Surgical Principles and Instrumentation

- **Surgical handling**
  - manipulations effect respiratory and cardiovascular function
  - contents of thoracal cavity are intolerant of crushing or clamping
  - minimise pleural irritation in order to avoid postoperative adhesion
  - surfaces should be kept moist with warm sterile solutions
  - gentle handling of intrathoracic structures and surfaces
  - careful hemostasis
  - suction rather than wiping

- **Surgical instrumentation**
  - special thoracic set
  - retractors - self retaining retractors (Finochietto)
  - hand-held retractors
  - vascular (atraumatic) clamps ("de Bakey")
  - fine sharp instruments (Metzenbaum scissors)
  - cutting and coagulating electrocautery
  - surgical suction device
  - moistened hemostatic gauze sponges and laparotomy pads

Anaesthesia for Thoracic Surgery

- **Instrumentation**
  - manually and mechanically controlled IPPV (intubation)
  - closed or semiclosed system
  - laryngeal suction unit
  - ECG
  - pulsoxymetry
  - capnography

- **Preparation for anaesthesia**
  - stabilisation of circulation, respiration, acid-base and electrolyt status
  - remove any free gas or fluid from the pleural space
  - remove hair from thoracotomy field before anaesthesia
  - circulating warm water blanket or bottle

- **Premedication**
  - sedation (benzodiazepines, α₂ agonists)
  - analgesia (opiates: butorphanol, buprenorphine, nalbuphine)

- **Induction**
  - iv. induction (thiopentone, ketamine, propofol)
  - "mask" induction (isoflurane)

- **Maintenance**
  - isoflurane, sevoflurane/oxygene
  - nitrous oxide to be avoided
Surgical Approaches to the Thoracic Cavity

- Lateral thoracotomy
- Median sternotomy

Surgical anatomy

Left side

Surgical anatomy

Left side

Surgical anatomy

Left side

Surgical anatomy

Right side
### Surgical Approaches to the Thoracic Cavity

- **Lateral Thoracotomy (right or left sided)**
  - exposes one half of the thoracic cavity
  - can be performed with or without rib resection
  - determine the location of the approach
  - intercostal, transmuscular incision and sharp dissection
  - retractor placement
  - closure with suture around the surrounding ribs
  - Polyglactin, Polydioxanone, Stainless steel
  - chest drainage (Heimlich-valve, one-way-suction drain)

### Target of surgery

<table>
<thead>
<tr>
<th>Target of surgery</th>
<th>Intercostal space</th>
</tr>
</thead>
<tbody>
<tr>
<td>- thoracic trachea</td>
<td>3 (r)</td>
</tr>
<tr>
<td>- oesophagus (cran.)</td>
<td>3-4 (r,l)</td>
</tr>
<tr>
<td>- oesophagus (at heart base)</td>
<td>4-5 (r)</td>
</tr>
<tr>
<td>- oesophagus (caud.)</td>
<td>7-8 (r,l)</td>
</tr>
<tr>
<td>- PDA, PRAA</td>
<td>4 (l)</td>
</tr>
<tr>
<td>- cran. lung lobe, pericardium</td>
<td>5 (r,l)</td>
</tr>
<tr>
<td>- middle lung lobe</td>
<td>6 (r)</td>
</tr>
<tr>
<td>- caud. and acc. lung lobe</td>
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Surgical Approaches to the Thoracic Cavity

- **Medial Sternotomy**
  - ventral midline approach
  - gives access to both pleural spaces and the lungs, heart and mediastinum
  - sternum is split with a power-driven oscillating saw
  - closure with orthopaedic wire sutures
Surgical Approaches to the Thoracic Cavity

• **Medial Sternotomy**
  - ventral midline approach
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Surgical conditions requiring thoracic surgery

• Thoracic trauma
• Esophageal Obstruction
• Patent Ductus Arteriosus (elective course)
• Persistent Right Aortic Arch (elective course)
• Lung lobectomy
• Diaphragmatic hernia
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Introduction

