- High-risk procedure (e.g., open abdominal, thoracotomy, trauma exploratory laparotomy) plus pneumonia; strongly consider prolonged mechanical ventilation.

**Adjuvants**
- Bronchodilator (albuterol).
- Maintain scheduled antibiotic dosing in addition to periop antibiotics.

**Postoperative Period**
- Increased risk for reintubation
- If pt remains intubated, maintain intraop mechanical ventilation settings.

### Anticipated Problems/Concerns
- Increased airway reactivity
- Impaired oxygenation secondary to shunt
- At risk for prolonged mechanical ventilation

# Pneumonia, Ventilator-Associated

Emily J. MacKay

### Risk
- Incidence of VAP is 1.2–8.5:1000 ventilator days; occurs in 9–27% of intubated mechanically ventilated pts
- Risk greatest in the first 5 d of mechanical ventilation
- Increased risk: Male sex; admission for trauma; underlying disease severity; surgery; previous antibiotic exposure

### Perioperative Risks
- Intraop decrease in FRC can worsen the severity of hypoxemia.
- Preop high levels of PEEP can lead to decreased preload and hypotension.

### Worry About
- Atelectasis and derecruitment of alveoli
- Hypoxemia
- Mucus plugging of main or intermediate bronchi

### Overview
- VAP is defined as pneumonia occurring in mechanically ventilated pts 48–72 h after endotracheal intubation.
- Implications of ETT placement:
  - Suppression of cough reflex leading to microaspiration around ETT cuff.
  - Pooling of secretions around cuff.
  - Biofilm coating ETT, including gram-negative and fungal organisms.
  - Impaired mucociliary clearance of secretions.
- Microbiology:
  - Early VAP (≤4 d on ventilator): Organisms usually sensitive to antibiotics.
  - Late VAP (≥5 d on ventilator): Increased risk of organisms resistant to antibiotics.

### Etiology
- Early VAP bacteria:
  - *Streptococcus pneumoniae*
  - *Haemophilus influenzae*
  - MSSA
  - Antibiotic-sensitive enteric gram-negative bacilli: *Escherichia coli, Klebsiella pneumoniae, Enterobacter* spp., *Proteus* spp., *Serratia marcescens*
- Late VAP bacteria:
  - MDR bacteria: MRSA, *Acinetobacter, Pseudomonas aeruginosa,* ESBL
  - Oropharyngeal bacteria: *Streptococcus viridans, Corynebacterium,* coagulase-negative *Staphylococcus, Neisseria* spp.
  - Polymicrobial infection
  - Fungal infection
- VAP pathogen incidence:
  - *P. aeruginosa* (24.4%)
  - *S. aureus* (20.4%; half MSSA and half MRSA)
  - Enterobacteriaceae (14.1%): *Klebsiella. E. coli, Proteus* spp., *Enterobacter* spp., *Serratia* spp., *Citrobacter* spp.
  - *Streptococcus* spp. (12.1%)
  - *Haemophilus* spp. (9.8%)
  - *Acinetobacter* spp. (7.9%)
  - *Neisseria* spp. (2.6%)
  - *Stenotrophomonas maltophilia* (1.7%)
  - Others (4.7%): *Corynebacterium, Moraxella, Enterococcus,* fungi
- MDR organisms' potential mechanisms:
  - *Pseudomonas*
    - Upregulation of efflux pumps (pump antibiotic out).
    - Lower expression of outer membrane porin channel (antibiotic cannot get in).
    - Beta-lactamases (break beta-lactam ring on beta-lactam antibiotics, rendering antibiotic inactive).
  - *S. aureus:* Lower affinity for beta-lactam antibiotics by production of penicillin-binding protein.
  - Enterobacteriaceae: Plasmid mediated production of beta-lactamases that destroy extended-spectrum beta-lactam drugs (ESBLs). ESBLs can also cause crossover resistance to aminoglycosides in addition to extended-spectrum beta-lactams.

