Pneumonia in Dogs and Cats: Nothing to Cough At!

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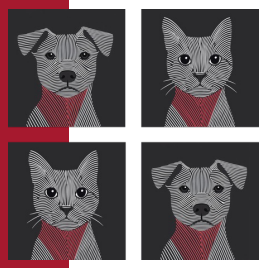

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Learning Objectives

- Compare and contrast pathophysiology of opportunistic invasion, community acquired and aspiration pneumonia in dogs and cats
- List common pathogens implicated in infectious and aspiration pneumonia in dogs and cats
- Describe clinicopathologic findings in dogs and cats with pneumonia focusing on C-reactive protein
- Discuss major diagnostic modalities used in diagnosis of pneumonia
- List the treatment algorithm for pneumonia, including rationale for various treatments

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Case 1—Ruby

- 1 year FS Pitbull mix
- 2-week history of cough, 1 week history of progressive lethargy
- Evaluated by primary DVM 4 days prior to presentation, started on amoxicillin/clavulanate (16 mg/kg PO q12)
- Progressive decrease in energy, today owner noted significant respiratory effort
- UTD on vaccines, including Bordetella
- Goes to day care/group hikes daily

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Ruby initial PE and diagnostics

- Depressed, ambulatory, mildly dehydrated
- Temp 104.6, HR 167, RR 48 with moderate respiratory effort
- Increased lung sounds with focal crackles in the left hemithorax
- Diagnostics
  - Venous blood gas: pH 7.46, CO2 29, lactate 3.6
  - CBC: 27k WBC, 22K neutrophils, 540 bands, 228 plts
  - Chemistry: WNL

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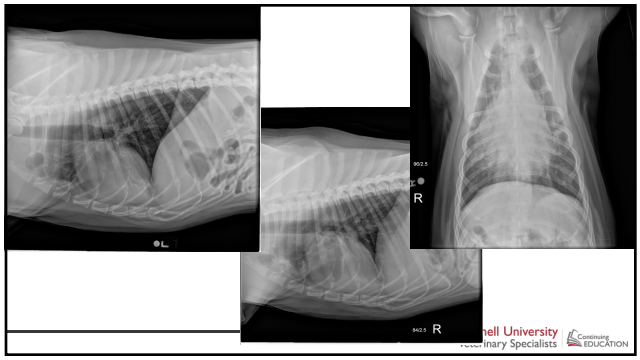

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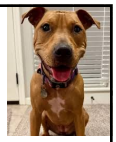
Differentials for Ruby



- Pneumonia
  - Opportunistic invasion
  - Aspiration
  - Community-acquired (infectious)
  - Hematogenous
- Etiologic agents
  - Bacterial
  - Fungal
  - Viral
  - Protozoal
  - Parasitic
- Lipid pneumonia
- Not pneumonia
  - Pulmonary edema
    - Cardiogenic vs. NCPE
  - Pulmonary thromboembolism
  - Pulmonary hemorrhage
  - Neoplasia
  - Atelectasis

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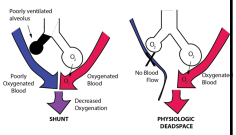
What is pneumonia?

- Inflammation of the lower airways and pulmonary parenchyma
  - Infection
  - Bacteria normally present in distal airways
- Typically originates at bronchoalveolar junction
  - Vulnerable: unprotected by mucus or cilia, site of most particle deposition
- Inflammatory response necessary to clear bacteria
  - Alveolar macrophages
  - Lymphoid tissues of pulmonary tree
  - Cytokines
- V/Q mismatch→hypoxemia



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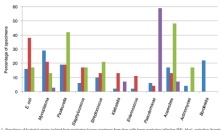
Opportunistic bacterial pneumonia etiologic agents

- Polymicrobial infections up to 46% of cases (dogs and cats)
- Gram negative enteric bacteria common in dogs
- Cats--Pasteurella spp., Streptococcus spp., Bordetella, E.coli, Pseudomonas, and Mycoplasma spp.
  - Mycoplasma NOT recovered from lower airways in healthy cats—considered a significant pathogen



