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Community-Acquired Pneumonia
A Review

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IMPORTANCE Community-acquired pneumonia (CAP) results in approximately 1.4 million emergency department visits, 740 000 hospitalizations, and 41 000 deaths in the US annually.

OBSERVATIONS Community-acquired pneumonia can be diagnosed in a patient with 2 or more signs (eg, temperature >38 °C or ≤36 °C; leukocyte count <4000/μL or >10 000/μL) or symptoms (eg, new or increased cough or dyspnea) of pneumonia in conjunction with consistent radiographic findings (eg, air space density) without an alternative explanation. Up to 10% of patients with CAP are hospitalized; of those, up to 1 in 5 require intensive care. Older adults (≥65 years) and those with underlying lung disease, smoking, or immune suppression are at highest risk for CAP and complications of CAP, including sepsis, acute respiratory distress syndrome, and death. Only 38% of patients hospitalized with CAP have a pathogen identified. Of those patients, up to 40% have viruses identified as the likely cause of CAP, with *Streptococcus pneumoniae* identified in approximately 15% of patients with an identified etiology of the pneumonia. All patients with CAP should be tested for COVID-19 and influenza when these viruses are common in the community because their diagnosis may affect treatment (eg, antiviral therapy) and infection prevention strategies. If test results for influenza and COVID-19 are negative or when the pathogens are not likely etiologies, patients can be treated empirically to cover the most likely bacterial pathogens. When selecting empirical antibacterial therapy, clinicians should consider disease severity and evaluate the likelihood of a bacterial infection—or resistant infection—and risk of harm from overuse of antibacterial drugs. Hospitalized patients without risk factors for resistant bacteria can be treated with β-lactam/macrolide combination therapy, such as ceftriaxone combined with azithromycin, for a minimum of 3 days. Systemic corticosteroid administration within 24 hours of development of severe CAP may reduce 28-day mortality.

CONCLUSIONS Community-acquired pneumonia is common and may result in sepsis, acute respiratory distress syndrome, or death. First-line therapy varies by disease severity and etiology. Hospitalized patients with suspected bacterial CAP and without risk factors for resistant bacteria can be treated with β-lactam/macrolide combination therapy, such as ceftriaxone combined with azithromycin, for a minimum of 3 days.

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Pneumonia, the most common infectious cause of hospitalization and mortality in adults in the US,[1] occurs when a pathogen infects the lower respiratory tract. The subsequent infection and inflammatory response cause respiratory (eg, cough, dyspnea) and systemic (eg, fever) symptoms, and may lead to sepsis, acute respiratory distress syndrome, and death.[2] Community-acquired pneumonia (CAP) is defined as pneumonia that is acquired outside the hospital setting or specifically in patients not hospitalized during the 48 hours before diagnosis. As of 2019, CAP includes patients previously classified as having "health care–associated pneumonia" who acquire pneumonia after a recent hospitalization or while in a nursing facility.[3,4] Community-acquired pneumonia does not include patients with hospital-acquired pneumonia who acquire pneumonia during hospitalization (ie, after more than 48 hours of hospitalization) or those with ventilator-associated pneumonia who acquire pneumonia while receiving mechanical ventilation.[4] Although CAP is typically treated in outpatient settings, up to 10% of patients with CAP are hospitalized, resulting in approximately 1.4 million emergency department visits, 740 000 hospitalizations, 41 000 deaths, and $7.7 billion in inpatient costs each year in the US.[1,5,6] The US incidence of hospitalization due to CAP is approximately 24.8 per 10 000 person-years for all adults, with a higher incidence (63.0 per 10 000 person-years) in those older than 65 years.[7] Thirty-day mortality after hospitalization for CAP varies from 2.8% for adults younger than 60 years to 26.8% for those aged 60 years and older and with comorbid conditions.[8]

This Review summarizes current evidence on pathogenesis, epidemiology, diagnosis, and treatment of CAP and focuses on adults without immune-compromising conditions.

