Acute Care SINS:

Surgical Insights for the Non-surgeon

Chapter 11: Cardiothoracic SINS

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Summary

“Surgical Insights for the Non-surgeon,” or SINS, is composed of several short chapters intended to cover fundamental surgical knowledge for non-surgeons. The authors focus on surgical pearls, operative insights, and applied anatomy. In Chapter 11 of this series, the authors address cardiothoracic surgical issues.

Résumé

L'ouvrage « Surgical Insights for the Non-surgeon » (aperçu de la chirurgie à l'intention du non-chirurgien) se compose de courts chapitres couvrant les connaissances fondamentales en chirurgie. Les auteurs se concentrent sur des enseignements tirés de leur expérience, des aspects opératoires et l'anatomie appliquée.

“To wake the soul by tender strokes of art; To raise the genius, and to mend the heart.”

—Alexander Pope

“How do you know who the cardiac surgeon is at a party? Oh, don't worry, he'll tell you”

—Anonymous

Anatomy

For centuries, the cardiocentric view predominated over the encephalocentric. After all, concluded Aristotle, the body dies when the heart stops; the voice emanates from the lungs; and one can (if so disposed) poke the brain without producing pain. It took centuries (and Galen) to convince us otherwise. It then took until after the Second World War to believe that we could safely operate in this arena. Regardless, poetry and pop-songs prove that the heart and its ailments still hold our attention. What follows is a more prosaic anatomic primer.

Thoracic cavity surgery involves one of three main anatomical areas: 1) the heart, 2) lungs and pleural spaces (including diaphragm and chest wall), and 3) other mediastinal structures (see below). Within the thorax, two lungs are attached to the mediastinum at the hilum (plural is “hila”). It is through these ‘roots’ that the blood vessels and bronchi pass. The lungs are not attached to the thoracic cavity at any other location. Each lung is covered by pleura – the lining which wraps around the lungs and also covers the inside of the thoracic cavity. *Visceral* pleura covers the lung; *parietal* pleura covers the inside of the chest wall, diaphragm, and mediastinum.

The right lung has three lobes (upper, middle and lower), separated by two fissures (oblique and horizontal). The left lung has two major lobes (upper and lower), separated by an oblique fissure. The bronchial tree starts within the mediastinum, and enters each lung through the hilum as right and left main bronchi. Each main bronchus divides into lobar bronchi (corresponding to each lung lobe) before dividing further into segmental bronchi. (Figure 1) Within the left lung lies the lingula (a smaller counterpart to the right middle lobe).

Figure 1. Anatomy of the bronchial tree.

The mediastinum is commonly described in four parts: superior; anterior; middle; posterior (Figure 2). The superior mediastinum contains the inferior trachea, esophagus, thoracic duct, aortic arch, brachiocephalic artery, left carotid and subclavian arteries, brachiocephalic veins, superior vena cava (SVC), phrenic nerve, vagus nerve (and its recurrent laryngeal branch), and lymph nodes. The anterior mediastinum contains the thymus and lymph nodes. The middle mediastinum contains the heart and pericardium, roots of the great vessels, azygous vein arch, lung roots, bronchial lymph nodes, and phrenic nerves. The posterior mediastinum contains the descending aorta, azygous and hemi-azygous vein, esophagus, thoracic duct, vagus and splanchnic nerves.

The chest wall consists of skin, subcutaneous tissues, and muscles: the pectoralis muscles (anteriorly), latissimus dorsi and serratus (postero-laterally), and the sternum (manubrium, body, xiphoid process). There are 12 ribs, with 1-7 considered “true” ribs (or “fixed ribs” or “vertebrosternal ribs”) because they attach directly from vertebra to sternum. Ribs 8-12 are “false ribs” (or “vertebrochondral ribs”): with 8-10 attaching to the sternum indirectly via the costal cartilages of the ribs above. Ribs 11 and 12 (which have cartilaginous tips) are called “floating ribs” because they attach only to the posterior vertebrae, and not to the sternum or sternal cartilage. Ribs 1-7 provide structure and protection; ribs 8-12 allow flexibility and respiratory excursion.