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Predisposing factors

- Typically caused by normal flora—what makes it pathogenic?
  - Age, organ failure, poor nutritional status
  - Environmental conditions—unsanitary, crowding
  - Upper respiratory disease
  - Foreign body migration
  - Anesthesia/surgery
  - Anatomic abnormalities

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Canine Infectious Respiratory Disease Complex (CIRDC)

- Range of infectious agents
  - "Kennel cough"
- Transmitted via aerosol route
- Usually causes mild infections for 1-2 weeks
- Can have co-infections—more severe signs
- Secondary bacterial pneumonia common in viral infections

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Canine Infectious Respiratory Disease Complex (CIRDC)

- Viral
  - Usually mild signs:
    - Canine adenovirus 2
    - Respiratory coronavirus
  - Distemper: also GI and neuro signs
  - Herpesvirus-1
  - Influenza
  - Parainfluenza

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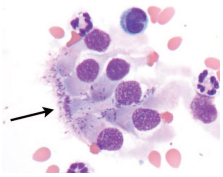
Canine Infectious Respiratory Disease Complex (CIRDC)

- Bacterial
  - *Bordetella bronchiseptica*
    - Gram- coccobacillus
    - Has been isolated from healthy dogs
    - Puppies and kittens
    - Adheres to cilia
  - *Mycoplasma cynos*
    - Obligate intracellular
    - Commensal in dogs--25% healthy dogs
  - *Streptococcus equi subspecies zooepidemicus*
    - Severe necrotizing hemorrhagic pneumonia
    - History of contact with horses



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Aspiration

- GI contents
- Drowning
- Normal response is laryngospasm and cough
- Severity of inflammatory response determined by:
  - Acidity of contents
  - Particulate debris
- Small volumes with very low pH, produce a chemical pneumonitis
- Very large volumes of neutral fluid, produce a "near-drowning" syndrome
- Particulate matter, cause obstruction of small airways and an inflammatory response

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Risks for aspiration

- Reduced level of consciousness
- Laryngeal/pharyngeal dysfunction
- Anatomic abnormalities
- Anesthesia/surgery
- Large intragastric contents
- Impaired function of esophagus/LES

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Pathophysiology of aspiration—3 phase response

Airway response
- Direct chemical burn and stimulation of airway sensory nerves
- Damage to the airway epithelium--bronchoconstriction and increased mucus production
- Increase in vascular permeability of the airways
- Obstruction of airways results in alveolar collapse
- Increases susceptibility to bacterial infection

Inflammatory response
- Within 4-6 hours of aspiration
- Increased vascular permeability
- Neutrophil infiltration
- V/Q mismatch

Secondary bacterial infection
- Aspiration of contaminated material greatly increases the risk of infection
- Timing of infection depends on bacterial load and patient's response

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Bacteria in aspiration pneumonia

- ~77% culture positive
- Most common: *E. coli*
- Common isolates: *Mycoplasma*, *Pasteurella*, *Staphylococcus*, *Klebsiella*, *Enterococcus*
- Gram-negative aerobes > gram-positive
- Anaerobes common
- Mixed infections frequent
- Less Common: *Pseudomonas*, *Acinetobacter*, *Corynebacterium*
  - May be hospital-acquired

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Clinical signs of pneumonia

Dogs

- Tracheobronchitis only:
  - May be asymptomatic or mild cough
- With pulmonary parenchymal involvement:
  - Fever (can be severe), lethargy, anorexia, dehydration, weakness, weight loss
  - Moist/productive cough ± nasal discharge
  - Tachypnea, tachycardia, respiratory distress
  - Harsh lung sounds, crackles, wheezes, or decreased sounds (consolidation)
  - ± cyanosis
  - Rarely hemoptysis

Cats

- Often non-specific signs
  - Fever, lethargy, inappetence
- Respiratory signs (especially cough) frequently absent

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Diagnosis of pneumonia

- Gold standard—histopathology
- Clinical signs, imaging findings, cytology, culture
  - Hard to interpret in face of normal flora in distal airways
- Is sampling of the airway always necessary?