Methods

PubMed searches, restricted to English-language articles published within the past 10 years, were performed on December 4, 2023, and updated on March 25, 2024, using title key words "community-acquired pneumonia" and title or abstract key words "epidemiology," "diagnosis," or "treatment." For treatment, the search was limited to randomized clinical trials, systematic reviews, and meta-analyses. For diagnosis and epidemiology, the search was limited to cohort and cross-sectional studies, randomized clinical trials, systematic reviews, and meta-analyses. Additional articles were identified from references of selected articles. Current practice guidelines and societal best practice documents were reviewed for additional references. We prioritized for inclusion meta-analyses, randomized clinical trials, and longitudinal studies along with larger studies and relevance to general medical practice.

Of 549 identified articles, 137 were included, consisting of 57 observational studies, 32 meta-analyses, 27 randomized clinical trials, 10 nonsystematic reviews, 6 systematic reviews without meta-analysis, and 5 practice guidelines (see also eTable 1 in the Supplement).

Discussion

Pathogenesis

The pathogenesis of CAP involves rapid proliferation of bacterial, fungal, or viral pathogens within the alveoli and adjacent small airways, combined with host inflammation, disrupting homeostasis both locally within the lungs (resulting in dyspnea and cough, impaired gas exchange, and radiographic air space consolidation) and systemically (resulting in fever, fatigue, altered mental status, and potentially sepsis) (**Figure**). Most respiratory viruses, including SARS-CoV-2,[9] spread via aerosol transmission or airborne particles less than 5 µM that remain suspended in air, bypass surgical masks, and directly access the lower respiratory tract via inhalation, and are typically not spread by short-lived respiratory droplets or by fomites (objects that retain viable pathogens on their surface).[9,10] This recent discovery has important implications for infection control and public health.[9,10] Recent advances in understanding of the lung microbiome have challenged long-held assumptions regarding the pathogenesis of bacterial pneumonia. Whereas lungs have traditionally been considered sterile in a healthy individual, recent studies documented that healthy lungs contain diverse communities of bacteria[9] (mostly of oropharyngeal origin) that are viable,[11] are metabolically active,[12] and contribute to the host's dynamic calibration of immune defenses.[13,14] Thus, rather than representing the invasion of a sterile space by an overwhelming inoculum of a single exogenous pathogen, bacterial pneumonia occurs when an organism emerges as a dominant one from within a changing, complex ecosystem. Factors that result in emergence of a single pathogenic organism within the lung are not fully understood. Potential factors include preceding viral infections, aspiration of large volumes of pharyngeal and gastric contents, or local immune impairment, such as ciliary dysfunction or impaired macrophage function.[14] Furthermore, prior systemic antibacterial use may select for a single organism, or resistant organism, that becomes dominant.

Previously, aspiration pneumonia, defined as pneumonia arising after aspiration of oropharyngeal or gastric contents, was understood to be caused by mixed communities of anaerobic pharyngeal microbiota such as *Bacteroides* species and *Fusobacterium* species. More recent studies of CAP microbiology have identified few anaerobic pathogens[7,15] and found that bacterial pathogens in patients with CAP with and without clinically suspected aspiration were not meaningfully different.[15,16]

