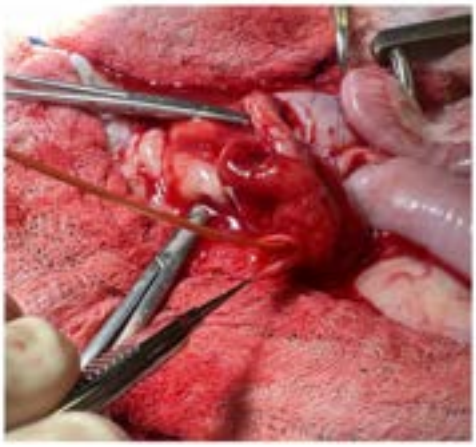
Intravesicular technique

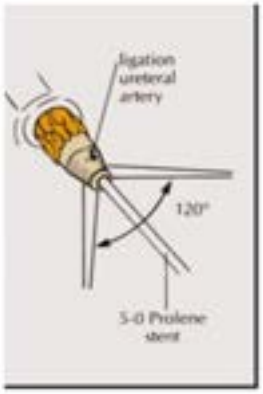
- Ligate and divide ureter more distal than you intend to reimplant
- Push hemostats through bladder apex
- Pull ureter back through

Debride peri-ureteral fat

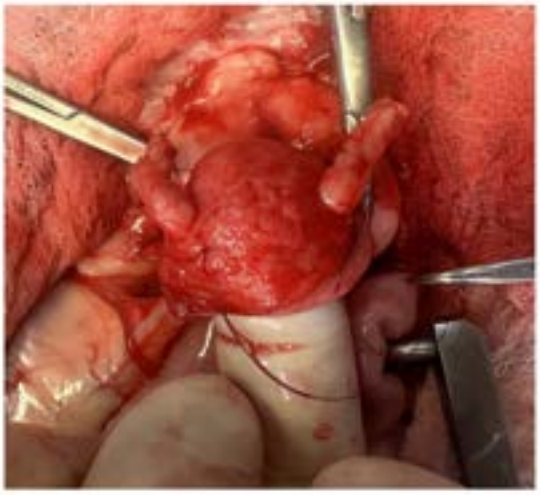


Spatulate the end of the ureter and ligate the ureteral vessel

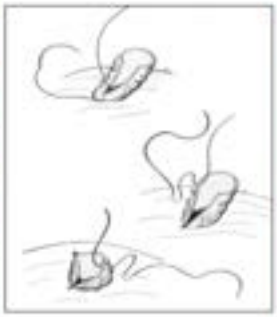




Invert the bladder so the mucosa is facing out



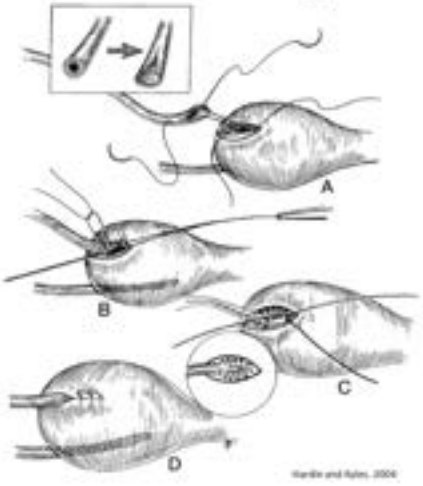
Suture the mucosa of the ureter to the bladder mucosa