- 15% of veterinary patients are traumatic (Kolata et al. 1974)
- 26 to 90% of traumatic cases are thoracic patients (Whitney & Middauff 1987, Fullington & Otto 1997, Vnuk et al. 2004)
- Thoracic trauma = circulatory + respiratory distress (Kuby 2004)

Etiology

- "High rise syndrome"
- Car accident
- Bite
- Shot
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• Upper airways (trachea, main stem bronchi)
• Lung parenchyma (contusion: edema, hemorrhage, laceration)
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• Chest wall (simple or multiple rib fracture, open chest injury)
• Cardiologic sequelae: arrhythmias, hemopericardium

ARD

• # Acute Respiratory Distress

Clinical signs (6 phases):
1. Hyperventilation / hyperpnoe
2. Tachypnoe
3. Dyspnoe
4. Breathing relieving posture
• # Acute Respiratory Distress
• Clinical signs (6 phases):
  1. Hyperventilation / hyperpnoe
  2. Tachypnoe
  3. Dyspnoe
  4. Breathing relieving posture
  5. Labial breathing (cat!)

• Oxigenisation ▼
• Hypoxemia
• Tissue hypoxia
• Respiratory acidosis
ARDS (cont’)

• Oxygenation
• Hypoxemia
• Tissue hypoxia
• Respiratory acidosis
• Asphyxia

ARDS ± SHOCK

Localisation

- Upper airways (trachea, main stem bronchi)
- Lung parenchyma (contusion: edema, hemorrhage, laceration)
- Pleural space (PTX, hemothorax, diaphragmatic hernia)
- Chest wall (simple or multiple rib fracture, open chest injury)
  - (Cardiologic sequelae: arrhythmia, hemopericardium)

Upper airway injuries

- Larynx, trachea
  - Rupture
  - Hematoma
  - Laceration

Upper airway injuries

- Physical signs
  - Open wound
  - Stridor/stretor
  - Subcutaneous emphysema
  - Inspiratory dyspnoe: larynx and/or upper tracheal injury
  - Expiratory dyspnoe: lower tracheal or main stem bronchial injury

- Radiography
  - Emphysema
  - Pneumomediastinum
  - Pneumoperitoneum
Upper airway injuries

- **Radiography**
  - Emphysema
  - Pneumomediastinum
  - Pneumoperitoneum

Upper airway injuries

- **Radiography**
  - Emphysema
  - Pneumomediastinum
  - Pneumoperitoneum

Upper airway injuries

- **Tracheobronchoscopy** (!)

Upper airway injuries

- **Surgery**
  - Surgical reconstruction
    - debridement
    - suturing
    - tracheostomy

Upper airway injuries

- **Conservative therapy**
  - oxygenisation (mask, nasotracheal tube, tracheostomy)
  - sedation (ACE, benzodiazepine)
  - iv. steroid (edema!)
  - iv. furosemide
  - analgesia (NSAID, opiate agonists/antagonists)

Upper airway injuries

- **Surgery**
  - Surgical reconstruction
    - debridement
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    - tracheostomy
**Thoracic trauma**

**Localisation**

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  - (Cardiologic sequelae: arrhythmias, hemopericardium)

**Injuries of the lung parenchyma**

- **Lung contusion**
  - edema
  - hemorrhage
  - laceration

**Physical signs**

- ARD
  - Varied according to...
    - severity (laceration+hemorrhage)
    - extent (No of lung lobes)
    - laterisation (uni- or bilateral)

**Radiology**

- edema N°1
- edema N°2
- Interstitial pattern
- Alveolar pattern
- Interst.-alveol. pattern

**Cardiologic sequelae**

- Arrhythmias
- Hemopericardium

**Thoracic trauma**

**Injuries of the lung parenchyma**

- Edema
- Hemorrhage
- Laceration
Injuries of the lung parenchyma

Radiology
- laceration (atelectasis+PTX)