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Diagnostic considerations

- POCUS/TFAST
- Radiographs
  - Distribution suggestive
  - Suggested that local airway defenses are not as good in ventral parts; gravity may diminish normal clearance mechanisms
  - Variety of patterns, especially cats
- Respiratory PCR
- Airway sampling
  - Endotracheal/transtracheal wash
  - Bronchoalveolar lavage
  - Lung aspirates
- CT scan

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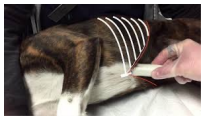
Point of care ultrasound (POCUS)

- Rapid bedside diagnosis (minutes, no transport or anesthesia)
- More sensitive than radiographs for early consolidation
- Excellent for daily monitoring
  - Best used serially as a real-time marker of lung aeration and treatment response
- Ideal for unstable or oxygen-dependent patients



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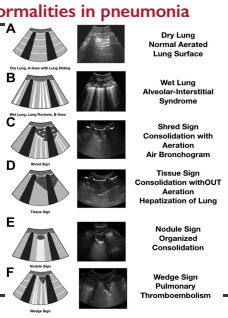
Common POCUS abnormalities in pneumonia



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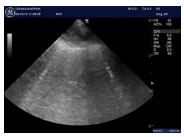
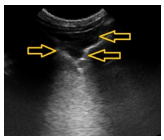
Common POCUS abnormalities in pneumonia

- Multiple/coalescing B-lines
  - Interstitial–alveolar involvement
- Shred sign
  - Irregular, shredded interface between consolidated and aerated lung
  - Highly suggestive of alveolar consolidation (pneumonia)
- Subpleural consolidations (“tissue sign” / hepatization)
- Dynamic air bronchograms
  - Supports infectious consolidation over atelectasis
- Pleural effusion





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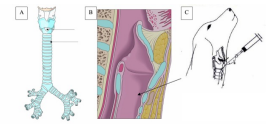
Tracheal wash

Indications

- Moderate–severe pneumonia where bronchoscopy is unavailable
- Patients too unstable for BAL
- When rapid cytology ± culture is needed
- Diffuse lung disease suspected



Advantages

- Fast and inexpensive
- Can be performed through ET tube or transtracheally
- Often feasible in unstable or oxygen-dependent patients
- Useful for bacterial pneumonia

Limitations

- Samples proximal airways (not alveoli)
- Higher risk of oropharyngeal contamination
- Less sensitive for focal or distal disease
- Limited evaluation of airway structure

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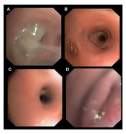
Bronchoalveolar lavage

Indications

- Stable patients with non-resolving or atypical pneumonia
- Suspected aspiration, fungal, parasitic, or inflammatory disease
- When bronchoscopy is available
- Need for targeted sampling of affected lobes



Advantages

- Samples distal airways + alveoli
- Better diagnostic yield for interstitial or focal disease
- Allows direct airway visualization
- More accurate culture results

Limitations

- Requires general anesthesia
- Risk of hypoxemia or bronchospasm
- Higher cost and equipment needs
- Not appropriate for severely unstable patients

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Airway sampling—cytology and culture

- Cytology
  - Extracellular bacteria and alveolar macrophages could represent normal airway
- Neutrophils/intracellular bacteria diagnostic
  - Not always visualized
- Culture important
  - Aerobic
  - Mycoplasma in cats

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Therapeutics for pneumonia

- Fluid therapy
- Antibiotics
- Oxygen therapy
- Bronchodilators?
- Steroids?
- Acetylcysteine?

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Fluid therapy

- Replacement fluids if dehydration/hypovolemia present
- Maintenance fluids
- Stop when adequate oral intake
- Avoid overhydration
  - Pulmonary vascular permeability
  - Increasing total lung water impairs oxygen exchange

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Antibiotic therapy

- Should not be withheld until culture obtained
  - Recent antibiotic therapy may not contribute to negative cultures
- Cultures obtained as soon as possible
- Is IV preferred over other routes?
  - Reserved for critically ill patients (sepsis, septic shock)
  - Immediate effect required
    - Surviving Sepsis Guidelines recommendation within 1 hour of diagnosis of sepsis
  - Oral antibiotics are not inferior if:
    - Voluntary oral intake
    - Functional GI tract
    - Antibiotic oral bioavailability is adequate
- Nebulized antibiotics
  - Not usually favored
  - Cystic fibrosis, severe ventilatory dependent drug-resistant pneumonias

