

Assessment Points				
System	Effect	Assessment by Hx	PE	Test
HEENT	Otitis Retinitis Conjunctivitis	Ear symptoms may affect 30%	Mucosal congestion	
RESP	Tracheobronchitis Pneumonia Asthma	Failure to respond to treatment with sulfonamide or penicillin	Persistent cough Expiratory wheezes	CXR Sputum
CV	Pericarditis Pericardial effusion Cardiac tamponade Myocarditis	Incidence 1–8.5% Approximately 50% will develop cardiac symptoms within 16 mo of <i>M. pneumonia</i> infection	Distant heart sounds S ₃ , JVD Pericardial rub	ECG, ECHO Tap effusion
CNS	Aseptic meningitis Meningoencephalitis Transverse myelitis Guillain-Barré Peripheral neuropathy Cerebellar syndrome	Incidence 7% Children more likely to die or have severe neurologic deficits	Focal or general neuro symptoms, diplopia, coma	CSF Elevated cytokines IL-6, IL-8 MRI Serology
HEME	Hemolytic anemia Cold agglutinins DIC	More common in children Likely due to cross reactive antibodies	Peripheral cyanosis	IgG Free Hgb Coombs
DERM	Maculopapular Vesicular rash Stevens-Johnson syndrome	May affect up to 25%	Rash, but needs to rule out rash due to antibiotics	<i>M. pneumonia</i> has been detected in cutaneous lesions
RENAL	Glomerulonephritis Tubulointerstitial nephritis IgA nephropathy Paroxysmal cold Hemoglobinuria	Brisk hemolytic anemia		UA Renal biopsy IgG, IgM, IgA

Key Reference: Waites KB, Balish MF, Atkinson TP: New insights into the pathogenesis and detection of *Mycoplasma pneumonia* infections. *Future Microbiol* 3(6):635–648, 2008.

Perioperative Implications

Preoperative Preparation

- Routine physical examination: Emphasis on respiratory, CNS, CV, and HEME systems
- Respiratory: Increased minute ventilation, low saturation; prolonged ventilation may be required.
- CNS: Document preexistent neuropathy.
- CV: JVD; rule out tamponade physiology.
- HEME: Hemolysis and anemia. If cold agglutinins are suspected, determine temperature range and titers.

- If surgery is nonurgent, consider postponing it until active issues resolved.

Monitoring

- Invasive monitoring necessary if respiratory and CV concerns

Airway

- Desaturation is possible due to decreased FRC
- High incidence of hyper-reactive airway disease

Maintenance

- Normothermia is essential to avoid cold agglutinins. Warm all fluids and humidify airway.
- If hemolysis develops: Optimized UO, alkalized urine, and use diuretics.

Extubation

- Clear mental status, good respiratory mechanics, able to clear secretions

Anticipated Problems/Concerns

- Respiratory distress secondary to asthma, COPD, high O₂ requirements may result in prolonged intubation.
- Neurologic deficit may delay extubation.
- CPB/cold agglutinins may result in circuit obstruction and impair myocardial protection.

Myelomeningocele

Marla B. Ferschl | Mark D. Rollins

Risk

- Incidence in USA: 1.7–10:10,000 live births.
- 70,000–100,000 individuals with myelomeningocele living in USA.
- Central Asian and Latin American countries have the highest incidence.
- Risk of myelomeningocele is 20 times higher in subsequent pregnancies.
- Reduced dietary folic acid, as well as antiepileptic medication exposure (valproic acid, carbamazepine), in early pregnancy also increases risk.

Perioperative Risks

- Fetal surgery:
 - Intraop fetal distress/demise.
 - Preterm labor/delivery.
 - Risk of nonobstetric surgery during pregnancy.
 - Maternal hemorrhage.
 - Chorioamnionitis.

- Uterine dehiscence; all future pregnancies require delivery by cesarean.
- Neonatal surgery:
 - Infection.
 - Apnea.
 - Hemorrhage and insensible fluid losses.

