- Respiratory failure may require NM paralysis in addition to sedation for effective PPV in the presence of severe spasms.
- Autonomic instability: Tachycardia, bradycardia, Htn, hypotension, arrhythmias, cardiac failure, and repeated cardiac arrest.
- Pneumonia, sepsis, myoglobinuria, pulm embolism, bony fractures, and hyperthermia.

Overview

- Infection of penetrating wounds or devitalized tissue with spores of anaerobic gram-positive bacillus *Clostridium tetani*; enters the CNS via peripheral nerves and spreads via retrograde intraneuronal transport to disable inhibitory pathways in the spinal cord and brain (glycine and GABA).
- CNS disinhibition characteristically begins with spasms of the masseter muscles ("risus sardonicus," lockjaw) and progresses to involve rest of the body, including spasms of respiratory muscles ("respiratory convulsions") that cause glottic spasm, airway obstruction, hypoxia, and respiratory failure.
- Autonomic instability is a hallmark of the disease and may cause fatal cardiac arrest.
- Initial injury may be insignificant or unnoticed by the pt.
- Neonatal tetanus typically presents 6–8 d after birth with trismus and inability to feed.
- Tetanus may follow surgery (usually intraabdominal or on contaminated tissues), burns, gangrene, dog bites, chronic infection, parenteral drug use, dental infection, abortion, and childbirth.

Etiology

- Infection of penetrating wound or devitalized tissue by spores of anaerobic, gram-positive bacillus *Clostridium tetani*; they proliferate and produce a potent exotoxin, tetanospasmin.
- Tetanospasmin is taken up by motor nerve endings and spreads to other neurons in skeletal muscle, the spinal cord, and brain, where it principally inactivates inhibitory interneurons in glycinergic and gamma-aminobutyric acid pathways.

Usual Treatment

- Neutralize circulating toxin with IV human antitetanus globulin.
- Eradication of the organism by wound care, surgical debridement, and antimicrobial therapy.
- High-dose metronidazole or penicillin G (erythromycin if penicillin allergy) therapy IV for 10 d is effective at eradicating spores and bacilli.
- Control muscle spasms by sedation, other muscle relaxants, and NM paralysis.
- Magnesium may control spasms and autonomic disturbances in mild cases, but has no beneficial effect on mortality compared to diazepam, which is considered the standard of treatment.
- Supportive therapy, including ventilatory support, treatment of autonomic instability, nutritional support, prophylaxis of DVT, and prevention of nosocomial infection, particularly ventilator-associated pneumonia.

Assessment Points

System	Effect	Assessment by Hx	PE	Test
HEENT	Laryngospasm and glottic obstruction	Dyspnea, noisy breathing	Stridor, retractions of accessory muscles, limitation of mouth opening and ROM of neck	
CNS	Generalized or localized muscle rigidity and spasms	Dysphagia, drooling, spasms	Opisthotonus, trismus, "risus sardonicus," onset of spasms with minimal stimuli, bony fractures	
CV	Cardiac failure, myocarditis, arrhythmias, Htn, hypotension, cardiac arrest	SOB, palpitations	Episodic fluctuations in BP, heart rate; arrhythmias, signs of cardiac failure	ECG, ECHO
RESP	Hypoventilation, apnea, respiratory failure, pneumonia	Dyspnea	Hypoventilation, limited chest excursions, decreased breath sounds, rhonchi, cyanosis	ABG, CXR
RENAL	Rhabdomyolysis	Pink or red urine	Hematuria	US, serum CK

Key References: Rodrigo C, Fernando D, Rajapakse S: Pharmacological management of tetanus: an evidence-based review, *Crit Care* 18(2):217, 2014; Rodrigo C, Samarakoon L, Fernando SD, et al: A meta-analysis of magnesium for tetanus. *Anaesthesia* 67(12):1370–1374, 2012.

Perioperative Implications

Preinduction/Induction/Maintenance

- Adequate sedation with benzodiazepines to control spasms; muscle relaxants may be necessary.
- Minimize environmental stimuli.
- Difficult airway or intubation: Consider fiberoptic intubation.
- Avoid pancuronium and desflurane (sympathetic stimulation).
- Resistance to multiple nondepolarizing agents has been described.

Monitoring

- ECG for dysrhythmias
- Echocardiography (CV decompensation)
- Arterial line for continuous BP measurement and arterial blood gas measurement
- NM monitoring with nerve stimulator

General Anesthesia

- Magnesium sulfate may be useful in controlling spasms, decreasing autonomic instability, and decreasing the requirements for sedative drugs.
- Watch for S-T segment and T-wave changes that may indicate toxic myocarditis.
- Hypotension and bradycardia may be indicative of brainstem involvement and a poor prognosis.
- Elective tracheostomy recommended for long-term ventilator support and pulm toilet.
- Consider pulm embolism in the event of sudden decompensation during anesthesia.
- Maintain alkaline diuresis in the event of myoglobinuria.

