

Hospital-Acquired Pneumonia

Etiology • pulmonary defenses • morphology • diagnosis

Clinicopathologic lecture

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Learning objectives

- Recognize HAP and VAP using an explicit clinical timeline.
- Explain how impaired pulmonary defenses and hospital exposures predispose to infection.
- Relate key bacterial pathogens to acute suppurative lung morphology.
- Integrate microbiology, imaging, and clinical findings; Recognize diagnostic uncertainty.
- Explain major complications and antimicrobial stewardship principles.

Pneumonia is infection of lung parenchyma

- A clinical syndrome rather than a single pathogen-defined disease.
- Inflammation of bronchioles and alveoli may impair gas exchange.
- Host susceptibility, inoculum, and microbial features shape presentation.
- Hospital onset changes the likely organisms and the resistance profile.

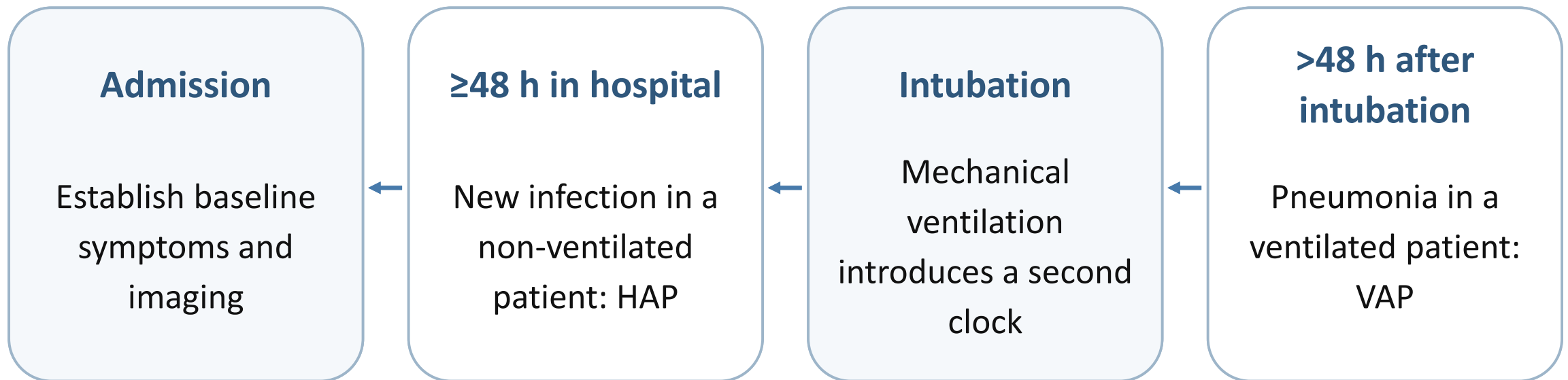
Core pathology

Intra-alveolar
inflammatory exudate
explains consolidation in
acute bacterial
pneumonia.

Hospital-acquired pneumonia: Defining feature

- New pulmonary infection arising during a hospital stay.
- Clinical definition (ATS/IDSA 2016): Not incubating on admission; Onset ≥ 48 h after admission.
- In contemporary ATS/IDSA guidance, “HAP” is used for pneumonia unrelated to mechanical ventilation.
- Hospital-acquired infection may worsen an illness that prompted admission.

HAP versus VAP: Use the clock



Definitions are clinical conventions; Neither interval alone proves infection.

Clinical setting modifies the differential

Setting	Practical interpretation	Typical emphasis
Community onset	Consider community-acquired pathogens	Not automatically a nosocomial infection
HAP: non-ventilated	Hospital-onset pneumonia after 48 h	<i>S. aureus</i> , gram-negative bacilli
VAP	Pneumonia after >48 h of intubation	Similar spectrum; more gram-negative bacilli
Aspiration-related	Entry of oral/gastric contents	Mechanism differs; bacterial overlap possible

“Healthcare-associated pneumonia”: Terminology caution

- The source chapter discusses healthcare-associated pneumonia (HCAP) as a separate group.
- ATS/IDSA 2019 CAP guidance recommends abandoning HCAP as an automatic trigger for broad coverage.
- A healthcare contact alone is insufficient to infer MRSA or Pseudomonas infection.
- Use locally validated resistance risk factors and microbiologic evidence.

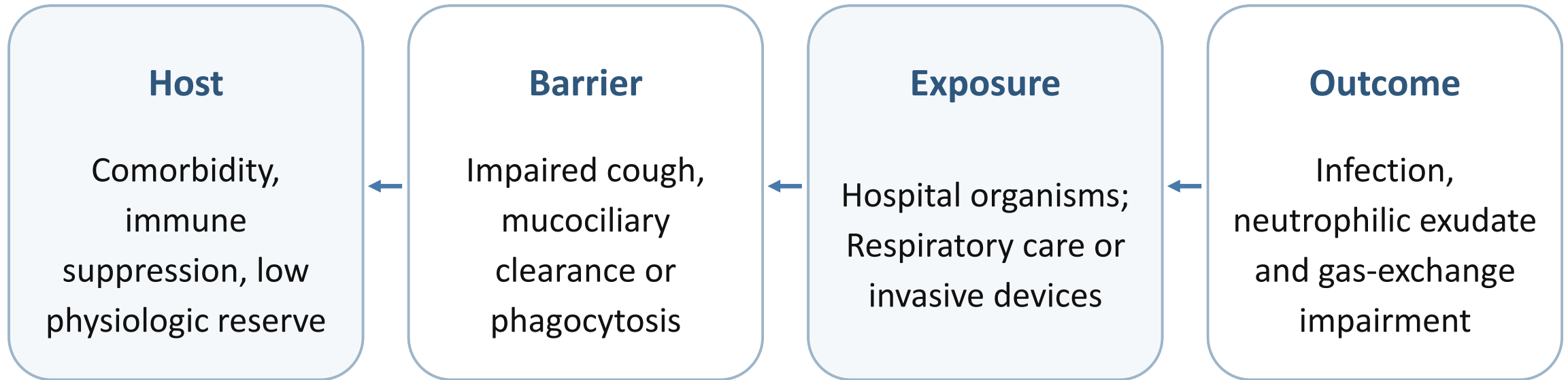
Why hospital-acquired pneumonia is consequential

- It is superimposed on the disease that required hospitalization.
- Severe illness and impaired host defenses can limit physiologic reserve.
- Potentially resistant nosocomial organisms complicate initial treatment.
- Severe disease may progress to respiratory failure or systemic infection.