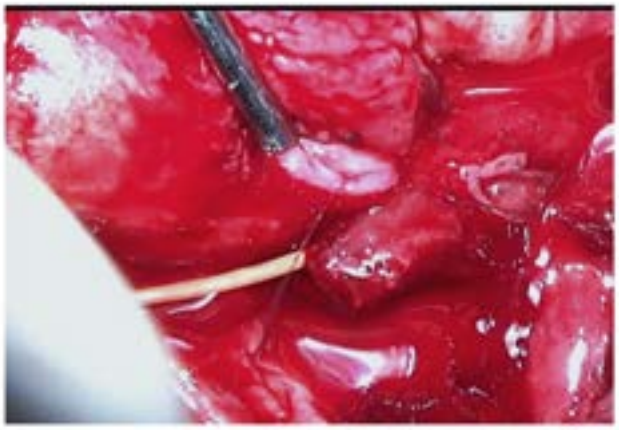
x superficial external sutures

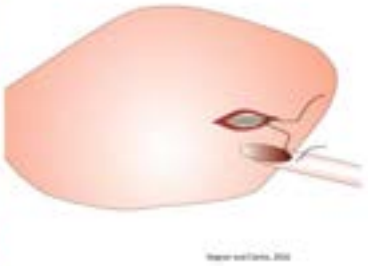
Extravesicular Ureteroneocystostomy

- Better for larger ureters (for me, anyway)
- Avoids a cystotomy



Extravesicular Ureteroneocystostomy

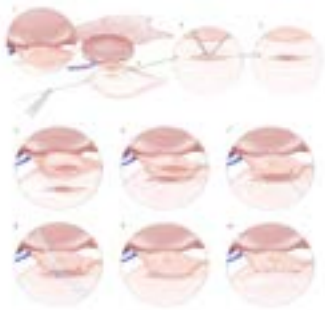




Side-to-Side Ureteroneocystostomy

Extravesicular, two-layer, side-to-side ureteroneocystostomy combined with tension-relieving techniques for feline proximal ureteral obstruction: A retrospective study

Kazuhisa Oyamada DVM[1] | Michiko Inoue DVM[1] | Kanae Sato Takada DVM, Diplomate ACVIM[1] | Tomomi Minamoto DVM, PhD[2] | Makoto Fujiki DVM, PhD[1]

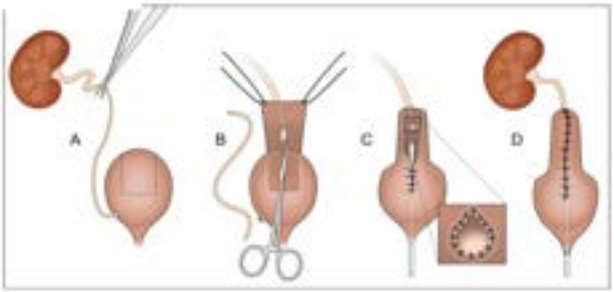


- 10 cats, all discharged
- Perioperative complications – ureteral catheter dislodgement (3), pollakiuria (2), dysuria (1)
- UTI post op – 3/10 cats
- Median follow up 648 days
- 7/10 alive without recurrent ureteral obstruction

Use of a modified Boari flap for the treatment of a proximal ureteral obstruction in a cat

Lillian R. Aronson VMD, DACVS[1] | Andreanne Cleroux DMV, IPSAV[1] | Chloe Wormser VMD, DACVS[1]

- 3 year old Russian Blue cat
- Proximal ureteral obstruction (mild ureteral edema, edema, periureteritis)
- One year follow up, normal imaging and biochemical profile



Aronson 2018

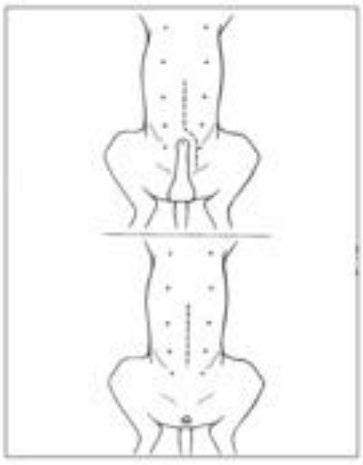
SURGERY OF THE BLADDER

Bladder Anatomy: Ligaments

- Lateral ligaments – innervation, blood supply
- Median ligament – nice landmark

Surgical Approach: Cystostomy

- Standard ventral midline
- Parapreputial – branches of Cd. superficial epigastric vessels
  - Prepucial ligament, vein, and muscle
- Think about whether a urethrotomy or urethrostomy may be required