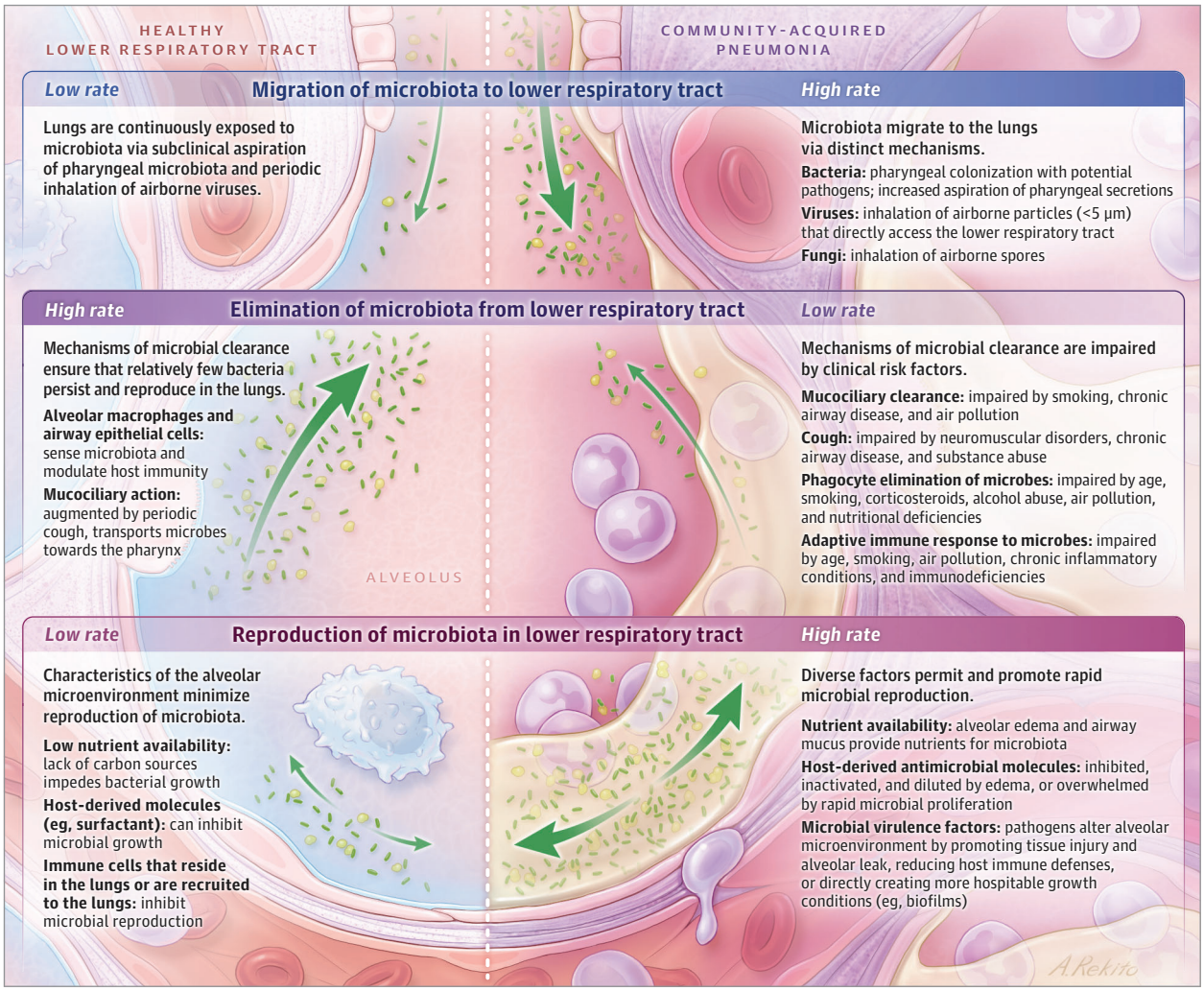
Epidemiology of CAP

According to a systematic review of 29 observational studies that included hospitalized and ambulatory adult patients with radiologically confirmed pneumonia, older age (≥65 years) is the strongest risk factor for CAP.[17] Other risk factors include impaired mucociliary clearance (eg, smoking [adjusted odds ratio {aOR}, 1.57; 95% CI, 1.12-2.77]), underlying lung disease (chronic obstructive pulmonary disease [aOR, 1.99; 95% CI, 0.67-13.53]; asthma [aOR, 1.71; 95% CI, 1.00-4.20]), poor oral health (aOR, 2.78; 95% CI, 1.60-4.40), poor nutritional status (aOR, 6.14; 95% CI, 0.65-11.58) or functional impairment (aOR, 2.13; 95% CI, 0.50-7.94), environmental exposures (eg, metals, dust, fumes), or immunosuppressive therapy (aOR, 3.10; 95% CI, 1.27-15.13).[17] Absolute rates were not provided in this systematic review.

Identification of the microorganism causing CAP is difficult. For example, in the Etiology of Pneumonia in the Community (EPIC) study of 2488 hospitalized patients with CAP,[7] only 38% of patients who underwent systematic evaluation for organisms (from blood, serum, urine, nasopharyngeal, and oropharyngeal samples, with sputum tested for those with productive coughs; invasive testing [eg, of pleural fluid] was conducted only if indicated as part of clinical care) had a pathogen identified in this study.[7] Although *Streptococcus pneumoniae* remains the most common bacterial cause of CAP,[18] the EPIC study detected *S pneumoniae* in only 5% of hospitalized patients with CAP,[7] representing 15% of those with an etiology identified. In contrast, respiratory viruses were identified in 23% of patients (40% with an etiology identified), most commonly human rhinovirus (9%) and influenza A or B (6%).[7] Because COVID-19 is now a common cause of CAP, EPIC and other epidemiologic studies may not represent current epidemiology of viral CAP (eTable 1 in the Supplement).