Regional Anesthesia

- Consider adding epidural anesthesia for autonomic hyperreactivity.

Postoperative Period

- Endotracheal intubation or tracheostomy is needed for assisted ventilation on ICU with sedation and NMBs.
- Benzodiazepines, magnesium sulfate, opioids, clonidine, and intrathecal baclofen may help control spasms; magnesium also decreases autonomic instability and the need for sedation.
- Nutritional support via enteral or parenteral feeding.
- DVT prophylaxis to prevent pulm embolism.

Anticipated Problems/Concerns

- Sudden CV instability or cardiac arrest may occur.
- Propranolol, labetalol, and phentolamine are assoc with increased risk of cardiac arrest.
- Mortality in US averages about 10%, rising to 50% in pts >60 y of age.
- Abnormal neurologic findings may persist for up to 2 y following recovery.

Tetralogy of Fallot

Sarah Deverman

Risk

- Occurs in 4-5:10,000 live births (1:2,000–2,500)
- Most common cyanotic CHD (10% of all CHDs)
- Occurs equally in males and females

Perioperative Risks

- If unrepaired, tet spells can lead to RVH, RV failure, and death (50% in first year of life).
- Mortality after TOF repair: 5–8% in first 2 y postrepair (if uncomplicated anatomy).
- Increased mortality if coexisting PA hypoplasia, atresia, or major AP collaterals.

Worry About

- Increased R-to-L shunt from decreased SVR or increased PVR
- Crying and agitation leading to tet spell leading to more hypoxemia, hypercarbia, acidosis
- Air bubbles in IV tubing
- Polycythemia and assoc thrombocytopenia
- RV failure after inadequate or late repair
- Arrhythmias following repair

Overview

- Anatomy:
  - RVOT obstruction: Infundibular narrowing, pulm stenosis, PA hypoplasia, pulm atresia.
  - VSD: Large, unrestrictive.
  - Overriding aorta.
  - RV hypertrophy.

- 5–12% have anomalous origin of LAD from RCA and cross the RVOT inferiorly. Must confirm prior to OR.
- 25% have right aortic arch.
- Severity of symptoms correlates with degree of RVOT obstruction, as this determines the degree of R-to-L shunting.
  - RVOT obstruction has fixed components (degree of infundibular obstruction, size of pulm valve annulus, size of PA) and dynamic components (infundibular muscle bundle spasm, PVR, SVR).
- Fixed factors determine amount of chronic cyanosis.
- Dynamic factors determine tet spells.
- Pink tets have minimal amount of PS.
- Avoid hypoxia, acidosis, high airway pressures, excitement, and agitation.
- Dx by ECHO, cardiac cath, and/or MRI.
- Associated with chromosome 22 deletions and diGeorge syndrome, VACTERL, CHARGE, and velocardiofacial syndrome.

Usual Treatment

- Primary repair: Usually done at 3–12 mo
- If not immediately operable (low birth weight, prematurity, other disease processes), palliative shunts to increase pulm blood flow (Blalock-Taussig shunt, aortopulmonary shunts)
- Beta-blockers to decrease infundibular spasm and spelling
- Treatment for tet spell:
  - 100% O_2 (pulm vasodilator)
  - Sedation (morphine/fentanyl)
  - Increased SVR (squatting, phenylephrine)
  - Propranolol (decreased contractility of infundibulum; decreased RVOTO)
  - Bicarbonate to correct metabolic acidosis

Assessment Points

System	Effect	Assessment by Hx	Test
GENERAL		FTT, clubbing	Growth charts
CHEST	RVH	Signs of right heart failure	CXR with boot-shaped heart
CV	See Overview	Frequency and severity of tet spells	ECHO, cath, MRI ECG-RVH, RA
HEME	Polycythemia from chronic hypoxemia Plt count may be low from polycythemia	Chronic cyanosis	Hct, plt count

Key References: Doyle T, Kavanaugh-McHugh A: Pathophysiology, clinical features, and diagnosis of tetralogy of Fallot. In Connolly HM, Triedman JK, Armsby C, editors, Waltham, MA, *UpToDate*, 2016. www.uptodate.com/contents/pathophysiology-clinical-features-and-diagnosis-of-tetralogy-of-fallot. (Accessed 13.06.16.); Schmitz ML: Anesthesia for right-sided obstructive lesions. Tetralogy of Fallot. In Andropoulos DB, editor: *Anesthesia of congenital heart disease*, ed 2, Hoboken, NJ, 2010, Wiley-Blackwell, pp 427–432.