### Usual Treatment (Empiric)
- Local antibiogram for hospital is *extremely important* (to show differing incidence of organisms)
- Early-onset VAP (≤4 d): Potentially treat with limited spectrum antibiotics for 8 d.
- Late-onset VAP (≥5 d): Requires broad-spectrum antibiotic for 10–14 d.
- Deescalation is extremely important to limit the development of MDR organisms.
- Antibiotic options for early-onset bacterial VAP (70-kg pt):
  - Monotherapy: Second- or third-generation cephalosporin (e.g., cefuroxime [second], 1.5 g q8h; ceftriaxone [third], 2 g daily; cefotaxime [third], 2 g q8h)
    OR
  - Monotherapy: Fluoroquinolone or levofloxacin, 750 mg daily; moxifloxacin, 400 mg daily
    OR
  - Combination therapy: Aminopenicillin plus beta-lactamase inhibitor (e.g., ampicillin plus sulbactam, 3 g q8h)
    OR
  - Monotherapy: Carbapenem (e.g., ertapenem)
- Antibiotic options for late-onset bacterial VAP (triple therapy required) (70-kg pt):
  - Third- or fourth-generation cephalosporin (e.g., ceftazidime [third], 2 g q8h; cefepime [fourth], 1–2 g q8h)
    OR
  - Carbapenem (e.g., imipenem plus cilastatin 500 mg q6h or 1 g q8h; meropenem, 1 g q8h)
    OR
  - Beta-lactam/beta-lactamase inhibitor (e.g., piperacillin plus tazobactam, 4.5 g q6h)
    PLUS
  - Aminoglycoside (e.g., amikacin, 20 mg/kg per d; gentamicin, 7 mg/kg per d; tobramycin, 7 mg/kg per d)
    OR
  - Antipseudomonal fluoroquinolone (e.g., ciprofloxacin, 400 mg q8h; levofloxacin: 750 mg daily)
    PLUS
  - Coverage for MRSA (e.g., vancomycin, 15 mg/kg q12h; linezolid, 600 mg q12h)

### Assessment Points

| System | Effect | Assessment by Hx | PE | Test |
|---|---|---|---|---|
| RESP | Tracheobronchitis<br>Pneumonia | Cough: Productive<br>Ventilator-dependent respiratory failure, fever, increased WBC | Inspiratory wheeze<br>Focal or nonfocal crackles on lung auscultation | CXR, endotracheal aspirate<br>CXR, endotracheal aspirate, bronchoalveolar lavage |

**Key References:** Kalanuria AA, Zai W, Mirski M: Ventilator-associated pneumonia in the ICU, *Crit Care* 18(2):208, 2014; Futier E, Constantin JM, Paugam-Burtz C, et al.: A trial of intraoperative low-tidal-volume ventilation in abdominal surgery, *N Engl J Med* 369(5):428–437, 2013.

### Perioperative Implications

**Preoperative Preparation**
- Intubated pt
- Assess mechanical ventilation settings in the ICU; if PEEP ≥10 cm $H_2O$ utilize ICU ventilator for transport and intraop.
- Consider having inhaled nitric oxide or epoprostenol available.
- Ensure that appropriate antibiotic therapy is initiated for VAP (especially if MDR organisms suspected).

**Monitoring**
- Arterial line for serial blood gas analysis.
- Consider central line.

**Airway**
- Ensure that ETT is secure.
- Suction ETT.

**Induction**
- With ETT already in place, proceed cautiously with inhalational induction.

### Maintenance
- Inhalational anesthesia has benefit of bronchodilation.
- Maintain protective lung ventilation strategy intraop (i.e., tidal volume of 6–8 mL/kg ideal body weight, PEEP ≥5 cm $H_2O$, maintain plateau pressure <30 cm $H_2O$)
- Limit intraop IV fluids.

### Extubation
- Intubated preop VAP pt; low threshold for ongoing mechanical ventilation.
- If considering extubation:
  - Rapid shallow breathing index <75 breaths/tidal volume (L) per min
  - Vital capacity >15 mL/kg ideal body weight
  - If arterial line available, $PaO_2$ >80 mm Hg on an $FiO_2$ <40%

### Adjuvants
- Bronchodilator (albuterol).
- Inhaled nitric oxide.
- Inhaled epoprostenol.
- Maintain scheduled antibiotic dosing in addition to periop antibiotics.

### Postoperative Period
- If intraop mechanical ventilation settings do not require high levels of PEEP, transport pt with oxygen and ambu bag with PEEP valve.
- If intraop mechanical ventilation settings are complex, transport pt with ICU ventilator.
- If ICU ventilator was utilized intraop, transport pt with ICU ventilator.

## Anticipated Problems/Concerns
- Impaired oxygenation secondary to shunt
- Hemodynamic instability
- Impaired RV function in the setting of high PEEP or increased PVR

# Poliomyelitis

David P. Martin | Luke Van Alstine

## Risk
- Acute disease eradicated in USA and most of Europe owing to effective vaccination (last USA case reported in 1979 and last case in the western hemisphere in Peru in 1991).
- Small parts of Africa and Asia still have areas of endemic wild-type poliovirus with less than 200 cases reported globally in 2014.
- Hundreds of thousands of survivors still live in USA with varying degrees of deficit.
- Postpolio syndrome is a constellation of signs and symptoms that constitute a synergy between normal aging and the decreased neuromuscular reserve and musculoskeletal effects of polio itself.