Anyone who has been for barbeque-ribs knows that the intercostal spaces contain layers of muscle. The external intercostals are positioned anterior-to-inferior, and the internal intercostals are posterior-to-inferior. The neurovascular bundle is found between two layers of the

Figure 2. Compartments of the thoracic cavity.

Figure 3. Coronary arteries (anterior view).

internal intercostal and sheltered behind the “blade” of the rib above (therefore place chest tubes above the rib, not below, so as to avoid a bloody mess). God put the internal mammary artery (or internal thoracic artery) near the midline: presumably to give cardiac surgeons easy access to this conduit vessel.

The diaphragm has three muscular leaflets that surround a central tendon. This muscular dome separates the thoracic from abdominal cavity. The diaphragm attaches to the xiphoid process and costal margin anteriorly, and the ribs and vertebrae posteriorly. The right and left crura (aka the posterior diaphragmatic tendons) insert into lumbar vertebrae L1 and L2. The body of the diaphragm has three foramina (windows) that allow passage of the esophagus, descending aorta and inferior vena cava (IVC).

The heart is covered by fibrous pericardium, beneath which the right and left coronary arteries provide myocardial blood supply. The right coronary artery starts above the anterior aortic valve leaflet. It branches to the right atrium and sinoatrial node before dividing into the right marginal (acute marginal) and posterior interventricular arteries (posterolateral branch and posterior descending artery - in patients with right dominant anatomy). The left coronary artery commences above the left posterior aortic valve leaflet and continues as the left ‘main stem’ before dividing into the left anterior descending (which in turn gives rise to diagonal branches) and the circumflex artery (which further divides into obtuse

marginal arteries and the posterior descending artery in left dominant anatomy). There is a variable degree of anastomotic linkage between the distal right and left coronary arteries. (Figure 3)

The heart is divided into right and left sides (referring to the ‘sides’ of the circulation, pulmonary versus systemic, rather than anatomic position). The atria are separated from the ventricles by atrioventricular (AV) valves (tricuspid and mitral). The semilunar valves (aortic and pulmonary) control blood egress from the ventricles. The right atrium can be thought of as an enlarged area within a continuous tube – the upper part of the tube being the SVC, and the lower portion being the IVC. The tricuspid (three-leaflet) valve sits between the right atrium (RA) and ventricle (Figure 4). The right ventricle sits partially on the diaphragm, and partially behind the sternum and anterior ribs (and therefore is the ventricle most commonly initially injured during stabbings). The right ventricle becomes the pulmonary trunk near its superior surface at the position of the trileaflet pulmonary valve. The left atrium, which collects blood from the pulmonary veins, sits almost beneath the carina of the bronchi (hence, when enlarged, it can cause “splaying” of the carina on chest Xray).

Functioning heart valves ensure unidirectional blood flow. The mitral is the only valve that normally has two leaflets. These leaflets, when together, resemble a Bishop’s hat : a mitre. After oxygenated blood passes through the mitral valve it enters the left ventricle, which sits to the left and partly

4. Anterior cardiac view with cutaway demonstrating valve and papillary muscles.

behind the right ventricle. The left ventricle is far more muscular than the right (hence the larger troponin increase with left-sided versus right-sided damage). In 2D short-axis echocardiography, the left looks like a thick-walled donut, whereas the right is thin and D-shaped. The left ventricular outflow tract contains the aortic valve (three leaflets normally; bicuspid occasionally- which can result in pathology) and the aortic root. Within both ventricles are papillary muscles, which anchor the AV valves in place. (Figure 4). The contraction of the muscle fibers of the heart is normally synchronized, however when the individual small fibers (or fibrilla, in Latin) start to contract independently of one another, the heart is said to fibrillate.

