Perioperative Implications

Preoperative Preparation

- Ensure adequacy of oxygenation, ventilation, acid-base balance.
- Assess pulmonary function, particularly expiratory phase of respiration.
- Evaluate for evidence of other opportunistic infections.
- Review CXR for evidence of infiltrates, abscesses, cystic lesions or cavitations, bullae, pneumothorax, effusions.

Monitoring

- If treated with sulfa drugs, confirm presence or absence of metHb.
- Interpret SpO_2 with caution if metHb present; measure SaO_2 by cooximeter.

Airway

- Minimize airway pressures, tidal volume.
- Consider local anesthesia to upper airway to manage increased airway reactivity.

Induction

- Maintain adequate PaO_2.
- Minimize airway pressures; risk of pneumothorax.
- Ensure adequate intravascular volume.
- Monitor for hypotension associated with positive-pressure ventilation, myocardial depressants.

Maintenance

- Ensure adequate oxygenation, ventilation.
- Minimize airway pressures.
- Administer bronchodilators.

Extubation

- May be delayed.
- Prolonged ventilatory support often required.

Postoperative Period

- Ensure adequate oxygenation, ventilation.
- If mechanically ventilated, minimize airway pressures using low-tidal-volume ventilation.
- Maintain intravascular volume; optimize myocardial function.
- Continue anti-*Pneumocystis* therapy; consider other antiviral agents.

Anticipated Problems/Concerns

- Deterioration of respiratory status; prolonged respiratory failure.
- Pneumothorax; may require surgical repair if tube thoracotomy unsuccessful.
- Nosocomial infections and associated viral infections.
- Monitoring oxygenation with pulse oximeter may be inaccurate if pt treated with dapsone or primaquine.
- Drug resistance.

Pneumonia, Community-Acquired

Emily J. MacKay

Risk

- Incidence of CAP requiring hospitalization is 24.8:10,000 individuals.
- Incidence is 9 times higher among those 65 y of age or older (compared with age group 18–49).
- Incidence is 25 times higher among those 80 y of age or older (compared with age group 18–49).

Perioperative Risks

- Intraop decrease in FRC could worsen the severity of hypoxemia.
- Prolonged mechanical ventilation.

Worry About

- Irritable airway at increased risk for laryngospasm
- Hypoxemia

Overview

- CAP is defined as involving no history of hospitalization within 90 d of onset of symptoms.
- The responsible pathogen is identified in approximately 40% of cases.

Etiology

- Viruses (23%):
  - Human rhinovirus most common (9%)
  - Influenza (6%)
  - HMPV, RSV, and parainfluenza viruses; coronaviruses and adenovirus
- Bacteria (11%):
  - *S. pneumoniae* most common (5%)
  - *M. pneumoniae*, *L. pneumophila*, and *C. pneumoniae* second most common (4%)
  - *Staphylococcus aureus* (1%)
  - Enterobacteriaceae (1%)
- Bacteria plus virus (2%)
- Fungus or mycobacteria (1%)

Viral pathogens:

- Human rhinovirus
- Influenza (A or B)
- HMPV
- RSV
- Parainfluenza virus

Bacterial pathogens:

- *Streptococcus pneumoniae* (gram-positive cocci in chains)
- *Mycoplasma pneumoniae* (small bacterium, Mollicutes, no peptidoglycan cell wall [no stain])
- *Legionella pneumophila* (gram-negative, aerobic, non-spore-forming)
- *Chlamydia pneumonia* (gram-negative, small)
- *Staphylococcus aureus* (gram-positive cocci in clusters)
- Enterobacteriaceae (gram-negative, enteric)

Usual Treatment (Empiric)

- Combination therapy: Beta-lactam (third-generation cephalosporin) plus macrolide. For example (70-kg pt):
  - Ceftriaxone (third-generation): 1.5 g q8h plus azithromycin 500 mg q24h
  - Cefotaxime (third-generation): 2 g q8h plus azithromycin: 500 mg q24h
- Monotherapy: Fluoroquinolone
  - Levofloxacin: 750 mg daily
  - Moxifloxacin: 400 mg daily

Assessment Points

System	Effect	Assessment by Hx	PE	Test
RESP	Upper respiratory infection Tracheobronchitis Pneumonia	Sore throat, rhinorrhea, headache, myalgias Cough: Nonproductive Cough: Productive, shortness of breath, fever	Inflammation of nasal turbinates Erythematous soft palate Inspiratory wheeze Focal or nonfocal crackles on lung auscultation	Nasopharyngeal swab Rapid strep test CXR, sputum sample CXR, sputum sample

Key References: Jain S, Self WH, Wunderink RG, et al.: Community-acquired pneumonia requiring hospitalization among US adults, *N Engl J Med* 373(5):415–427, 2015; Futier E, Constantin JM, Paugam-Burtz C: A trial of intraoperative low-tidal-volume ventilation in abdominal surgery, *N Engl J Med* 369(5):428–437, 2013.

Perioperative Implications

Preoperative Preparation

- Elective procedure: Delay surgery for at least 6 wk.
- Urgent or emergent procedure: Proceed with caution.
- If sputum purulent, send for sputum culture.
- Ensure that appropriate antibiotic therapy is initiated.
- Bronchodilator must be available in the OR.

Monitoring

- Routine.
- Consider arterial line for serial blood gas analysis.

Airway

- At risk for rapid desaturation secondary to shunt
- At risk for laryngospasm and bronchospasm secondary to inflammation

Induction

- Ensure adequate depth of anesthesia prior to airway instrumentation (increased risk of bronchospasm).
- Use neuromuscular blockade (increased risk of laryngospasm).

Maintenance

- Inhalational anesthesia has benefit of bronchodilation.
- Consider avoiding desflurane (increased risk of airway reactivity).
- Consider 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).

Extubation

- Awake and following commands
- Vital capacity >15 mL/kg ideal body weight
- Adequate analgesia to accommodate aggressive pulmonary toilet

- 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 Pneumonia	Cough: Productive Ventilator-dependent respiratory failure, fever, increased WBC	Inspiratory wheeze Focal or nonfocal crackles on lung auscultation	CXR, endotracheal aspirate 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.