Pathology link

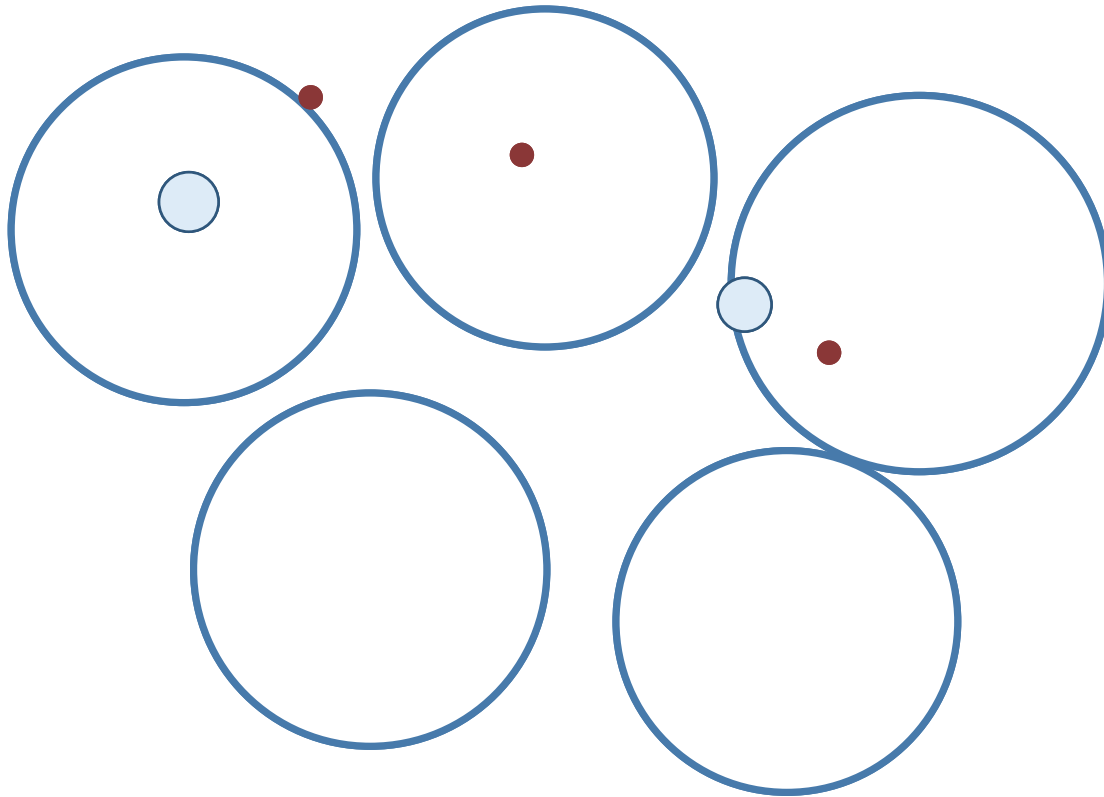
The same inflammatory exudate causes more harm in a lung with limited functional reserve.

Susceptibility requires multiple converging factors



Normal air-space defenses

Simplified cross-section — schematic, not histology



- Air-space macrophage phagocytoses organisms
- Mucociliary clearance removes airway deposits
- Neutrophil recruitment amplifies bacterial killing

Two complementary antimicrobial defenses

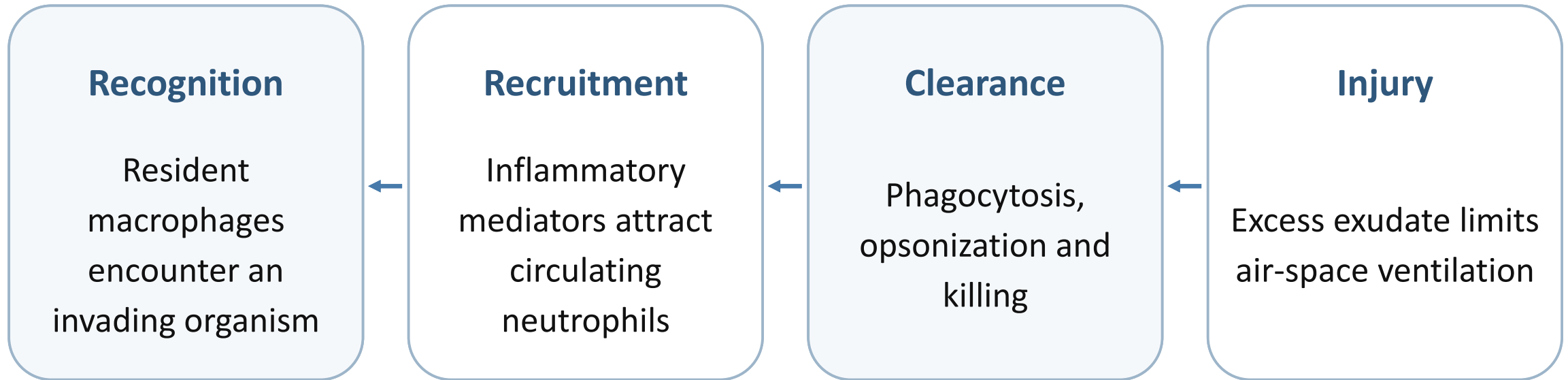
Innate

- Mucus traps inhaled organisms.
- Cilia move mucus toward larger airways.
- Alveolar macrophages remove air-space organisms.
- Neutrophils arrive during inflammatory recruitment.

Adaptive

- Secretory IgA inhibits epithelial attachment.
- IgG can opsonize organisms in alveolar lining fluid.
- Antibodies activate complement.
- T cells support control of intracellular pathogens.

From alveolar macrophage to neutrophil



Systemic vulnerabilities in hospitalized patients

Serious underlying disease

Reduced respiratory reserve and multiple overlapping risk factors.

Immunosuppression

Lower ability to clear microbes and control replication.

Leukopenia or impaired neutrophil function

A weaker acute response to pyogenic bacteria.

Prolonged antibiotic exposure

Selection pressure changes resident microbial ecology and resistance risks.