## Perioperative Risks
- Potential predisposition to respiratory complications (such as aspiration and postop respiratory failure), chronic pain syndromes, altered sensitivity to muscle relaxants and anesthetics, and positioning challenges.
- Hyperkalemia with succinylcholine is a risk if there is significant muscle denervation.

## Worry About
- Weakness of the pulmonary or swallowing muscles, which are believed to be at greatest risk for postsurgical complications.
- Polio survivors often underestimate or minimize their degree of weakness.
- Postpolio syndrome may predispose pts to respiratory difficulties, sleep apnea, swallowing impairment, and impaired ability to deal with temperature changes.

## Overview
- Caused by the poliovirus, a subtype of the human enterovirus C group.
- The virus is transmitted most commonly via fecal-oral contamination but can also be transmitted by pharyngeal spread during outbreaks.
- Most infected individuals are asymptomatic (primary or "minor" viremia) but a small percentage (<10%) will go on to develop a "major" viremia characterized by the typical viral symptoms ranging from malaise to fever and nausea/vomiting. A fraction of these individuals (<1%) will develop selective destruction of motor neurons, leading to weakness (paralytic polio).
- Weakness is often asymmetric and varies from one muscle group to another.
- The virus can also affect other neurons, including the brain stem, which can lead to respiratory insufficiency and bulbar dysfunction.
- Bulbar involvement can include dysphagia, dysarthria, and difficulty controlling secretions.

## Etiology
- Spread of poliovirus to the CNS is not well understood. It can spread laterally to other neighboring motor neurons and/or via transneuronal spread through the axon.

## Usual Treatment
- Treatment is supportive, ranging from mechanical ventilation for respiratory failure to pain management and physical therapy.
- Many pts deal with long-term sequelae, from chronic weakness and pain to potential development of postpolio syndrome later in life, for which treatment is again supportive.

## Assessment Points

| System | Effect | Assessment by Hx | PE | Test |
|---|---|---|---|---|
| HEENT | OSA | Snoring<br>Daytime somnolence | Neck circumference<br>Htn | Sleep study |
| RESP | Respiratory failure<br>Aspiration risk | Dyspnea<br>Pneumonia | Tachypnea | CXR, PFTs<br>ABG |
| CNS | Muscle denervation<br>Bulbar weakness<br>Opioid tolerance | Difficulty swallowing | Weakness | EMG<br>Swallow study |
| MS | Weakness<br>Disability<br>Chronic pain | Gait<br>Mobility aids | Joint contractures<br>ROM | Radiographs |

**Key References:** Jubelt B: Polio and infectious diseases of the anterior horn. In Shefner JM, editor. Waltham, MA, 2016, *UpToDate*. www.uptodate.com/contents/polio-and-infectious-diseases-of-the-anterior-horn. (Accessed 01.06.16.); Van Alstine LW, Gunn PW, Schroeder DR, et al.: Anesthesia and poliomyelitis: a matched cohort study, *Anesth Analg* 122(6):1894–1900, 2016.

## Perioperative Implications

### Preoperative Preparation
- Thorough preop physical and exam looking for signs/symptoms of respiratory insufficiency, bulbar dysfunction, OSA, chronic pain, or neurologic deficits.
- Consider PFTs if respiratory insufficiency is known preop.

### Monitoring
- As appropriate for planned procedure.
- Consider postop oximetry.

### Airway
- Evaluate for neurologic deficits, which can limit airway options if there is cervical involvement.
- Potential for unrecognized difficult airway due to bulbar dysfunction and/or OSA.

### Preinduction/Induction
- May need special positioning if neurologic deficits or contractures are present.
- Avoid succinylcholine if pt has significant muscle denervation.

### Maintenance
- Individualized; no specific technique identified as safer than any other for these pts.

### Extubation
- Be mindful of bulbar dysfunction, which can lead to postextubation difficulties.
- OSA may be present; close monitoring postop is recommended.

### Adjuvants
- Many of these pts deal with chronic pain and may have a tolerance to opioids; this subgroup may benefit from procedure-specific regional anesthesia.

## Anticipated Problems/Concerns
- Respiratory: Pulm insufficiency and/or OSA, which are often unrecognized or not diagnosed.
- Neurologic: These pts commonly have long-standing neurologic deficits and/or contractures.
- Pain: Chronic pain common; pt may have opioid tolerance.