Cardiothoracic Incisions

Access to the thoracic cavity is obtained by:

- Median sternotomy
 - Sternum is split and the ribcage spread apart
 - Typically reserved for cardiac (a.k.a. open-heart) surgery
 - Or complex anterior thoracic surgery
 - E.g. excision of a massive retrosternal goiter
 - *This hurts a lot*
- Lateral and posterolateral thoracotomy
 - Incision made in an intercostal space
 - Ribs “spread” apart, or partially resected
 - *This hurts a lot, too*

- Partial (or minimally invasive) sternotomy
 - There are upper and lower variations
 - Choice is based upon optimal surgical site access
 - *This hurts less*
- Keyhole intercostal incisions
 - Providing space to insert an endoscope
 - Minimally invasive: video-assisted thoracotomy (VATS)
 - *This hurts least*

Lung Resection Surgery

- Most commonly for cancer
 - Sometimes for bullae or infections
 - E.g. chronic suppurative diseases or aspergilloma
- Requires pre-op assessment of respiratory reserve
 - Ventilation-perfusion lung mapping
 - To ensure patients can cope following resection
 - Ideally, the recommended residual postoperative FEV₁ is > 1.5L for lobectomy and > 2L for pneumonectomy
 - Each lobe provides approximately 1/5 of lung capacity (if healthy)
 - But may contribute less if already diseased
 - Therefore, bad lungs aren’t missed!
- Lung resection options
 - Resection of a lobe (lobectomy)
 - Resection of part of a lobe (partial lobectomy or wedge resection)

- Resection (rarely) of an entire lung (pneumonectomy)
- With carinal disease, a “sleeve pneumonectomy” may be performed
 - Resect the diseased lung and its bronchus
 - Reattach the good lung back to the trachea
- Can disrupt post-op lymphatic drainage/ciliary flow
- Lung volume reduction surgery (LVRS)
 - For severe hyperinflation in emphysema
 - Technically, similar to other lung resection surgery
 - But the aim is to remove the least functional part of the lung
 - And preserve cardiovascular flow in and preserve airflow out
- Complications of lung resection surgery include:
 - Pain
 - Respiratory failure
 - Especially in patients with frailty/extensive lung disease
 - Pneumonia and sepsis
 - Especially with pre-existing abscess
 - Or if infected secretions were trapped distally
 - Dysrhythmias
 - Especially atrial fibrillation (AF)
 - AF is also associated with post-op pneumonia or mediastinitis
 - Persistent pneumothorax, and bronchopleural fistulae (air leaks) (see below)
 - Hemorrhage and hemothorax
 - Pulmonary embolus (far less common than pneumonia)

Chest (a.k.a Pleural) Drains

- Common on both surgical and medical wards
- Multiple drains may be placed during thoracic surgery
 - Typically, one is placed apically
 - To drain pneumothoraces
 - Another is basal, or next to the resected area
 - To drain blood or effusion
 - Occasionally, contralateral drains are placed
 - These can pass *over* the mediastinum
 - To the uninitiated, the Xray can look as if tubes pass *through* the heart
- There are many potential complications of chest drain insertion, including:
 - Hemorrhage
 - Trauma to the lung, pericardium, or mediastinal structures
 - Never insert a surgical chest drain using a trocar
 - Never do that – trocars are sharp and will easily

- penetrate heart and other structures.
- Migration or misplacement of tubes
 - In the obese it is common to misplace into subcutaneous tissues rather than the thoracic cavity
 - Chest tube drainage holes can migrate until they are outside the patient
 - Which loses the airtight seal, and can entrain air
- Damage to the diaphragm or abdominal viscera
 - More common when drains are outside of the “safe zone”
 - The safe zone is:
 - Superior to the nipple; inferior to the axilla; lateral border of pectoralis major, anterior border of latissimus dorsi)
 - Insertion advice:
 - In women: follow the infra-mammary crease to the mid axillary line
 - In men: follow the nipple line laterally to the mid axillary line
 - Accidental trans-diaphragmatic chest drains
 - The chest drain goes through abdominal structures (such as liver) before entering the thoracic cavity
 - More common when using Seldinger insertion kits, or when not using ultrasound
- Persistent bleeds may require surgical exploration (see surgical pearl)
- Persistent pneumothoraces may indicate a bronchopleural fistula
- Chest drains may need to be on suction to encourage drainage (typically minus 20cmH₂O)
 - Later, you may need to decrease that suction to allow hole to heal
 - Or a second chest drain may be required
 - Which is usually placed in a different position
- Maintain an index of suspicion regarding occult pneumothoraces
 - Especially in patients on positive pressure ventilation
 - On supine Xrays, pneumothoraces may not be visible apically
 - Air collects anteriorly, so look for:
 - Abnormally deep costophrenic or cardiophrenic recess
 - Sharp cardiomedistinal border or pneumomediastinum
 - “Double diaphragm” sign outlining inferior lobes
 - Air ‘bands’ in the minor fissures