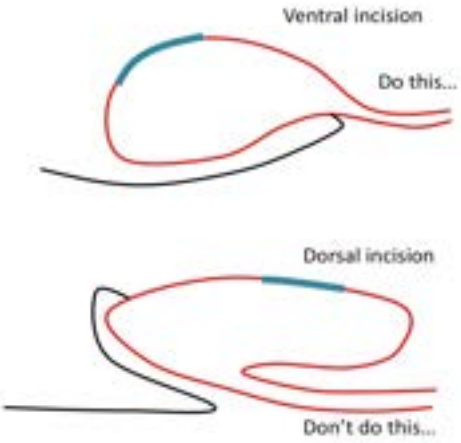


Principles

- Pack off the abdomen
- Stay sutures to manipulate the bladder
- Aspirate urine / use suction
- Catheterize the urethra
- Monofilament, absorbable suture
- One layer or two
- Holding layer – SUBmucosa
- Leak test

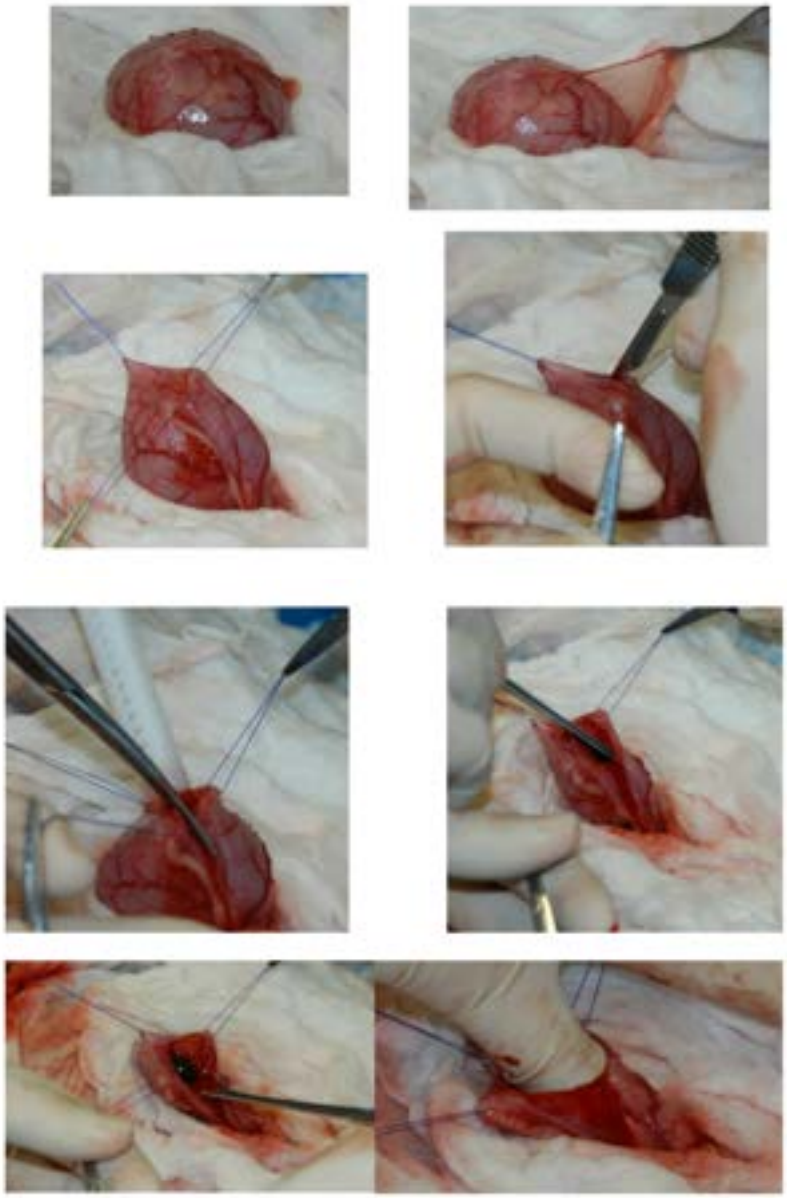
Cystotomy Dorsal vs Ventral?