Conservative therapy
- oxygenisation (mask, nasotracheal tube, tracheostomy)
- sedation (ACE, benzodiazepine)
- iv. steroid (edema!)
- iv. furosemide
- analgesia (NSAID, opiate agonists/antagonists)
- hypotensive resuscitation (infusion/therapy)
  - slow, low dose colloid+cristalloid
  - syringe pump
- therapy of the pleural space
  (see later)

Surgery
- ideal: unilateral, 1-2 lung lobe
  - hemorrhage
  - laceration
  - thoracotomy/sternotomy
  - partial lobectomy
  - total lobectomy
**Localisation**

- Upper airways (trachea, main stem bronchi)
- Lung parenchyma (contusion: edema, hemorrhage, laceration)
- **Pleural space (PTX, hemothorax, diaphragmatic hernia)**
- Chest wall (simple or multiple rib fracture, open chest injury)
- (Cardiologic sequelae: arrhythmias, hemopericardium)

**Injuries of the pleural space**

- PTX
- Traumatic hemothorax
- Traumatic diaphragmatic hernia

**Injuries of the pleural space**

- PTX
  - 20 to 63% of closed chest injuries (Vusk et al. 2004, Whitney & Mehlhaff 1987)
  - 100% of open chest defects
  - closed vs. open vs. tension
  - ARD
  - tympanic percussion sound
  - decreased respiratory sounds

**Injuries of the pleural space**

- PTX
  - Radiography

**Injuries of the pleural space**

- PTX
  - „tap before rad“ vs. „rad before tap“
Injuries of the pleural space

- **PTX**
  - "tap before rad" vs. "rad before tap"
  - recommended therapeutic protocol:
    1. thoracocentesis - tapping - recheck (rad)

Injuries of the pleural space

- **PTX**
  - "tap before rad" vs. "rad before tap"
  - recommended therapeutic protocol:
    1. thoracocentesis - tapping - recheck (rad)
    2. chest drainage - intermittent/constant suction - recheck
Thoracic trauma
Chest drainage

Injuries of the pleural space

- **PTX**
  - “tap before rad” vs. “rad before tap”
  - recommended therapeutic protocol:
    1. thoracentesis - tapping - recheck (rad)
    2. chest drainage - intermittent/constant suction - recheck
    3. thoracotomy / sternotomy - lobectomy - chest drainage

Localisation

- Upper airways (trachea, main stem bronchi)
- Lung parenchyma (contusion: edema, hemorrhage, laceration)
- Pleural space (PTX, hemothorax, diaphragmatic hernia)
- **Chest wall** (single or multiple rib fractures, open chest injury)
  - (Cardiologic sequelae: arrhythmia, hemopericardium)

Physical signs

- ARD + SHOCK
- Closed or open injury
- Skin defect ≠ chest status!!!
  (Davidson 1998)
- Mortality = chest status!!!

Radiology

- Double projection

Chest wall injuries

- Bite !!!
  - Shamir et al (JSAP, 2002)
  - 185 bitten dogs, 11 bitten cats
  - Most relevant: male, 10 kg > dogs with chest wall defect
- Shot
- Stab
Thoracic trauma

Chest wall injuries

- Radiology
  - Double projection

Surgical conditions requiring thoracic surgery

- Thoracic trauma
- Esophageal Obstruction
- Patent Ductus Arteriosus (elective course)
- Persistent Right Aortic Arch (elective course)
- Lung lobectomy
- Diaphragmatic hernia

Esophageal Obstruction

Definition
- partial or complete blockage of esophageal passage usually caused by foreign body
- localisation: pharyngeal, cervical and thoracic

- Incidence
  - dogs, cats, horses, cattles
  - young puppies, playful, greedy animals
  - bone, stone, potato, bolus

- History
  - apathy
  - vomiting, regurgitation just after eating in undigested form
  - constant attempt to eat and drink
  - cough, aspiration

- Diagnostics
  - anamnesis
  - direct visualisation or palpation of the obstruction (pharyngeal, cervical)
  - orogastric tube
  - X-ray (plain, contrast)
  - oesophagoscopy
Esophageal Obstruction