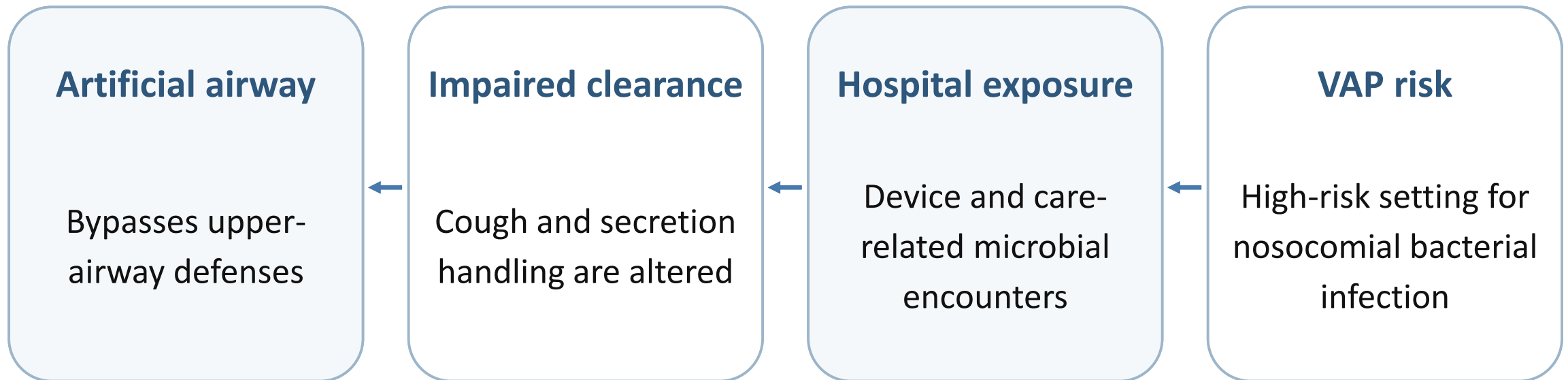
Loss of cough permits downward movement of secretions

- Depressed consciousness, anesthesia, neuromuscular disorders and drugs reduce protective cough.
- Oral and pharyngeal material may more readily enter lower respiratory airways.
- Impaired cough works together with retained secretions and poor mucociliary transport.
- Aspiration is a potential route, not a synonym for every hospital-onset pneumonia.

Retention of secretions increases local infection risk

- Bronchial obstruction and mucociliary dysfunction hamper microbial clearance.
- Viral epithelial damage, tobacco smoke and corrosive exposures can impair cilia.
- Static secretions permit organisms to persist near respiratory epithelium.
- Small-airway plugging may worsen regional atelectasis and ventilation.

Mechanical ventilation creates several vulnerabilities



Hospital environments add exposure opportunities

Close contact

More opportunities for organisms to spread between patients and settings.

Invasive access

Tubes, catheters and procedures can breach normal barriers.

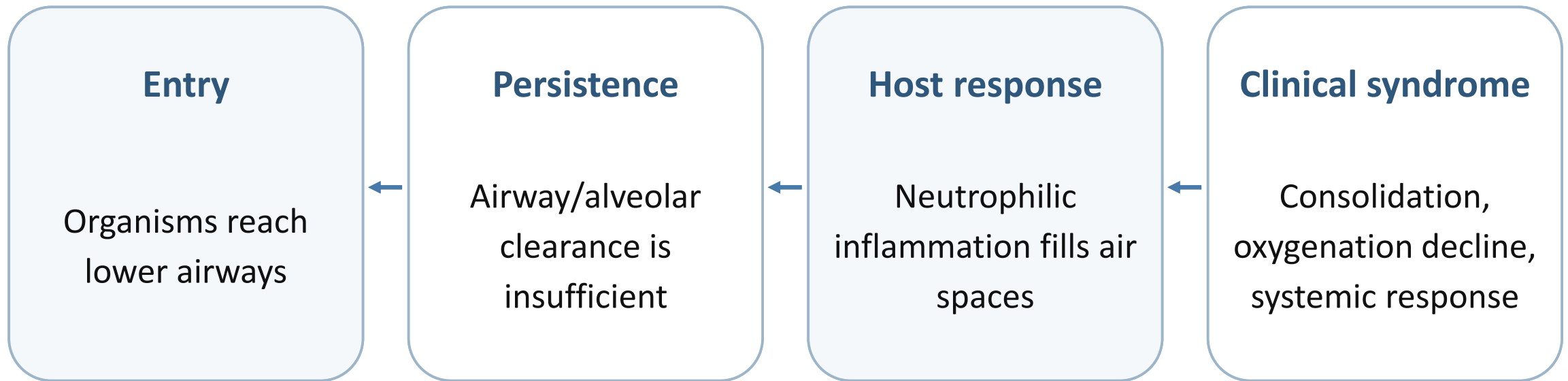
Respiratory equipment

Contamination can introduce organisms into care pathways.

Antibiotic selection

Hospital flora may show resistance following antibiotic pressure.

Conceptual pathogenesis of nosocomial bacterial pneumonia



Not every infiltrate represents an infectious process.

HAP often overlays another clinical disorder

- Many hospitalized patients have cardiopulmonary, neurologic or systemic comorbid disease.
- Pulmonary edema, atelectasis and pre-existing lung injury can coexist with pneumonia.
- Baseline fever, laboratory abnormalities and infiltrates complicate recognition.
- Assess the change from the patient's prior condition.

The core pathogen spectrum

Organism group	Named examples	Teaching significance
Gram-positive cocci	Staphylococcus aureus	Major cause of HAP; resistant isolates possible
Enterobacteriaceae	Klebsiella spp.; Serratia marcescens; Escherichia coli	Enteric gram-negative rods; susceptibility varies
Nonfermenting gram-negative rods	Pseudomonas species	Especially relevant to nosocomial/VAP settings

Staphylococcus aureus: Clinically important HAP pathogen

- A major gram-positive organism's HAP spectrum.
- May cause severe suppurative pneumonia with necrotizing complications.
- Prior influenza infection is another recognized setting for staphylococcal pneumonia.
- Organism identification and susceptibility testing guide treatment.

MRSA: A resistance phenotype, not a microscopic diagnosis

- MRSA means methicillin-resistant *Staphylococcus aureus*.
- Methicillin-resistant isolates in nosocomial pneumonia.
- Routine H&E tissue morphology cannot establish methicillin resistance.
- Resistance information requires appropriate microbiologic testing.