Community-acquired pneumonia etiology varies by severity of the pneumonia. Patients with severe illness, such as the 1 in 5 of those hospitalized who require intensive care unit (ICU) stay, are more likely to have a bacterial cause for CAP. For example, in the EPIC study, 19% of patients in the ICU vs 9% of those hospitalized but not in the ICU ($P < .001$) had a bacterial etiology of CAP,[7] and patients in the ICU had a higher prevalence of *S pneumoniae*, *Staphylococcus aureus*, and Enterobacteriaceae infections.[7] *Legionella* is a potential etiology for patients with severe CAP or any patient with CAP and exposure to water aerosol (eg, from a hot tub).[19] In contrast, outpatients and younger patients who develop CAP are more likely to have viral infections or atypical pathogens such as *Chlamydia pneumoniae* and *Mycoplasma pneumoniae*.[19] Community-acquired pneumonia epidemiology varies by region, and other pathogens should be considered according to seasonality and geographic region (eg, coccidioidomycosis in the Southwestern US), exposure (eg, to tuberculosis), and immune compromise (eg, *Pneumocystis* pneumonia).

Figure. Ecologic Model of Community-Acquired Pneumonia Pathogenesis



Community-acquired pneumonia occurs when pathogens (bacterial, viral, or fungal) rapidly proliferate within the lower respiratory tract, provoking robust host inflammation, collectively resulting in disruption of local (respiratory) and systemic homeostasis. Like any community, the microbiota of the lower respiratory tract are determined by 3 ecologic factors: migration, elimination, and the relative reproduction rates of microbiota. In health, migration of pharyngeal microbes is common (via subclinical aspiration and inhalation of microbe-laden air) but adequately offset by microbial elimination, and reproduction of viable microbes in the lower respiratory tract is minimal. Community-acquired pneumonia occurs when increased migration, impaired elimination, and enhanced microbial reproduction together result in the emergence and outgrowth of a dominant pathogen, associated with host inflammation and tissue injury. Local (alveolar) inflammation and tissue injury provoke the respiratory manifestations of community-acquired pneumonia: air space filling, impaired gas exchange, dyspnea, and cough. Dissemination of pathogens and their products, along with host-derived immune mediators (eg, tumor necrosis factor-α), mediates the systemic manifestations and sequelae of community-acquired pneumonia: fever, fatigue, altered mental status, and sepsis.

Diagnosing CAP

Pneumonia is diagnosed by a combination of 2 or more signs (eg, temperature >38 °C or ≤36 °C; leukocyte count <4000/µL or >10 000/µL) or symptoms (eg, new or increased cough or dyspnea) of pneumonia in conjunction with consistent radiographic findings (eg, air space density) without an alternative explanation for the signs, symptoms, or radiographic findings (**Table 1**).[22] Among 17 290 hospitalized patients with CAP across 48 hospitals, new or worsening cough, sputum production, and dyspnea were the most common symptoms (Table 1).[20] Although no individual signs or symptoms have a high sensitivity and specificity for diagnosing CAP when considered alone, a systematic review and meta-analysis of 17 cohort studies found that absence of abnormal vital signs can help rule out CAP (sensitivity, 93%; negative likelihood ratio, 0.25; 95% CI, 0.11-0.48).[21] In this study, egophony and dullness to percussion, although uncommon, had a specificity of 0.99% and 0.94%, respectively.[21] In contrast, other auscultatory findings such as crackles, decreased breath sounds, or rhonchi had mixed sensitivity and specificity.[21] Altogether, the 48-hospital study found that only 58.6% of 15 211 patients with CAP had any auscultatory findings documented (compared with 42.6% of 2079 patients with an inappropriate diagnosis of CAP); similarly, the meta-analysis found that any abnormality on the lung examination result had a sensitivity of 59% and a specificity of 57% for CAP.[20]

Because of the poor sensitivity and specificity of clinical signs and symptoms for diagnosing CAP, all patients considered to have