Plain esophagography

Positive contrast esophagography

Therapy

- **Pharyngeal**: oral removal
- **Cervical**: push back to the pharynx
  - endoscopic removal
  - surgical exploration $\rightarrow$ pushing back
  - esophagotomy

Surgery - Esophagotomy
### Surgical conditions requiring thoracic surgery

- Thoracic trauma
- Esophageal Obstruction
- Patent Ductus Arteriosus (elective course)
- Persistent Right Aortic Arch (elective course)
- **Lung lobectomy**
- Diaphragmatic hernia

---

### Lobectomy

⇒ surgical removal of (a) lung lobe(s)

---

### Lobectomy

**Indication**
- circumscribed neoplasia, abscess, foreign body of a lung lobe
- severely injured and collapsed lung lobe
- spontaneous pneumothorax causing pulmonary lesion
- lung lobe torsion

**Diagnosis**
- respiratory symptoms
- laterolateral and ventrodorsal X-ray projection
- bronchoscopy

**Surgery**
- right or left sided lateral thoracotomy
- isolation of the affected lung lobe
- partial lobectomy → V-shaped resection on the edge
- lobectomy → ligature of accompanying pulmonary vessels
- closure with double layer of continuous sutures
- chest drainage
**Partial lobectomy**
Injured lung lobe

**Lobectomy**

- **Surgery**
  - right or left sided lateral thoracotomy
  - isolation of the affected lung lobe
  - partial lobectomy → V-shaped resection on the edge
  - lobectomy → ligature of accompanying pulmonary vessels
  → closure with double layer of continuous sutures
  - chest drainage

**Postoperative care**
- monitoring of respiration
- postoperative analgesia
- check-up X-ray

**Thoracic trauma**
**Esophageal Obstruction**
**Patent Ductus Arteriosus** (elective course)
**Persistent Right Aortic Arch** (elective course)
**Lung lobectomy**
**Diaphragmatic hernia**
Diaphragmatic Hernia

- **Definition:**
  - abnormal dislocation of abdominal organ(s) into the thoracal cavity through a congenital or acquired, normal or abnormal defect of the Diaphragm
  - clinical consequences due to the compression of the intrathoracal organs and the morphological as well as functional disorder of the affected abdominal structures

### Classification:

- **Congenital** (abnormal development of segments)
  - pleuroperitoneal diaphragmatic hernia (hereditary)
  - peritoneopericardial hernia (PPDH - defect of septum transv.)
  - hiatal hernia (sliding/axial or rolling/paroesophageal)
  - diaphragmatic eventration

- **Acquired, traumatic** (90-95%)
  - left / right sided or bilateral
  - circular, radial or combined hernial gate

---

**Peritoneopericardial Diaphragmatic Hernia (PPDH)**

- **Definition**:
  - abnormal opening between the peritoneal and the pericardial sac
  - dislocation of abdominal organs to the pericardium

- **Definition**:
  - abnormal opening between the peritoneal and the pericardial sac
  - dislocation of abdominal organs to the pericardium
Diaphragmatic Hernia

- Classification:
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    - pleuroperitoneal diaphragmatic hernia (hereditary)
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    - diaphragmatic eventration
  b. Acquired, traumatic (90-95%)
    - left / right sided or bilateral
    - circular, radial or combined hernial gate

Hiatal Hernia (HH)

- Definition
  - displacement of the abdominal esophagus, esophagogastric junction and/or part of the stomach into the thorax
Diaphragmatic Hernia

- **Classification:**
  - *Congenital* (abnormal development of segments)
    - pleuroperitoneal diaphragmatic hernia (hereditary)
    - peritoneopericardial hernia (PPDH - defect of septum transv.)
    - hiatal hernia (sliding/axial or rolling/paraesophageal)
    - diaphragmatic eventration
  - *Acquired, traumatic* (90-95 %)
    - left / right sided or bilateral
    - circular, radial or combined hernial gate