Diagnostic distinction

S. Aureus can produce a suppurative pattern;
MRSA requires a microbiologic resistance determination.

Pseudomonas aeruginosa in hospital-onset infection

- A prominent gram-negative rod among hospital-acquired pathogens.
- The parent chapter describes susceptibility in neutropenic and immunocompromised patients.
- Vascular invasion and extrapulmonary spread are recognized potential consequences.
- Empirical coverage depends on illness severity and local susceptibility data.

Enteric gram-negative rods: A shared pathogen group

- *Klebsiella* spp., *Serratia marcescens* and *Escherichia coli*.
- These are distinct species with potentially different antibiotic susceptibilities.
- Their shared gram-negative rod morphology does not identify the species.
- Clinical cultures link a morphologic syndrome to an actionable etiologic diagnosis.

Klebsiella pneumoniae: Capsule and suppuration

- The parent chapter links Klebsiella pneumonia with debilitating illness.
- Abundant capsular polysaccharide produces thick, mucoid secretions.
- The organism can cause acute, potentially necrotizing bacterial pneumonia.
- A classic description should not substitute for species identification.

Serratia and Escherichia coli: Species matters

- Both are included' hospital-acquired gram-negative list.
- Species names describe probable etiology, not a unique H&E pattern.
- Gram-stain morphology alone cannot reliably distinguish these organisms.
- Culture, identification and susceptibility testing determine the microbiologic diagnosis.

VAP: Similar organisms, somewhat different distribution

- *S. Aureus* and gram-negative bacilli remain major causes.
- Gram-negative bacilli are somewhat more common in VAP.
- No universal organism percentage should be assumed from this statement.
- Unit-level microbiology is important because distribution changes by hospital.

A pathogen list is not a hospital antibiogram

Textbook identifies

Local data must determine

Likely genera and species

Which organisms currently dominate an individual unit

Possible resistance phenotype

Susceptibility proportions in that specific institution

Potential complications

How local outcomes vary by patient and organism

Broad syndromic differential

Selection of initial coverage appropriate to that patient

Resistance and tissue virulence are different axes

Resistance

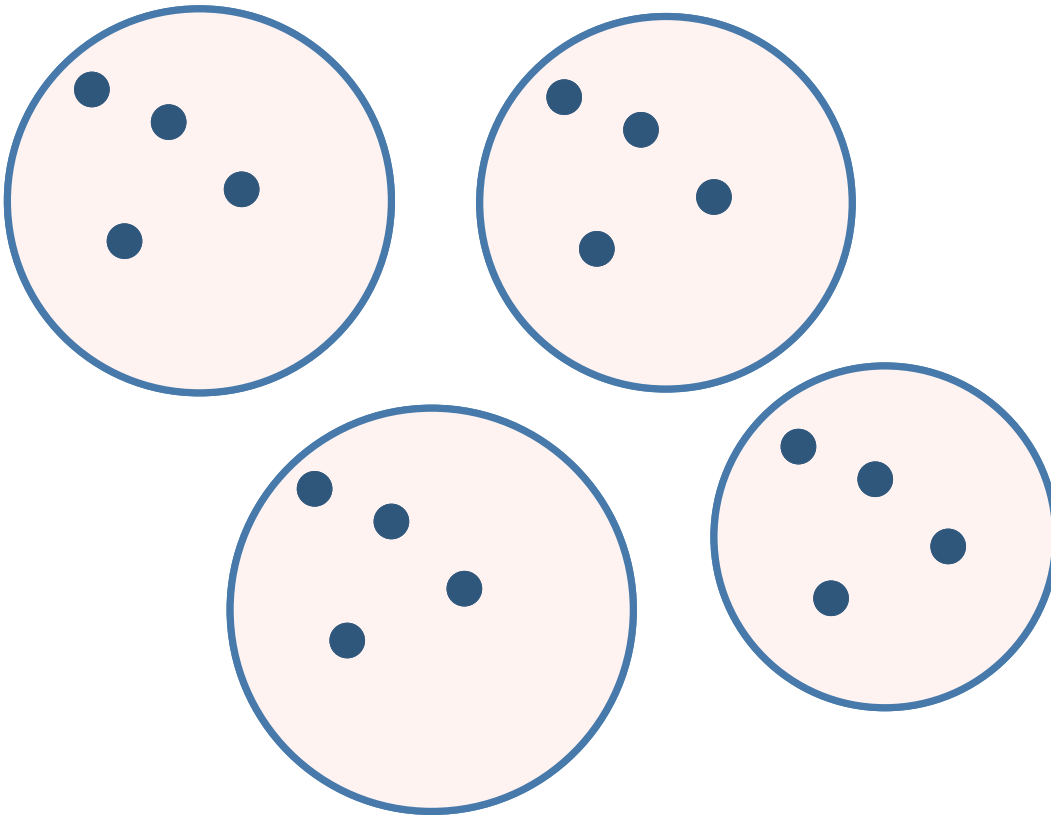
- Determines which antimicrobials may fail.
- Demonstrated by susceptibility or resistance testing.
- Does not have a distinctive routine H&E signature.

Tissue virulence

- Reflects invasion, toxin effects and host response.
- Contributes to necrosis, exudate and abscess risk.
- Cannot be inferred reliably from resistance status alone.