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Antibiotic therapy—aspiration

- Broad spectrum inclusive of most likely causative agents
- Aspiration pneumonia examples:
  - Ampicillin/sulbactam +/-enrofloxacin
  - Piperacillin/tazobactam
  - Clindamycin/ceftazidime

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Journal of Veterinary Internal Medicine ACVIM Open Access

Guideline and Recommendation

Antimicrobial use Guidelines for Treatment of Respiratory Tract Disease in Dogs and Cats: Antimicrobial Guidelines Working Group of the International Society for Companion Animal Infectious Diseases

M.R. Lappin, J. Blondeau, D. Boothe, E.B. Breitschwerdt, L. Guardabassi, D.H. Lloyd, M.G. Papich, S.C. Rankin, J.E. Sykes, J. Turnidge, and J.S. Weese

- Pneumonia
  - Mild, no systemic illness (shelter/boarding exposure):
    - Doxycycline
  - Moderate–severe / septic:
    - IV fluoroquinolone (e.g., enrofloxacin) + ampicillin or clindamycin
  - De-escalate based on culture

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Antibiotic therapy

- Why didn't Ruby get better with Clavamox?
  - Viral disease
  - Clavamox does not cover Mycoplasma
  - What about Bordetella?
    - Often intrinsically resistant to many β-lactams
    - Partial intracellular survival + biofilm → poor antibiotic penetration
    - Localization in airway secretions/upper respiratory ciliated cells
      - Doxycycline, fluroquinolones, azithromycin more effective

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Bronchodilators

Pros

- Increased airflow and improved mucokinetics
  - Improved ciliary activity
- Increase in the serous component of bronchial secretions
- Direct anti-inflammatory effects
  - Decrease mucosal edema and down-regulating cytokine release

Cons

- Worsen V/Q mismatch
- Reverse hypoxic pulmonary vasoconstriction
- Suppress cough reflex

- I use in:
  - Suspect acute bronchospasm—witnessed aspiration
  - Reactive airway component

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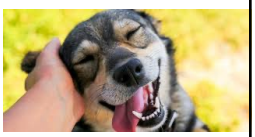
Management of the pneumonia patient

- Sedation for dyspnea/anxiety PRN
  - Butorphanol 0.1-0.4 mg/kg IV, IM, SQ
  - Dexmedetomidine 1-2 mcg/kg IM, IV, SQ
  - Acepromazine 5-10 mcg/kg IV, IM, SQ
- Gentle handling
- Sternal recumbency
- Early mobility
- Oxygen supplementation



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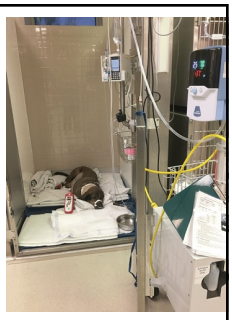
Oxygen therapy

- When to supplement?
- Flow-by
- Oxygen cage
- Nasal oxygen
  - Conventional
  - High flow
- Mechanical ventilation
- Oversupplementation is harmful
  - Oxygen toxicity
  - Absorption atelectasis
- Humidification



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Nebulization

- Improves hydration of distal airways and mucociliary clearance
- Particles at most 3 microns—vaporizers and humidifiers don't achieve that
- 0.9% NaCl favored over water
- Hypertonic saline
- Furosemide
  - Reduces subjective sensation of dyspnea
  - Does not improve oxygenation
- Acetycysteine
  - Breaks down mucus di-sulfide bonds
  - Glutathione donor