- **Incidence:**
  - cat > dog

- **Aetiology:**
  - car accident
  - falling down
  - penetrating wound

- **Pathogenesis:**
  - depends on
    - time of anamnesis
    - size of hernial gate (incarceration)
    - dislocated organs (omentum, liver etc)
    - status of intrathoracic organs (lungs)
  - systemic alteration
    - shock
    - ARD

- **Pathogenesis (cont.)**
  - *intrathoracic alterations*
    - thoracic contusion
    - pulmonary oedema/hemorrhage
    - pneumothorax, hemothorax
  - *abdominal disorders*
    - hepatic contusion, congestion, rupture
    - splenic congestion/rupture
    - gastrointestinal laceration, obstruction
Traumatic Diaphragmatic Hernia

**Diagnosis**
- general assessment
- detailed examination
- supplementary examination
- differential diagnosis

**General assessment**
- weakness, apathy
- lying or sitting position
- cyanotic, pale mucous membranes
- prolonged CRT
- tachypnoe, dyspnoe

**Detailed examination**

- **Circulation:**
  - shock
  - tachycardia
  - dislocation or lack of heart sounds

- **Thorax:**
  - Auscultation
    - increased respiratory sounds (pulm. oedema)
    - lack of resp. sounds (liver, spleen or PTX)
    - gastrointestinal sounds (stomach, intestine)

- **Thorax:**
  - Percussion
    - dislocated diaphragmatic line
    - decreased resonance (liver, spleen, omentum)
    - increased resonance (stomach, intestine, PTX)
    - fluid line (hemothorax)

- **Abdomen:**
  - Palpation
    - abnormal, "empty" feeling
**Traumatic Diaphragmatic Hernia**

**Supplementary examination**

- **X-ray:** plain laterolateral and dorsoventral projection
  - line of Diaphragm
  - position of intrathoracic organs
  - lung pattern (oedema, hemorrhage, contusion)
  - free contents of thoracic cavity (fluid, gas)
  - position of liver and stomach
  - positive contrast examination (Ba)

- **Ultrasonography:**
  - line of Diaphragm
  - position of intraabdominal organs

- **Laboratory examination**
  - blood gas analysis
  - complete blood-count
  - biochemical parameters (ALT, AP, lipase, amylase, urea, creatinine etc)
  - thoracocentesis

---

**Traumatic Diaphragmatic Hernia**

**Plain X-ray**

![Plain X-ray](image1)

**Positive contrast study**

![Positive contrast study](image2)

**Ultrasoundography**

- Hernia diaphragmatica traumatica
**Traumatic Diaphragmatic Hernia**

**Differential Diagnosis**

- Pleural effusion without herniation (hydro-, hemo-, chylo-, pyothorax)
- Pulmonary oedema, hemorrhage, pneumonia
- PTX
- GDV, intestinal obstruction
- Cardiac disorders

**Therapy**

> absolute indication of surgery!

1. **Stabilisation of circulatory and respiratory status**
   - oxygenisation (mask, intubation, tracheostomy)
   - shock management
   - diuretics (furosemide)
   - correction of acid-base and ionic imbalance
   - sedation (diazepam, acepromazine)
   - thoracocentesis (7-8. intercostal space)

2. **Surgery** (cont.)
   - reposition of abdominal organs
   - evaluation of the vitality of organs
   - removal of necrotic tissues (lobectomy, resection)
   - restoration of the Diaphragm (one or two layers, interrupted or continuous, absorbable or nonabsorbable)
   - chest drain placement (?)
**Traumatic Diaphragmatic Hernia Surgery**

- Postoperative care
  - oxygenisation
  - intensive monitoring (blood gas analysis)
  - infusion, diuresis
  - analgesia (flunixin meglumine, opiates)
  - mashy diet

**Assessment of Prognosis**
- time of anamnesis
- response to stabilisation therapy
- status of lungs and the liver
- return of spontaneous respiration after surgery
- survival of the first 24 hours postoperatively

**Thank You for Your Attention!**