Acute bacterial pneumonia: Exudate fills air spaces

Simplified cross-section — schematic, not histology



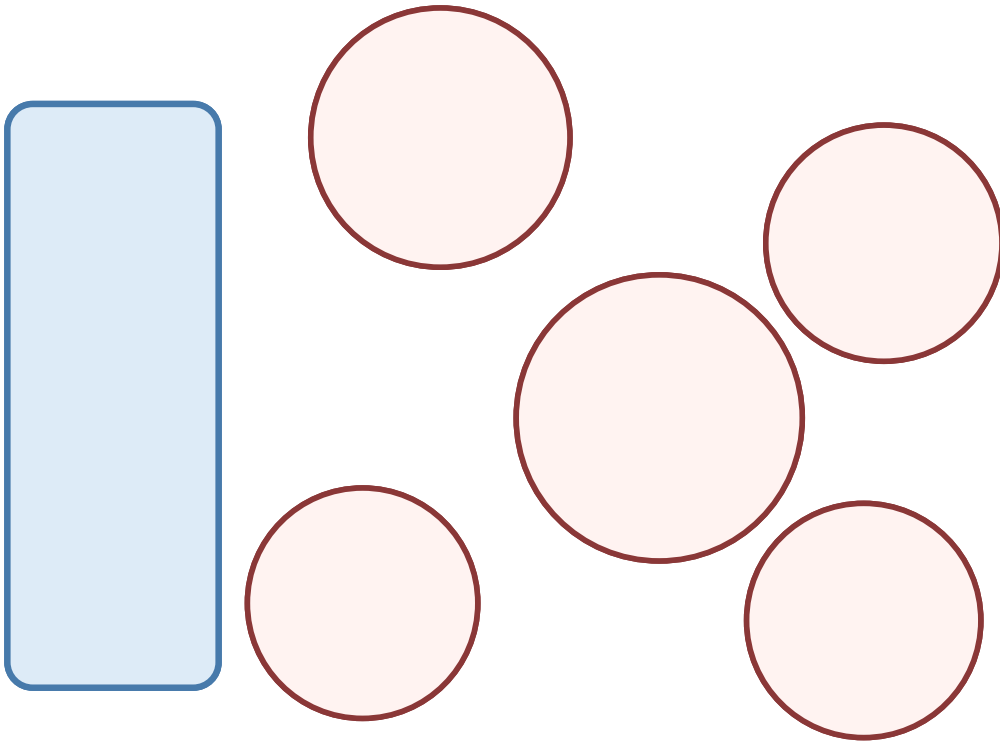
- Acute bacterial infection attracts neutrophils
- Protein-rich exudate occupies air spaces
- Air-space filling creates consolidation

Bronchopneumonia: A patchy anatomic distribution

- Scattered foci of suppurative consolidation rather than uniform lobar involvement.
- Frequently bilateral, multilobar and accentuated in dependent regions.
- Lesions may become confluent, obscuring neat anatomic distinctions.
- The pattern is descriptive; It cannot identify the causative microbe.

Bronchiolocentric foci: A simplified distribution

Simplified cross-section — schematic, not histology



- Patchy air-space inflammation centered on bronchioles
- Individual foci may coalesce into larger areas
- Schematic distribution; Not a patient specimen

Microscopic bronchopneumonia: What to look for

- Neutrophil-rich exudate involving bronchi and bronchioles.
- Adjacent alveolar air spaces contain inflammatory cells and fluid.
- Suppurative foci may be unevenly distributed across sampled parenchyma.
- A tissue sample demonstrates the injury pattern; Etiology still requires correlation.

Microscopic signature

Neutrophilic bronchiolitis plus intra-alveolar neutrophils is consistent with acute suppurative bronchopneumonia.

Lobar pneumonia versus bronchopneumonia

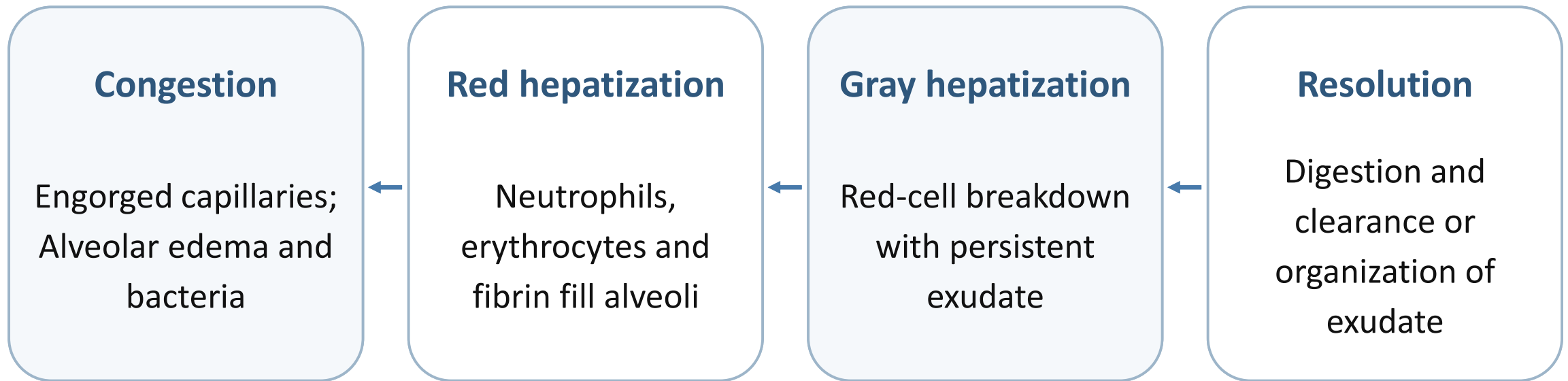
Lobar pneumonia

- Consolidation of a large part or all of a lobe.
- Classic red and gray hepatization sequence.
- Can be caused by several bacterial organisms.

Bronchopneumonia

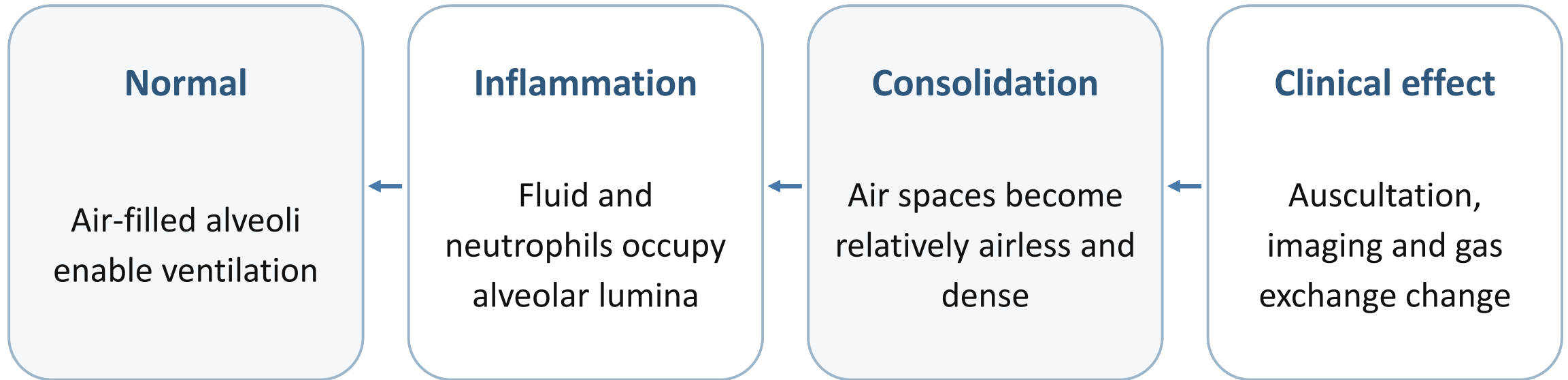
- Patchy consolidations centered on small airways.
- Often multilobar or basal with possible confluence.
- Cannot define HAP versus CAP by morphology alone.