Worry About

- Fetal surgery:
 - Intraop fetal monitoring
 - Fetal stress and movement during repair
 - Intraop fetal distress/demise and need for resuscitation
 - Inadequate uterine relaxation
 - Maternal pulm edema
 - Maternal postop pain control
- Neonatal surgery:
 - Meningitis/sepsis if not closed within 72 h after birth

- Latex exposure
- Apnea, vocal cord paresis, or swallowing difficulties with the Chiari II malformation

Overview

- Failure of neural tube to close in third to fourth wk of gestation.
- Results in herniation of the nerve roots, meninges, and CSF in a fluid-filled sac.
- Most frequently occurs in lumbar or sacral portion of spinal cord but can occur anywhere along length of cord.
- Pts most often have loss of sensation and motor function below the level of the lesion.
- Bowel and bladder incontinence is common; pts require clean intermittent urinary catheterization to fully evacuate their bladder and avoid chronic renal disease.
- Hydrocephalus is a frequent complication. 85–90% of pts require ventriculoperitoneal shunting; shunts

- carry lifelong morbidity because they can malfunction or become infected.
- The Chiari II malformation, which includes a small posterior fossa, as well as downward displacement of the medulla, cerebellum, and fourth ventricle into the spinal canal, is present in the majority of pts. This manifests as
 - Headache and/or neck pain.
 - Irregular breathing or periods of apnea.
 - Swallowing difficulties.
 - Vocal cord paresis.
- Tethered cord is also a common finding and should be suspected when progressive deterioration in motor or bowel/bladder function is noticed.

- Intelligence is often low normal, and many pts with myelomeningocele have learning disabilities.

Etiology

- Due to failure of primary neurulation
- Due to a variety of genetic, environmental, and/or intrauterine exposures
- Severity worsened by intrauterine exposure of neural tissues to amniotic fluid

Usual Treatment

- Postnatal repair: Closure of the neural tube and overlying skin within 72 h after birth
- Prenatal repair: Available at specialized fetal treatment centers worldwide

- Prenatal treatment occurs during the second trimester (19–26 wk gestational age) and involves a maternal general anesthetic for laparotomy, hysterotomy, and fetal repair. In addition, fetal resuscitation drugs are available, intraop fetal monitoring is used, and intramuscular opioids and muscle relaxants are typically provided to the fetus.
- Prenatal repair may prevent further neural tissue damage and reduce the incidence of hydrocephalus requiring a ventriculoperitoneal shunt. A multi-institutional RCT has noted benefit to prenatal repair.

Assessment Points

System	Effect	Assessment by Hx	PE	Test
HEENT	Hydrocephalus Increased IOP Vocal cord paralysis	Headache Choking	Increased head circumference Papilledema Vocalization	Ultrasound MRI Fiberoptic bronchoscopy
RESP	Aspiration pneumonia OSA Restrictive lung disease	Cough Fever Snoring, apnea	Tachypnea, hypoxia Lung field consolidation Scoliosis	CXR and hypoxia Polysomnography Spine radiographs, measurement of Cobb angle
CV	ASD/VSD Critical CHD	Dyspnea	Murmur Crackles Cyanosis	Antenatal or postnatal ECHO
GI	Bowel incontinence, constipation	Constipation	Abd distention	Abdominal imaging
CNS	Hydrocephalus Chiari II malformation Tethered cord Cognitive delay Loss of sensory and motor function below level of lesion	Headache, irritability Headache, back pain, scoliosis	Increasing head circumference, papilledema Diplegia Worsening sensory or motor function	Head ultrasound, MRI demonstrating ventriculomegaly, downward displacement of hindbrain MRI spine Neurocognitive testing Neurologic exam
RENAL	Neurogenic bladder	Bladder incontinence		Serum creatinine level Renal and bladder US
MS	Kyphosis, scoliosis Club feet		Scoliosis, compromised cardiac and pulm function. Feet turned inward	Spine radiographs, measurement of Cobb angle Lower extremity radiographs

Key References: Sandler AD: Children with spina bifida: key clinical issues. *Pediatr Clin North Am* 57(4):879–892, 2010; Ferschl MB, Ball R, Lee H, et al.: Anesthesia for in utero repair of myelomeningocele. *Anesthesiology* 118(5):1211–1223, 2013.

Perioperative Implications

Preoperative Preparation

- Fetal surgery:
 - Maternal history and physical exam.
 - Fetal workup (MRI, ECHO) to exclude other anomalies and determine fetal weight and lesion location.
 - Maternal lumbar epidural (L2-3) placed and test-dosed.
 - Maternal premedication with a nonparticulate antacid and rectal indomethacin for tocolysis.
 - Preparation of maternal and fetal blood products; fetal blood must be type O-negative, irradiated, leukocyte depleted, CMV negative, and cross-matched against the mother.
- Neonatal surgery:
 - Birth history and physical exam.
 - Cardiac evaluation (antenatal or postnatal) to exclude concurrent congenital heart disease.
 - Preparation of type-matched and cross-matched blood products.