- Depressed ipsilateral diaphragm
- May require lateral Xray or CT
 - But beware the “donut of death” (a.k.a. the CT scanner!)
 - Only send for imaging if stable
 - Radiation never cures a pneumothorax but it can endanger a patient
- Rarely clamp chest drains
 - It may result in tension pneumothorax
 - However, after pneumonectomy, tubes may require a ‘clamp and release’ protocol
 - This encourages fluid to collect in the resected hemithorax
 - Which may decrease post-pneumonectomy syndrome
 - A mediastinal shift that compresses/ stretches the tracheobronchus/esophagus
 - Resulting in shortness of breath, dysphagia, or heartburn
- Perform a chest Xray after all chest drain insertions
 - Including chest drains placed during surgery

Surgical Pearl:

Hemorrhage from chest drains:

- The commonest causes of bleeding are:
 - Intercostal vessel damage (e.g. during scalpel incision, or laceration during drain insertion)
 - Intraparenchymal damage (e.g. during drain insertion)
 - Damage to associated tissues (e.g. trans-diaphragmatic insertion)
- Anything that results in ≥ 600 mls in 6 hours requires surgical review, e.g.
 - 600 mls in one go
 - 200 mls/hour for 3 hours
 - 100 mls/hour for 6 hours
- If bleeding is suspected, obtain an urgent chest Xray and/ or ultrasound
 - Ultrasound (U/S) good for detecting fluid within the thoracic cavity (and may visualize fibrin-stranding associated with hemorrhage)
 - U/S not good for seeing through adipose (i.e. obese patients) or air (e.g. pneumothorax/surgical emphysema)
 - Hemorrhage may be occult/invisible (i.e. the chest drain may be blocked)
- No absolute indications for surgery
 - Instead, respond to the patient’s condition

Pleural And Chest Wall Surgery

- Pleurectomy
 - Performed for recurrent pneumothoraces
 - Complication = hemorrhage
- Decortication
 - Literally, resection of an outer layer
 - Performed for mesothelioma or organized empyema
 - Complications include hemorrhage or septic “shower” during/after surgery
- Chest wall surgery
 - Most often for lesions involving ribs or intercostal muscles
 - Rib fixation is becoming more common following traumatic flail-chest
 - Severe pectus excavatum (in-drawn, or dish-shaped chest)
 - Open repair (Ravitch procedure), or
 - Minimally invasive repair with a metal bar (Nuss procedure)

Pain after thoracic surgery or thoracic trauma

- Thoracotomy incisions can be very painful
- As with all incisions, movement (in this case, breathing) exacerbates pain
- Pain can lead to shallow breathing
 - Which in turn leads to lung atelectasis and retention of secretions
 - Which in turn leads to respiratory failure
- Physiotherapy and early mobilization are very beneficial
- Good analgesia also important
 - As a *minimum*, patients should cough and deep-breathe
 - Better still if they can mobilize, and engage with physio
- Analgesia depends upon patient’s characteristics, and staff skill,
 - Options include:
 - Epidural infusions or paravertebral infusions
 - Requires experience to insert, trouble-shoot and monitor
 - Watch for hypotension: due to sympathetic blockade
 - Systemic opiates
 - Given as infusions, boluses, or patient-controlled (PCA)
 - Watch for sedation and respiratory depression
- Pneumonia is a common complication of thoracic injuries or surgery
 - Antibiotics should cover hospital-acquired bugs and aspiration
- Chronic, neuropathic pain can be associated with chest trauma and surgery

Illustration by Rachel G. Khadaroo and Dawne Colwell

Figure 5. Esophageal resection with gastric pull-up. The stomach replaces the esophagus.

Figure 6. Chest radiograph after an esophagectomy.