- Fears: gravity → leakage, adhesions, stones
- Pressure spreads out the force, so equal risk of leakage
- No difference in adhesions, use omentum
- Absorbable suture ↓ risk of stones greatly



Dorsal vs Ventral

- Dorsal cystotomy puts the hidden course of the intramural ureter at risk!
- Calculi roll down into the urethra – much easier to access with ventral cystotomy



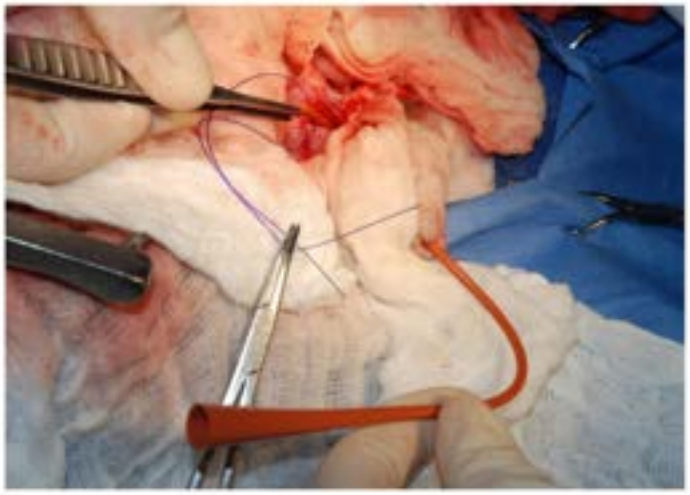
Evaluate the Urethra

- Pass a catheter retrograde first!
- Flush retrograde – remember to "pressurize" the urethra
- Flush normograde & evaluate the stream