The classic stages of lobar pneumonia

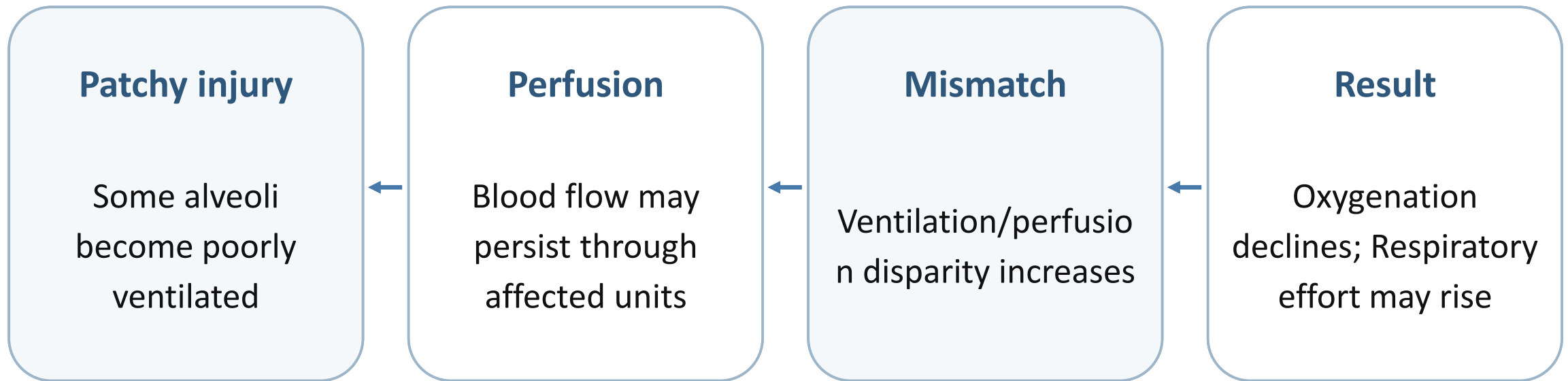


These textbook stages describe lobar pneumonia generally, not obligatory stages of HAP.

Why exudate produces pulmonary consolidation



How pneumonia contributes to hypoxemia



Schematic functional explanation; Severity depends on extent and baseline disease.

Clinical clues: Assess a change from baseline

- New or progressive respiratory symptoms and secretions.
- Fever or a new inflammatory response, interpreted against competing causes.
- New or worsening pulmonary opacity on imaging.
- Deteriorating oxygenation or increasing respiratory support needs.

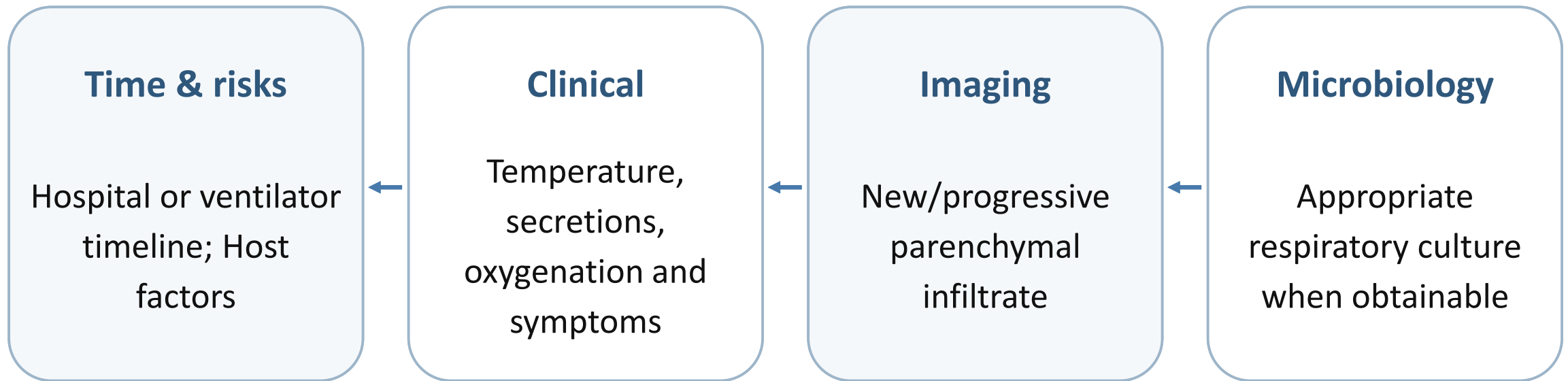
Clues in mechanically ventilated patients

- Increased or newly purulent endotracheal secretions.
- New or progressive infiltrates paired with an infectious clinical picture.
- Fever, leukocytosis or worsening oxygenation may increase suspicion.
- No single sign establishes VAP: Alternatives can mimic each component.

Radiographic patterns need clinical correlation

Appearance	Compatible process	Important limitation
Focal patchy opacity	Bronchopneumonia or atelectatic change	Opacity alone does not prove infection
Confluent lobar opacity	Extensive air-space consolidation	Organism cannot be identified radiographically
Bilateral multifocal opacities	Multifocal infection or edema/acute lung injury	Distribution is not etiologically specific

Syndromic diagnosis: Combine independent evidence



Reassess if an alternative noninfectious explanation is stronger.

There is no single gold standard for HAP or VAP

- The ATS/IDSA 2016 guideline explicitly notes diagnostic uncertainty.
- A new radiographic infiltrate is not specific for infection.
- Positive respiratory cultures can reflect airway colonization.
- Clinical probability depends on converging findings and disease course.

Respiratory sampling answers etiologic questions

- Identify the pathogen, when possible, from an appropriate respiratory specimen.
- Evaluate sample quality and possible contamination or colonization.
- Use microbiologic data alongside clinical suspicion rather than as a substitute.
- Obtain susceptibility results to support focused antimicrobial therapy.