Perioperative Implications

Preoperative Preparation

- Heavy premedication to avoid agitation, crying

Monitoring

- Standard monitors plus radial arterial line, CVP, and TEE

Airway

- Standard oral or nasal intubation

Preinduction/Induction

- Mask induction with sevoflurane and oxygen. Ketamine (1–2 mg/kg) with fentanyl (10 mcg/kg) and rocuronium (1 mg/kg) if IV present. AVOID decrease in SVR.

Maintenance

- Phenylephrine appropriately drawn up and diluted.
- Avoid increase in PVR and decrease in SVR.

Extubation

- Pts are taken to the ICU monitored and intubated.

Anticipated Problems/Concerns

- Intraop tet spells
- Arrhythmias

Thalassemia

Sohail Bampoe | Michelle R. Cole

Risk

- Over 60,000 children are born annually with severe beta-thalassemia.
- Global regions that are primarily affected include the Mediterranean, North Africa, and Southeast Asia, where alpha thalassemia is more common.
- Beta-trait carrier status has a global prevalence of approximately 1.5%.
- Over 200,000 pts are currently receiving treatment for thalassemias.
- In endemic areas with highest frequency, carrier status is present in as many as 1:7 individuals, and thalassemia major can occur in 1:158 live births.

Perioperative Risks

- Abnormal globin chains result in severe anemia (mild microcytic anemia in those with carrier status).
- CHF is the leading cause of death.
- End-organ effects of hemochromatosis from chronic iron therapy: Cardiomyopathy, cirrhosis, endocrinopathies (e.g., diabetes, hypopituitarism).
- Diabetes mellitus is common.
- Restrictive lung dysfunction and pulm Htn.
- Airway difficulties, including maxillofacial abnormality secondary to bone marrow expansion.
- Hypercoagulopathy in asplenic pts, and coagulopathy in pts with cirrhosis.
- Alloimmunization secondary to multiple blood transfusions. Obtaining appropriately cross-matched blood may require prolonged testing.

Worry About

- Difficult airway secondary to maxillary deformation in up to 19%
- Cardiac arrhythmias or HF
- Hypercoagulability
- Pulm Htn
- Immunocompromisation

Overview

- Thalassemia is a heterogeneous group of inherited microcytic anemias that result from a genetic mutation causing a defect in the synthesis of one or more globin chain subunits of the HbA, which is normally composed of $\alpha 2\beta 2$.
- Thalassemia is classified according to the genotype that correlates with clinical severity.
- Alpha thalassemia: Alpha globin gene deletion leads to a decrease in alpha chain production with a relative overproduction of beta chains. This leads to formation of β4 tetramers, which causes RBCs to be more rapidly removed leading to anemia.
- Alpha thalassemia silent carrier: One gene absent (aa/a-); healthy except occasional mild anemia.
- Alpha thalassemia trait: Two genes absent on the same or different chromosomes (a-/a- or aa/--); mild anemia.
- Alpha thalassemia intermedia (Hb H disease): inactivation of three genes (a-/--) leads to a spectrum for manifestations; mild to moderately severe anemia, splenomegaly, icterus, abnormal RBC indices; recurrent infections. Heinz bodies = beta chain tetramers. Hb H disease results in poor oxygen delivery to the tissues due its high affinity for oxygen.
- Alpha thalassemia major (Hb Barts): Complete deletion of all alpha chain genes resulting in the formation of Hb-Bart's, which has an exceptional affinity for oxygen resulting in extremely limited tissue oxygen delivery. Incompatible with life; hydrops fetalis unless intrauterine blood transfusions.
- Beta thalassemia: Decreased beta chain production relative to the alpha chain production as a result of mutation resulting in either absence (beta o) or decrease (beta+) in the production of beta globin. Alpha chains are in excess and precipitate leading to inadequate erythroid maturation and hemolysis. In most severe forms, this leads to splenomegaly, anemia, massive expansion of medullary and extramedullary erythropoietic tissue leading to skeletal growth, and metabolic abnormalities.
- Beta thalassemia is a silent carrier (beta/beta+); it shows no clinical symptoms except for low RBC counts.
- Beta thalassemia trait (beta/beta+) = beta thalassemia minor: Mild anemia, abn RBC indices, hypochromia, microcytosis.
- Beta thalassemia intermedia (beta/beta o, beta+/beta+, beta+/beta o): A compound heterozygous state; profound anemia, which periodically may require transfusion support and occasionally splenectomy.