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Monitoring

- SpO_2
- Arterial blood gas
- Radiographs?
- POCUS
- C-reactive protein

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C-reactive protein

- Major acute-phase protein produced by the liver in response to inflammatory cytokines (especially IL-6)
  - Reflects systemic inflammation (not infection specifically)
  - Most useful when trended serially
- Physiologic role
  - Binds damaged cells and microbes
  - Activates complement
  - Enhances phagocytosis
  - → Part of the innate immune response
- Key kinetics (dogs)
  - Rises within 6–12 hrs of inflammation
  - Peaks at 24–48 hrs
  - Short half-life (~19 hrs) → falls rapidly when inflammation resolves
- Species Difference
- Dogs: CRP is the dominant acute-phase protein
- Cats: CRP response is minimal → SAA / AGP are preferred markers

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C-reactive protein

- Sensitive marker of systemic inflammation
  - Typically markedly elevated in canine bacterial pneumonia (often >50–100 mg/L (RI, <10 mg/L))
  - Dogs with bacterial pneumonia have significantly higher CRP than healthy controls and dogs with noninfectious respiratory disease
- Excellent for monitoring response to therapy
  - Declines rapidly (within ~3–5 days) with effective antimicrobial treatment
  - Persistent elevation suggests ongoing infection, complications (e.g., abscess), or inadequate source control
  - Serial CRP measurements correlate well with clinical improvement and outcome
- Outperforms leukogram and temperature for trending
  - CRP normalizes earlier than neutrophilia/bandemia and often before radiographic improvement
- Supports (but does NOT confirm) bacterial pneumonia
  - Elevated CRP reflects inflammation, not etiology
  - Must be interpreted alongside imaging + airway sampling
- CRP trends are useful for:
  - Identifying non-responders early
  - Guiding duration of antibiotics
  - Detecting occult complications

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Back to Ruby

- Hospitalized for 48 hours
  - Nasal oxygen
  - Enrofloxacin 15 mg/kg IV q24
  - Cerenia 1 mg/kg IV q24
  - Plasmalyte maintenance rate
- Fever resolved in 24 hours
- Started eating, weaned IVF, switched to oral enrofloxacin

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Werner

- 4-year MC DSH
- 4-day history of progressive lethargy, anorexia
- 2 days prior to presentation evaluated by primary DVM
  - Started on famciclovir for possible URI
- Indoor only, lives with another cat, FeLV/FIV negative

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Werner

- PE: T=104.3, HR 140, RR 67, 3+ effort
- Depressed, dehydrated
- Increased lung sounds, no crackles, no murmurs
- Initial diagnostics:
  - POCUS: lung consolidation
  - VBG: CO2 46, lactate 3, BG 216
  - CBC: WBC 1.9, Neuts 817, bands 218,
  - Chemistry: bilirubin 0.9 mg/dL
  - Radiographs

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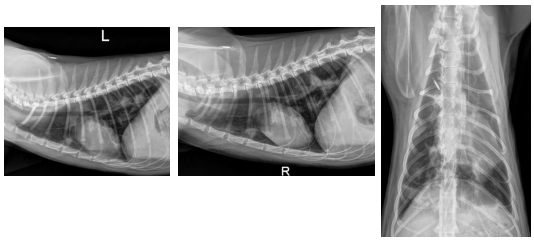
Werner radiographs



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Utility of CT in pneumonia

- Detects subtle disease missed on radiographs
  → early consolidation, ground-glass change, focal bronchial plugging
- Defines distribution & severity
  → cranioventral vs dependent vs focal lesions (helps distinguish aspiration, hematogenous spread, or localized infection)
- Identifies complications
  → abscesses, cavitation, necrosis, pleural effusion/empyema, bronchiectasis
- Guides sampling & intervention
  → targets BAL/TTW, helps plan thoracocentesis or drainage, improves diagnostic yield
- Useful in non-responders
  → clarifies why antibiotics are failing (hidden abscess, foreign body, obstructed bronchus)

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Werner additional diagnostics

- **CT of chest and abdomen**: multiple soft tissue-attenuating pulmonary nodules and masses, the largest measuring nearly 2 cm
- **ETW:** marked mixed inflammation with chronic hemorrhage suggested by hemosiderin-laden macrophages and no identifiable organisms
- **Lung aspirates**: mixed inflammation without detectable pathogens
- **Culture:** Neisseria animaloris heavy growth
- Toxoplasma serology
- FeLV/FIV
- Cryptococcus
- Heartworm antigen/antibody