Make Sure ALL Stones are Out

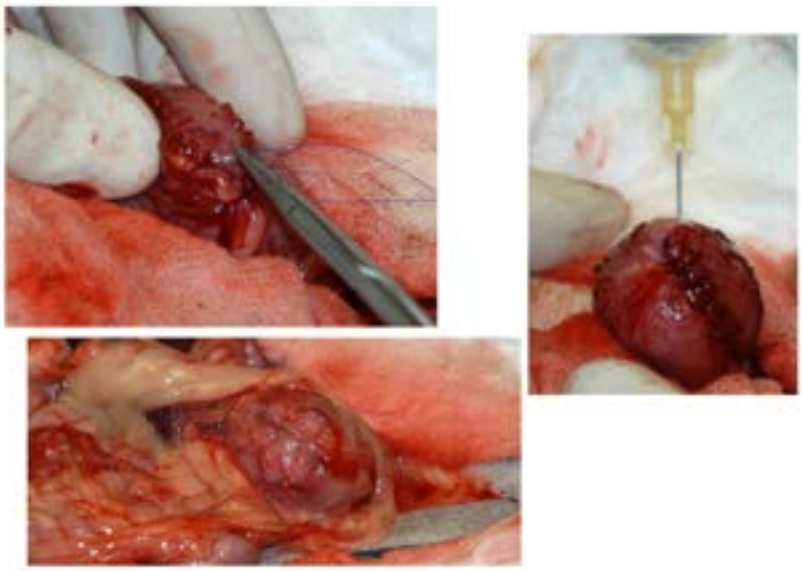
- Palpate

Urethral Catheterization



Submit samples

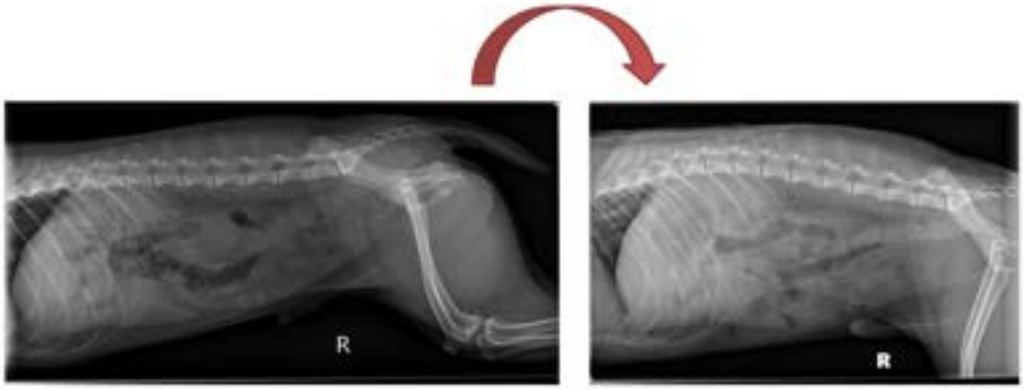
1. Bladder mucosa – best culture
2. Stones – analysis ±culture
3. Bladder wall - histopathology



Single vs Double Layer Closure

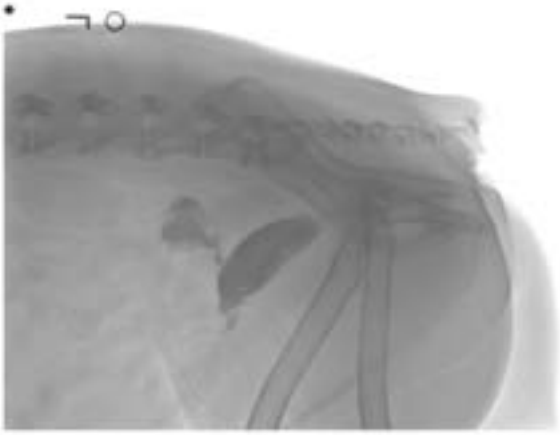
- Surgeon's preference
- Holding layer is SUBmucosa
- Options: full thickness simple continuous, continuous cruciate, 2 layers of simple continuous, simple continuous with an inverting oversew
- Small bladders = 1 layer

Always take post operative radiographs to confirm stone removal!



Complications of Cystostomy

- Urine leakage
- Stranguria/pollakiuria
- Hematuria
- Ureteral injury



VET EXPERT

BASED ON EVIDENCE

🎉 We're Live! Welcome to **vetexpertorder.in**

– Your Trusted Pet Care Partner! 🐾

www.vetexpertorder.in

WEBSITE LAUNCH
FEBRUARY 26, 2025

We're thrilled to announce the launch of vetexpertorder.in, vet-go-to destination for premium pet healthcare products! 🐶🐱

🌟 WHAT WE OFFER:

✅ SPECIAL DISCOUNTS FOR VET

✅ HASSLE-FREE SHOPPING & FAST DELIVERY

EXCLUSIVE FOR VETS ONLY!

www.vetexpertorder.in

NVF VETERINARY FOUNDATION

SKILL + KNOWLEDGE + EMPOWERMENT

OUR INDUSTRY PARTNER

VET EXPERT
BASED ON EVIDENCE

drools
Feed Real. Feed Clean.

SAVAVET
Shaping the Future

TAGO
The Animal Care Organization

ROYAL CANIN
INCREDIBLE IN EVERY DETAIL

ENAVANT PETCARE

SKY EC
Committed to Quality

veteducation

zoetis

Globalvets

VENKY'S PET
The expression of loyalty

PURINA
Your Pet, Our Passion.

FUJIFILM

INDIAN IMMUNOLOGICALS LIMITED

SIGNATURE
Healthier Pets, Happier you !
GRAINZERO | FREEDOM

drools
VET-PRO

Farmina Pet Foods
Happy pet. Happy You.

scientific remedies

Mankind's
PetStar V Diet

OPUSPET
PASSION UNITES INNOVATION

OriHeal
LIFESCIENCES

Vetrina
Animal Nutrition & Health

MSD
Animal Health

Happy Pet

VIVALDIS
Animal Health

Veko

Virbac

Boehringer Ingelheim

WELLCON
Animal Health

NVF VETERINARY FOUNDATION ®

Regd. Office : 5/39, Old Rajinder Nagar, New Delhi-110060
E-mail: nvfworld@gmail.com • Website: www.nvf.world