Esophageal Resection (Figure 5)

- Performed for esophageal disease
 - e.g. cancer or benign strictures
 - e.g. leaks or trauma (i.e. drinking bleach; iatrogenic perforation)
- Common techniques include:
 - Ivor Lewis approach (for distal esophageal tumors)
 - Involves a right thoracotomy and an upper midline incision
 - McKeown's approach (for proximal esophageal tumors)
 - Involves a right thoracotomy and a neck incision
 - Trans-diaphragmatic approach
 - Transhiatal rather than transthoracic
 - Mobilization of the esophagus, and stomach
 - With a 'pull-through' the diaphragm (so no thoracotomy is performed)
- Resulting esophageal "conduit" can have tenuous blood supply
 - Prone to anastomotic breakdowns and mediastinitis
- Complications:
 - Similar to lung resection surgery
 - Also chyle leaks

- Fatty fluid, from the lymphatics/thoracic duct in the thorax
- As well as chest drains, a naso-gastric (NG) tube often left as an endo-luminal drain after surgery (Figure 6)
 - Placed at the level of the anastomosis
 - Therefore, on Xray, it may seem ‘malpositioned’
 - I.E. it sits above the diaphragm
 - Do not manipulate the NG tube
- Esophageal surgery is mediastinal surgery
 - Therefore, effusions/hemorrhage can be contralateral to the thoracic incision
- Rarely, esophageal tumours can adhere to the pericardium
 - Cardiac complications, such as tamponade, can occur

Surgical Pearl:

Esophageal leaks and ruptures

Causes include:

- Esophageal cancer
- Trauma/iatrogenic perforation (e.g. during endoscopy, trans-esophageal echocardiography, dilatation of an esophageal stricture)
- Spontaneous esophageal rupture
 - Boerhaave’s syndrome (associated with vomiting – patients often describe a “popping” feeling).
 - Perforation of esophageal erosions, or an infected ulcer (typically HIV-related)
 - Ingestion of corrosive substances, or ‘pill-esophagitis’

Esophageal rupture/leak associated with:

- History of sustained vomiting, dysphagia, odynophagia
- Unexplained chest pain, occasionally radiating to the left shoulder
- Unexplained surgical emphysema, pneumothorax or pneumomediastinum – especially if pneumothorax persists despite adequate drainage
- Grossly contaminated pleural fluid (often with particulate matter)
- Enteric organisms in the pleural fluid (particularly mixed flora, enterococcus, or candida)

Diagnosis often delayed due to differential diagnosis:

- Pneumonia/lung abscess
- Myocardial infarction
- Spontaneous pneumothorax
- Pancreatitis
- Pericarditis

Treatment: i) Adequate chest drainage (often a large bore drain due to particulate matter), ii) Broad-spectrum antibiotics (due to the organisms mentioned above), iii) Early surgical consultation

Other considerations

Fluid balance after surgery and thoracic trauma

- Lung vascular permeability is increased
- Restricting intravenous fluids can reduce interstitial edema (‘dry lungs are happy lungs’)
 - Approximately 1-1.5 ml/kg/hour
 - But, must be balanced against the need for intravascular resuscitation

Coronary Revascularization Surgery

- Coronary artery bypass grafting (CABG)
 - To circumvent (i.e. bypass) stenotic coronary arteries in critical ischemic heart disease
 - Increasingly, first line therapy is percutaneous coronary intervention (PCI)
 - CABG is preferred for:
 - Multi-vessel disease
 - Left main stem disease
 - Mild-moderate left ventricular dysfunction (ejection fraction 35-50%) and either multi-vessel disease or proximal LAD disease
 - Diabetic with multi-vessel disease
 - Complex three-vessel coronary artery disease
 - Possibly also chronic kidney disease
- Options for conduit include:
 - Saphenous vein; radial artery; left internal mammary artery (LIMA) (also referred to as left internal thoracic artery (LITA))
- Typically patients mechanically ventilated for a short period after surgery
 - Early post-op care performed in an intensive care unit (ICU)
 - Median sternotomies not usually as painful as other thoracotomies (unless, one is the actual recipient of the sternotomy incision, in which case, it still hurts like heck)
 - So, less analgesia required; ventilator weaning usually rapid
- Complications include:
 - Myocardial infarction (MI)
 - Leading cause of death post-CABG; increased subsequent incidence of heart failure and hospital readmission