Monitoring

- Fetal surgery:
 - Large-bore peripheral IVs ± arterial line.
 - Continuous fetal monitoring with ultrasound.
- Neonatal surgery:
 - Standard ASA monitors ± arterial line.
 - Consider preductal and postductal oxygen saturation monitoring.

Airway

- Fetal surgery:
 - Rapid-sequence intubation with succinylcholine.

- Neonatal surgery:
 - Endotracheal intubation required.
 - Pts with a Chiari II may have more pronounced vagal tone; consider atropine pretreatment before direct laryngoscopy.

Preinduction/Induction

- Fetal surgery:
 - Left uterine displacement preinduction.
 - Confirm fetal well-being preinduction.
 - Fetal medications prepared and transferred to scrub nurse in sterile fashion (rocuronium 2–3 mg/kg + fentanyl 10 mcg/kg, epinephrine 10 mcg/kg, atropine 20 mcg/kg).
 - Prepare neonatal resuscitation equipment if there is a plan for delivery in the event of fetal distress.
- Neonatal surgery:
 - Consider lateral positioning or supine positioning on a foam donut to avoid pressure on myelomeningocele sac during intubation.
 - IV or inhalational induction appropriate; consider nondepolarizing muscle relaxant.
 - Latex-free OR environment to avoid sensitization.

Maintenance

- Fetal surgery:
 - High-dose volatile agent for adequate uterine relaxation (2–3 MAC); may consider supplemental IV anesthesia with remifentanyl/propofol and also administration of IV nitroglycerin infusion if uterine tone remains high
 - Use of vasoactive medications (phenylephrine, ephedrine, glycopyrrolate) to maintain maternal blood pressure within 10% of baseline

- Restrict IV fluids to <2 L to avoid maternal pulm edema
- Load magnesium 4-6 g IV once uterine closure begins for tocolysis
- Discontinue volatile agents once magnesium load is complete; continue 1-2 g/h magnesium following load; activate epidural
- Neonatal surgery:
 - Volatile anesthetic agent titrated appropriately; MAC requirements less in the neonate
 - IV opioids titrated for analgesia
 - Use of dextrose-containing IV fluids to maintain normoglycemia
 - Meticulous attention to temperature to avoid hypothermia, with use of warm ambient room temperature, forced air warming blankets, and/or radiant warmers

Extubation

- Fetal surgery:
 - Carefully assess for residual neuromuscular blockade if nondepolarizing medications are given to the mother because magnesium potentiates blockade.
 - Extubate once fully awake.
- Neonatal surgery:
 - Consider postop intubation because pts are at risk for postop apnea due to their age, as well as for the Chiari II malformation.
 - If intraop extubation is planned, make sure pt is fully awake with regular breathing pattern.

Postoperative Period

- Fetal surgery:

- Continued monitoring of uterine activity and fetal HR.
- Pt-controlled epidural analgesia.
- Neonatal surgery:
 - Pt should avoid supine position for 14 d.
 - Carefully titrate opioids with continuous monitoring in intensive care setting.

Anticipated Problems/Concerns

- Fetal surgery: Delivery for this and future pregnancies requires cesarean section due to high risk of uterine rupture.
- Neonatal surgery: Pt may require concurrent placement of ventriculoperitoneal shunt at time of surgery

or may require shunt placement at a later date if head circumference continues to enlarge.

Myocardial Contusion (Blunt Cardiac Injury)

Andrew L. Rosenberg

Risk

- Incidence unknown, in part due to absence of clear diagnostic criteria/test
- 2 million motor vehicle accidents/y, with ~40% involving closed chest injury
- 20–70% incidence by clinical criteria
- 16–20% incidence by autopsy
- Motor vehicle > falls > crush injuries
- Males > females (5:1)
- Commotio cordis a rare form of BCI due to low impact chest injury (sports) causing sudden death

Perioperative Risks

- Abnormal ECG
- Nonspecific ST-T wave changes (70% of trauma pts)
- Q-wave and ST-segment elevation
- 7–17% false negative
- 60% false positive
- Ventricular arrhythmias, most common in cases of contusion
 - Trifascicular conduction block.
- Other cardiac conditions: Thrombosed or lacerated coronary arteries in spasm, ventricular hypofunction, pericardial effusion/tamponade, pericarditis, valvular