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Neisseria in cats

Vet Record Cambridge

CASE REPORT
Companion or pet animals

Successful treatment of pulmonary abscesses caused by *Neisseria* species in two cats

Cat News[1] | Catherine Cercos[2] | Yekaterina Burtka[3]

- Gram negative diplococcus: oral commensal
- Causes multifocal nodular / abscessing pneumonia → mimics metastasis
- Likely spread: bite-associated bacteremia or hematogenous seeding
- Clinical signs: fever, lethargy, anorexia ± cough / respiratory distress
- Imaging: multiple pulmonary nodules / masses
- Dx: lung FNA or ET wash + aerobic culture
- Tx: prolonged antibiotics (~3–4 wks) (often fluoroquinolone ± β-lactam)

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Werner progression

- O_2 therapy
- Clindamycin 10 mg/kg IV q12, enrofloxacin 5 mg/kg IV q24
- Supportive care: IVF, Cerenia, gabapentin
- Continued to be moderately dyspneic with severe b-lines/shred with no clinical improvement
  - Started dexamethasone 0.1 mg/kg IV q24 day 3
- Discharged day 5
- Clinically doing well on rechecks, antibiotics stopped after 3 weeks

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Corticosteroids in pneumonia

FOR

- Severe inflammatory lung injury/ ARDS
- Septic shock
- Suspected concurrent immune-mediated or eosinophilic airway disease
- Refractory bronchoconstriction not responding to bronchodilators

AGAINST

- No veterinary evidence of benefit in uncomplicated bacterial pneumonia
- May impair bacterial clearance (macrophage + neutrophil dysfunction)
- Increased risk of GI ulceration, hyperglycemia, muscle catabolism, and delayed healing
- May promote secondary/opportunistic infections

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Refractory pneumonia cases

- Increased risk:
  - Pediatric and geriatric patients
  - Immunosuppression
  - Other significant disease
- Negative prognostic markers (humans):
  - Hypoalbuminemia
  - Leukopenia
  - Thrombocytopenia
  - Increased serum creatinine
- Reason for not responding:
  - Antibiotic failure
  - Concurrent viral or fungal pathogens
  - Lung abscesses
  - Incorrect diagnosis
  - Functional or anatomic defects in pulmonary defenses
  - Sepsis

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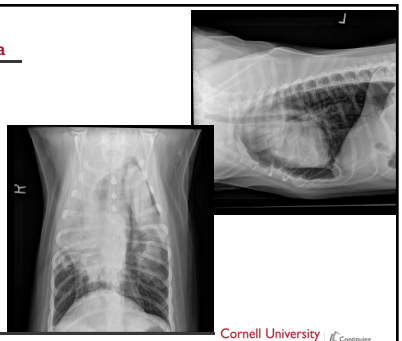
Complications of pneumonia

- Pneumothorax
- Pyothorax
- Abscess
- ARDS



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Follow up

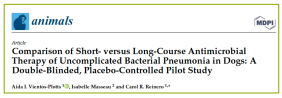
- When to stop antibiotics
- Recheck radiographs?
- CRP?

STANDARD ARTICLE

Journal of Veterinary Internal Medicine ACVIM

Antimicrobial discontinuation in dogs with acute aspiration pneumonia based on clinical improvement and normalization of C-reactive protein concentration

Nina Fernandes Rodrigues | Léna Giraud | Géraldine Bolen | Aline Fastrès | Cécile Clercx | Kris Gommeren | Frédéric Billen



animals

MDPI

Article

Comparison of Short- versus Long-Course Antimicrobial Therapy of Uncomplicated Bacterial Pneumonia in Dogs: A Double-Blinded, Placebo-Controlled Pilot Study

Aida I. Viretto-Pinto, Isabelle Maussen and Carol R. Reinero

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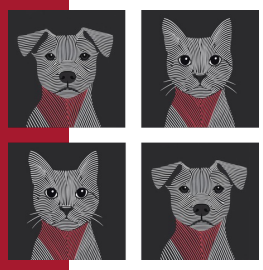
Thank you!

Questions?



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