- Approximately 1-in-30 patients have a perioperative MI
 - Increased MI risk persists for approximately 30 days
 - Some need lengthier mechanical circulatory support
 - Intra-aortic balloon counter pulsation devices (IABP) or ventricular assist devices may be inserted with surgery
- Low Cardiac Output Syndrome
 - Inadequate cardiac output/end-organ oxygen delivery
 - Reduced myocardial performance (systolic dysfunction) (RV, LV, or both) or diastolic dysfunction
- Cardiac dysrhythmias
 - Most commonly AF
 - More malignant rhythms too (ventricular tachycardia, etc)
 - Intraoperative temporary epicardial pacing leads are commonly placed
 - These allow for post-operative cardiac pacing
- Adverse cerebral outcomes
 - Of varying severity, but affects approximately 6%
 - Full stroke in 1 - 4%
 - Up to 50% of patients may experience delirium
 - Many also suffer post-operative cognitive deterioration/decline
 - A.K.A. “post-perfusion syndrome” / “pump head” (due to its association with cardiopulmonary bypass, CPB)
 - Contributory factors: pre-existing cerebral vascular disease, peripheral vascular disease, age, duration of CPB, smoking, diabetes, renal failure, use of deep hypothermic circulatory arrest
 - Peri-operative emboli from the aorta (atherosclerosis, plaque disruption from aortic cross-clamp application/manipulation)
 - Also air-emboli; debris; micro emboli (fibrin, etc.)
- Decreased renal function
 - Approximately one-third of patients
 - Varying severity
 - Some patients require post-operative dialysis
 - Multifactorial etiology
 - Pre-renal (most often); renal and post-renal (less often)
- Infection
 - Affecting the sternotomy wound, or donor graft sites
 - Look for incisional drainage; erythematous, excessively warm wound and a ‘sternal click’ (i.e. sternal instability)
- Hemorrhage
 - Peri-operative bleeding can lead to tamponade
- Always have a high index of suspicion - ‘it’s tamponade until proven otherwise’
- Central venous pressure (CVP) may NOT be elevated - caval compression from clot can prevent SVC/RA distension
- Look out for oliguria, elevated lactate, and other signs of low cardiac output syndrome
- BEWARE: anticoagulation is required for cardiopulmonary bypass
 - Risk of bleeding increased if inadequately reversed after surgery
 - Coagulopathy is common after cardiac surgery (heparin ‘rebound’, fibrinolysis)

Surgical Pearl:

Cardiac arrest after cardiac surgery

- Epinephrine (adrenaline) to be used with extreme caution and probably reduced dose – to reduce hemorrhage and ischemia.
- Epicardial pacing helps if asystole or severe bradycardia
- Re-open the sternotomy early (even if tamponade not clinically obvious)

In some centers, different guideline are used for arrests following cardiac surgery (these guidelines differ from the AHA/ACC guidelines – and are called cardiac advanced life support or CALS)

Cardiopulmonary bypass (CPB)

- Most cardiac surgery is performed using CPB (heart-lung machine)
- CPB maintains systemic circulation by isolating/excluding heart and lungs
- The heart is arrested to facilitate a motionless, bloodless, surgical field
 - Usually achieved by infusing a cold, potassium-containing, cardioplegia solution: directly into the aortic root or coronary ostia
 - After surgery, the heart is restarted and the patient weaned from CPB
 - Less commonly, surgery can be performed “off-pump”
 - This uses a stabilization system which typically means a specialized retractor or suction cup system (intended to reduce the motion of the target cardiac wall)
 - Allows surgery while the heart is still beating
- Prior to arresting the heart, patient is cannulated and connected to an extracorporeal circuit, consisting of:

- A venous reservoir to drain blood under gravity from the venous system (right atrium and IVC via a single cannula; or bicaval drainage using two cannulae)
- Blood tubing circuit and roller pump
- Heat exchanger
- Oxygenator and carbon dioxide removal membrane
- Filter to remove air and clot.
- Cardioplegia delivery system.
- Return arterial line to deliver blood
 - Typically returned to the ascending aorta
- Circuits need to be primed (air-removed) prior to use
 - Most commonly primed with crystalloid/colloid solutions in adults
 - Can result in hemodilution (which may offer some rheological advantages to the microcirculation)
- Blood needs to be anticoagulated during CPB
 - Typically with unfractionated heparin
 - Reversed with protamine
 - Heparin-rebound and bleeding can occur
- CPB may cause a systemic inflammatory response
 - This can persist after surgery