Why a positive culture can mislead

Colonization

An organism may be present without causing invasive pneumonia.

Specimen quality

Upper-airway contamination may complicate organism attribution.

Prior antibiotics

Sampling after therapy can alter organism recovery.

Discordance

Culture, imaging and clinical response may point in different directions.

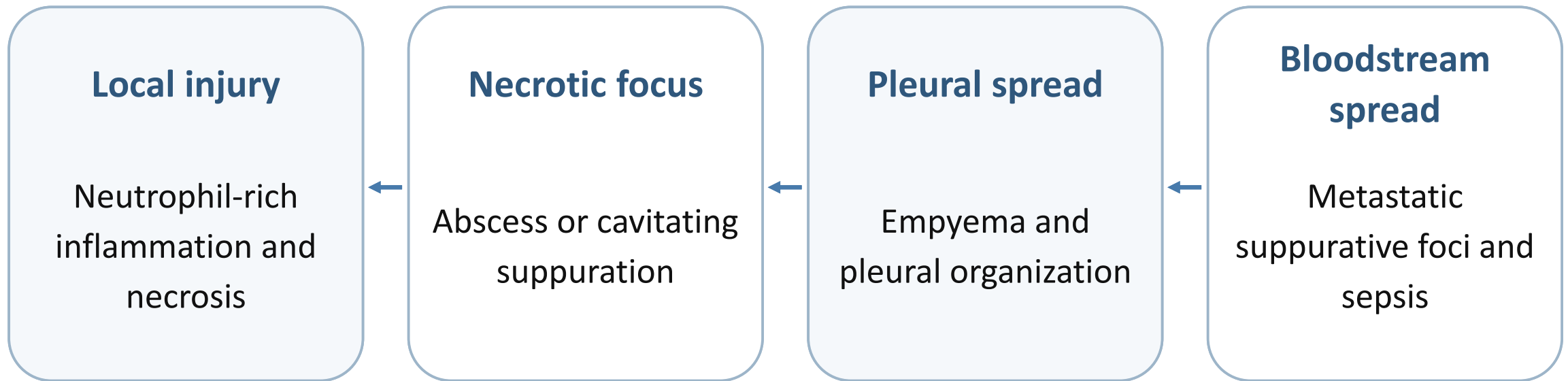
VAP: Noninvasive sampling is often adequate

- ATS/IDSA 2016 suggests endotracheal aspiration with semiquantitative culture for suspected VAP.
- The recommendation was weak and supported by low-quality evidence.
- Invasive quantitative culture methods have not shown clear outcome superiority.
- Local protocols and the patient's clinical condition still matter.

Histology describes injury, not acquisition setting

- Neutrophilic air-space inflammation establishes a suppurative tissue response.
- Neither H&E morphology nor gross distribution can define “hospital acquired.”
- Culture or molecular testing may identify the responsible microorganism.
- Temporal and clinical context is required to diagnose HAP or VAP.

Major complication pathways



Outcomes are potential pathways; Not a universal sequence.

Lung abscess: Localized destructive suppuration

- Destruction of lung parenchyma creates a cavity containing purulent material.
- Necrotizing complications with several pyogenic organisms.
- *S. Aureus* and *Klebsiella* are among clinically important causes.
- An abscess represents a complication, not a defining requirement of HAP.

Empyema: Infection extends to the pleural cavity

- Spread of bacterial inflammation to the pleural space can produce pus.
- The pleural response is fibrinosuppurative rather than purely intra-alveolar.
- Organization may lead to fibrous thickening and adhesions.
- Pleural involvement may alter both clinical findings and treatment needs.

Bacteremic dissemination produces distant complications

- Pulmonary infection may lead to bloodstream dissemination of organisms.
- Potential seeding of heart valves, pericardium, brain, kidneys and joints.
- Examples include endocarditis, meningitis and metastatic abscesses.
- Evaluate for systemic infection when clinical severity is disproportionate.

Noninfectious mimics of suspected hospital pneumonia

Mimic	Overlapping finding	Discriminating question
Atelectasis	New opacity and oxygenation decline	Is there volume loss or airway obstruction?
Pulmonary edema	Bilateral opacities and hypoxemia	Does fluid balance or cardiac dysfunction explain the picture?
Acute lung injury	Diffuse opacities and respiratory failure	Is there an alternative inflammatory insult?
Aspiration injury	Acute dependent opacities	Was aspiration temporally evident?

Aspiration pneumonitis versus HAP

Aspiration process

- Entry of gastric or oropharyngeal material.
- Chemical injury may precede bacterial infection.
- May occur during hospitalization but has its own mechanism.

Hospital-acquired bacterial pneumonia

- Infection developing after hospital exposure.
- Hospital flora and impaired defenses are central.
- Overlap can occur; Use chronology and microbiology.

CAP versus HAP: What the setting changes

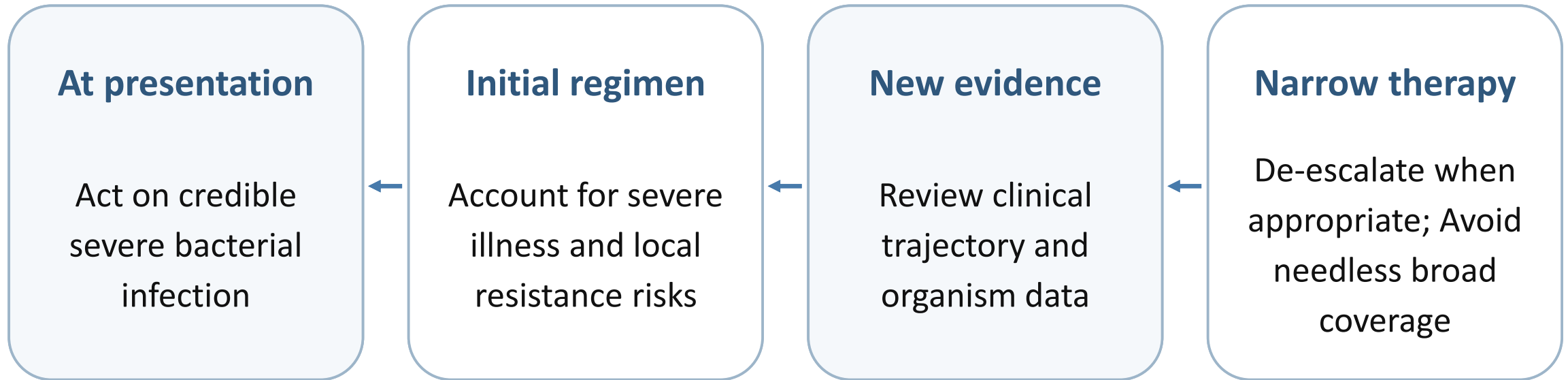
Community-acquired pneumonia

- Acquired outside hospital or present at admission.
- Community epidemiology guides initial differential.
- Can still be caused by resistant organisms in selected patients.