- insufficiency (left-sided > right), ventricular wall rupture (including septum)
- Possible increased risk of cardiac complications (arrhythmias, hypotension) with increased CK-MB troponins and abnormal ECHO
- No evidence of increased mortality assoc with GA

Worry About

- Malignant ventricular arrhythmia (acute and delayed)
- Cardiac conduction blocks include complete heart block
- Hemopericardium
- Volume status
- Acute hypotension
- Delayed myocardial rupture
- Associated injuries: Pulm contusion, hypoxemia, injuries to the thoracic aorta, flail chest
- Attribution of hemodynamic instability to myocardial contusion versus occult hemorrhage elsewhere

Overview

- Traumatic injury with hemorrhagic, well-circumscribed lesions of partial or full thickness from myocardial contusion.

- Usually affecting the RV but can be multichambered.
- BCI frequently seen in severe blunt chest trauma and after CPR and precordial thumps, but difficult to definitively diagnose.
- Incorporation of clinical suspicion, anginal chest pain unrelieved by nitrates, ECG—especially ventricular dysrhythmia, CK-MB, troponin I and T levels; 2D ECHO for Dx.
- Amount of malignant arrhythmias may be proportional to the severity of myocardial contusion.

Etiology

- Mechanical contusion of myocardium from posterior sternum.
- Ram effect from increased transdiaphragmatic pressure or sudden deceleration.
- Automobile accident most common cause, representing ~15% of cases.
- Falls ~10%.
- Crash, sports-related assaults ~15%.

Usual Treatment

- Supportive
- Adequate volume replacement

Assessment Points

System	Effect	Assessment by Hx	PE	Test
CV	Ventricular contusion	Angina-like chest pain unrelieved by nitrates Dyspnea	Chest wall, sternal tenderness Hypotension with severe dysfunction S ₃ Rales	Serial ECG Increased troponin I and T within 6 h ECHO SPECT MRI
	Arrhythmia Valvular disruptions Coronary artery injury: thrombosis, laceration, spasm Effusion/tamponade	Palpitations, dizziness, syncope Dyspnea Chest pain Chest pain	Pulse Auscultatory murmurs Pericardial friction Diminished heart sounds Distended neck veins	ECG monitoring ECG Angio TTE 2D cardiography PA catheter
RESP	CHF Pulm contusion	Dyspnea Orthopnea Chest tightness	S ₃ Rales Wheezing Tachypnea	CXR O ₂ saturation

Key References: Clancy K, Velopoulos C, Bilaniuk JW, et al.: Screening for blunt cardiac injury: an Eastern Association for the Surgery of Trauma practice management guideline, *J Trauma Acute Care Surg* 73(5 Suppl 4):S301–S306, 2012; Moore EE, Malangoni MA, Cogbil TH, et al.: Organ injury scaling. IV: thoracic vascular, lung, cardiac, and diaphragm, *J Trauma* 36(3):299–300, 1994.

Perioperative Implications

Preoperative Preparation

- FAST is usual first imaging and diagnostic choice to rule in/out pericardial effusion (hemopericardium being the major concern).
- 2D ECHO or abnormal TEE predict periop hypotension and/or valve/septum disruption.
- Assess volume and ensure adequate volume replacement.
- Assess and treat associated concurrent injuries.
- No evidence for benefit of prophylactic antiarrhythmic agents.
- The Cardiac Injury Scale (American Association for Surgery of Trauma) may be useful for quality scoring, research purposes, and objective measures.

Monitoring

- Continuous ECG for arrhythmias.
- Consider PA cath for large fluid shift operations or pts with signs of LV dysfunction.
- Increased risk of periop arrhythmias without increased mortality.

Airway

- Evaluate for associated airway injury.

Preinduction/Induction

- Adequate volume replacement.
- Hypotension more likely with large contusions; avoid cardiodepressant induction agents.

- Extra attention to avoid hypoxia; care required with increased mean airway pressure ventilator strategies (e.g., PEEP).

Maintenance

- No one agent or technique shown to be superior.
- Avoid known pulm vasoconstrictors: catecholamine, hypoxia, acidosis, histamine-releasing agents (MgSO₄, mivacurium).
- Consider high inspired O₂ if there is a contusion.
- NO can aggravate pulm Htn.
- Elevations in PVR may unmask RV failure.
- Increased LV filling pressures and decreased cardiac output often reflect hypovolemia or are secondary to RV failure, not LV failure.