Surgical Pearl:

Extra Corporeal Membrane Oxygenation (ECMO)

- a.k.a. bedside CPB

- Principles are similar to CPB
- But specifically refers to use in ICU for prolonged support when conventional hemodynamic and/or ventilatory support has failed
 - Venovenous (VV) ECMO - respiratory support only; preferred when only lung support is required
 - Single cannula (Right Internal Jugular, IJ); or
 - Dual or triple cannula (IJ, femoral vein, femoral vein)
 - Venoarterial (VA) ECMO - cardiac and respiratory support
 - Central cannulation (axillary artery or aorta directly; and right atrium)
 - Peripheral cannulation (usually femoral artery/femoral vein)

Aortic Surgery - Aneurysm And Dissection

- Thoracic aortic aneurysms can be caused by:
 - Hypertension
 - Atherosclerosis
 - Connective tissue disorders (e.g. Ehlers-Danlos or Marfan's syndrome, annuloaortic ectasia)

- Infection/inflammation (e.g. vasculitis secondary to giant cell arteritis, Takayasu's arteritis, rheumatoid arthritis, syphilitic aortitis)
- High-velocity blunt thoracic trauma
- High-intensity weight lifting
- Classification - most useful clinically is the Stanford system:
 - Type A - involves the ascending aorta, regardless of the site of the intimal tear
 - Type B - all other dissections
- Aortic Dissection is a high-mortality, vascular catastrophe.
- Unfortunately, aneurysms typically asymptomatic unless they suddenly leak, rupture, or dilate; at which point: at which point:
 - Chest pain is common (often mistaken for MI)
 - Sharp, tearing chest pain
 - Typically, anterior chest pain in Type A
 - Typically, back pain in Type B - radiates to between the shoulder blades
- For patients with chest pain, always ask: '*why is this not an aortic dissection?*'
 - Because administering thrombolytics can be fatal
 - And because EKG changes can also occur with aneurysms
 - Due to coronary involvement
 - Look for tachycardia, nausea, and a feeling of "impending doom"
 - Admittedly, this latter symptom sounds trite
 - Anecdotally, however, it is surprisingly common
 - Less common signs include:
 - Dysphagia
 - Hoarseness, or occasionally stridor
 - Neck swelling
 - Stroke
- Presentation can also include:
 - Coronary dissection (hence the EKG changes)
 - Rupture/cardiac tamponade
 - Malperfusion syndromes (mesenteric ischemia, limb ischemia, neurologic deficit)
- Surgery usually required for ruptured/leaking aneurysms
 - And considered for subclinical aneurysms ≥ 6 cm
 - Descending aorta aneurysms may be amenable to intravascular stenting
 - Either way, time is of the essence: rapid diagnosis and intervention essential

Aortic Transection/Blunt Aortic Injury

- High-velocity blunt chest trauma with rapid deceleration

- Typically distal to left-subclavian artery (aortic isthmus)
- CXR findings:
 - Left apical cap (pleural blood superior to left lung)
 - Widened mediastinum
 - Hazy aortic knob
 - Left hemothorax
 - Left main stem bronchus displaced
 - Nasogastric tube deviated towards right
 - Tracheal deviation towards right
 - Right mainstem bronchus deviation downwards
 - Widened left paravertebral stripe
- Diagnosis: chest CT angiogram
- Injury classification
 - Type I: Intimal tear
 - Type II: Intramural hematoma
 - Type III: Pseudoaneurysm
 - Type IV: Rupture
- Type I treated medically
- Type II-IV repaired with stenting or surgery
- Increasingly, endovascular (a.k.a. stenting) repair is performed, reducing need for open thoracic repair via thoracotomy
- You can commonly delay that repair if the patient is hemodynamically-stable
 - Without increased risk of rupture

Complications of aortic surgery:

- Includes all of those mentioned following CABG surgery, and also:
- Graft infection
 - Complex problem! Reoperation is high risk!
 - Especially if an aorto-enteric fistula occurs
 - e.g. an anastomotic leak after esophagectomy with aortic inflammation/rupture
- Paralysis (paraplegia)
 - Occurs in descending thoracic aortic surgery (3-4%)
 - Because the aorta provides direct blood supply to the spinal column via segmental arteries
 - Artery of Adamkiewicz is the largest segmental artery (although substantial anatomic variability)
 - Intercostal artery re-implantation and lumbar CSF drainage may be protective- but it is often too late!
- Vocal cord paralysis possible with aortic arch surgery (left recurrent laryngeal nerve injury/transection)
- Death
 - 5-10% die after aortic graft surgery
 - Type A aortic dissection mortality risk is 30%

Valve Surgery

- Valves may be repaired or replaced for failure (regurgitation, stenosis, or infection)
- Most common causes of failure (based upon valve) is:
 - Chronic calcification and degeneration (aortic valve)
 - Chronic rheumatic disease (mitral and aortic valves)
 - Myxomatous disease (mitral valve)
- Systemic causes include
 - Carcinoid syndrome or infectious endocarditis
 - Mechanical failures (e.g. dilatation or papillary muscle rupture)
 - Tricuspid valve infections are most common in intravenous drug users
- Valves can be replaced with tissue (biologic) or mechanical (pyrolytic carbon):
 - Tissue: bovine pericardial, porcine or cadaveric human (homograft)
 - Homograft useful for extensive aortic valve endocarditis with root abscess/significant tissue destruction
 - Mechanical
 - Require life-long anticoagulation (typically acetylsalicylic acid and warfarin)
 - Most common is a bileaflet tilting disc design
 - “Tissue” valves typically last 10-15 years - generally less in younger patients
- Trans-catheter aortic valve implantation/replacement (TAVI/TAVR); balloon aortic valvuloplasty (BAV)
 - An option for frailer patients
 - BUT given its new-ness there is less experience
 - TAVI/TAVR
 - Transfemoral or transapical approach
 - Minimally invasive: less anesthesia; less recovery time
- Complications of valve surgery mirror those following CABG surgery, but also include:
 - Early valve failure
 - Hematoma or suture dehiscence
 - Perivalvular leak
 - Infective endocarditis
 - Both early or late
 - Persistent anatomical disruption of the valve
 - I.e. Annular dilatation of the aortic root
 - Resulting in valve insufficiency
 - Death
 - Approximately 1-in-50 mortality risk after aortic valve surgery

Surgical Pearl:

Native valve endocarditis - indications for consideration of early surgery

- Congestive heart failure from severe aortic/mitral valve regurgitation, or obstruction by vegetation
- Severe pulmonary hypertension
- Paravalvular abscess, fistula tract formation, heart-block
- Recurrent embolism of vegetations
- Vegetations likely to embolize (i.e. >15mm, or >10mm with at least 1 embolic event)
- Transient ischemic attack or stroke
 - Conversely, cerebral haemorrhage leads to surgical delay: because of the risk of further hemorrhage (due to anticoagulation for surgery)
- Relapsing or persistent systemic sepsis (prolonged fever / bacteremia > 7 days)
- Sepsis caused by aggressive or resistant organisms (e.g. *S. Aureus*, meticillin resistant *S. Aureus*, *Brucella*, *S. Lugdunensis*, *Pseudomonas aeruginosa*, Q fever, vancomycin resistant enterococci, fungi)

Bibliography

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The Regina Qu'Appelle Health Region is seeking team-oriented and professional specialist to join our dynamic and expanding department. The specialist will join our team of twelve internal medicine specialists, in a community based, fee-for-service internal medicine practice.

General Internal Medicine Opportunity:

Our internists have admitting and consulting privileges and provide service at our two acute care sites (Regina General Hospital and Pasqua Hospital). The Regina Qu'Appelle Health Region is dedicated to learning and is a partner in the growing educational needs of medical students and residents from the College of Medicine, University of Saskatchewan.

Qualifications:

Successful candidates will hold certification or be eligible for certification from the Royal College of Physicians and Surgeons of Canada and be eligible for provisional or regular licensure. In accordance with immigration requirements, preference will be given to Canadian citizens and permanent residents of Canada.

For information or to submit a CV, please contact:
Kimberly Merk Phone 306.766.0743
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