Hospital-acquired pneumonia

- Develops ≥ 48 hours after hospital admission.
- Nosocomial pathogens and resistance are of greater concern.
- Hospital-unit antibiograms can guide empiric choices.

Antimicrobial stewardship has two directions



Empirical treatment is a risk-adapted clinical choice

- Initial therapy is guided by severity, organism likelihood and local antibiograms.
- *S. Aureus* and relevant gram-negative bacilli need consideration in HAP.
- MRSA and resistant *Pseudomonas* coverage is guided by validated risk and local susceptibility.
- Avoid treating all hospital-exposed patients as identically resistant.

De-escalation and treatment duration

- ATS/IDSA 2016 suggests de-escalation rather than fixed broad-spectrum treatment.
- A 7-day antibiotic course is recommended for VAP and HAP in uncomplicated improving cases.
- Shorter or longer treatment may be appropriate with different rates of recovery or complications.
- Reassess clinical status, cultures and competing diagnoses throughout treatment.

Preventable links in the causal chain

Exposure control

Use infection-prevention practices to limit cross transmission.

Device necessity

Reassess invasive respiratory support and device need.

Airway care

Maintain safe secretion management and respiratory equipment practices.

Antibiotic review

Avoid unnecessary exposure that selects resistant flora.

Case 1 — new infiltrate after admission

A patient with severe heart failure develops fever, purulent sputum, a new patchy opacity and increasing oxygen requirement on hospital day 5. The patient has not been mechanically ventilated.

Discussion prompts

- Which timing category best describes the syndrome?
- Name two noninfectious alternatives to assess.
- What sampling or clinical evidence could strengthen causation?

Case 1 — structured interpretation

- HAP is a plausible clinical syndrome: Non-ventilated hospital day 5 with new compatible findings.
- Pulmonary edema and atelectasis remain competing explanations for opacity and hypoxemia.
- Interpret respiratory cultures with specimen quality and overall infection probability.
- Empiric decisions require severity assessment and local susceptibility data.

Case 2 — deteriorating oxygenation during ventilation

An intubated ICU patient has been ventilated for 6 days. Oxygen requirement rises, secretions become purulent and imaging shows new multifocal opacities. Endotracheal aspirate grows a gram-negative bacillus.

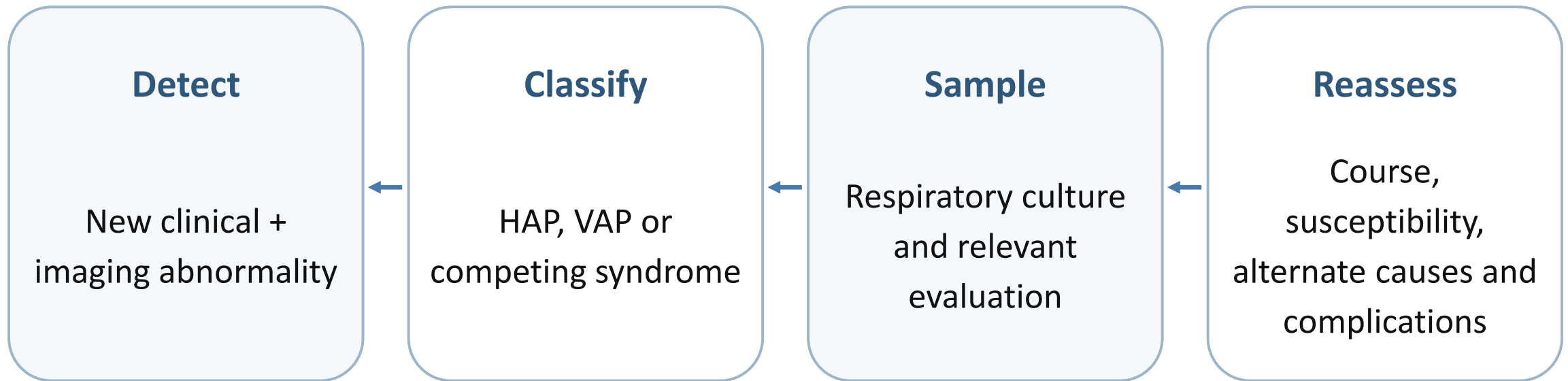
Discussion prompts

- Which pneumonia category should be considered?
- Does the culture alone prove invasive infection?
- How should final organism identification affect therapy?

Case 2 — structured interpretation

- VAP is a consideration because the new syndrome developed >48 hours after intubation.
- Endotracheal growth may reflect either infection or colonization; Correlate all findings.
- Gram-negative bacilli are common in VAP; Species and susceptibility remain essential.
- Reassess the diagnosis and de-escalate treatment when appropriate.

Integrated diagnostic reasoning map



A clinical pathway for teaching; Not a universal prescription.

What should be retained from this lecture?

- Timing and mechanical ventilation distinguish HAP from VAP in ATS/IDSA usage.
- Host defenses, devices and exposure together determine risk.
- *S. Aureus* and gram-negative bacilli dominate the textbook pathogen spectrum.
- Suppurative bronchopneumonia is a common pattern, but morphology is not etiologic proof.
- Clinical diagnosis requires correlation; Culture and local antibiograms support stewardship.

Selected source literature

Robbins, Cotran & Kumar. Pathologic Basis of Disease. 11th ed. Elsevier; 2026. Ch. 15, The Lung, pp. 643–649.

Kalil AC, et al. Management of adults with HAP and VAP: 2016 IDSA/ATS clinical practice guidelines. Clin Infect Dis. 2016;63:e61–e111. doi:10.1093/cid/ciw353.

Metlay JP, et al. Diagnosis and treatment of adults with CAP: 2019 ATS/IDSA guideline. Am J Respir Crit Care Med. 2019;200:e45–e67. doi:10.1164/rccm.201908-1581ST.

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