Table 1. Signs, Symptoms, and Radiologic Findings of CAP[a]

Sign or symptom of CAP	Prevalence in patients hospitalized with CAP, %[20,b]	Sensitivity[21,c]	Specificity[21,c]
Respiratory symptoms			
New or increased cough	86.5	0.88	0.16
Adverse change or increase in sputum production[d]	51.7	0.52-0.71	0.35-0.52
New or increased dyspnea	79.8	0.63	0.51
Respiratory signs			
Hypoxemia[d]	33.2	0.36	0.83
Auscultatory findings such as egophony or rales	58.6	0.60	0.67
Tachypnea (respiratory rate >20/min)	68.9	0.53	0.84
Infectious signs			
Temperature			
>38 °C or ≤36 °C	60.0	0.63[e]	0.55[a]
>38 °C[d]	44.6	0.34	0.87
≤36 °C	41.7	NA	NA
Leukocyte count <4000/μL or >10 000/μL; or >15% bands	68.4	NA	NA

Abbreviations: CAP, community-acquired pneumonia; NA, not available.

[a] Pneumonia is diagnosed by a combination of 2 or more of the signs or symptoms of pneumonia in conjunction with consistent radiographic findings without an alternative explanation.

[b] Prospective cohort of 17 290 hospitalized, non–intensive care patients with CAP across 48 Michigan hospitals.

[c] Systematic review that includes 9 primary care and 7 emergency department–based studies.

[d] Definitions between studies varied.

[e] Subjective fever was used to assess sensitivity and specificity.

CAP should undergo radiographic evaluation to confirm or exclude the diagnosis.[3] Because it is relatively inexpensive and accessible, chest radiography is often the initial diagnostic test, but its sensitivity (median, 70%; range, 16%-95%) and specificity (median, 55%; range, 0%-94%)[23] vary according to image quality and whether there is prior imaging available for comparison. For highest-quality images, a chest radiograph should be obtained with both posterior-anterior and lateral projection while the patient stands upright holding a deep inspiration and without any spinal rotation or obstructing objects, such as cardiac monitors or jewelry. If a chest radiograph does not show evidence of CAP but pneumonia is suspected, chest computed tomography is an appropriate next step; a retrospective study of 3423 patients with cardiorespiratory symptoms who had chest computed tomography and radiography as part of clinical care found that only 43.5% of opacities visible with chest computed tomography were also identified with chest radiography.[23] Chest computed tomography can also better evaluate patients for alternative diagnoses, such as pulmonary embolism, than chest radiograph.[24-34] Air space opacities or infiltrates are the most common radiographic finding (>95%)[20] in CAP; however, they are nonspecific and may be caused by atelectasis, fluid (eg, edema), or aspiration pneumonitis. Less common radiographic findings of pneumonia include pleural effusion (particularly unilateral and with loculations), cavitation, and a masslike appearance.[20] Although lung ultrasonography when used by a trained technician has a higher sensitivity (median, 95%; range, 69%-100%) and specificity (median, 75%; range, 0%-100%) than chest radiograph for diagnosing CAP,[24-34] quality varies among technicians, and the utility of ultrasonography for diagnosing CAP is unclear.[35]

The lack of highly sensitive and specific clinical findings or diagnostic tests for CAP has led to its substantial overdiagnosis. Approximately 10% to 30% of patients treated for CAP do not meet diagnostic criteria (ie, signs, symptoms, and radiographic findings) for CAP.[20,22,36,37] Patients without symptoms who have infiltrates on radiographs should not be treated for CAP. Patients with CAP symptoms in combination with radiographic results without physical examination evidence of CAP should undergo chest computed tomography and be evaluated for alternative causes of their symptoms. The differential diagnosis for pneumonia includes exacerbation of chronic cardiopulmonary diseases (eg, chronic obstructive pulmonary disease), acute upper airway disease (eg, acute bronchitis), aspiration pneumonitis, malignancy, and pulmonary embolus.[3] In a study of more than 40 000 inpatient veterans aged 65 years or older and receiving a diagnosis of pneumonia, 9.2% received a diagnosis of pulmonary malignancy after hospital discharge, 27% of which were diagnosed within 90 days of hospitalization.[38]

Diagnostic Testing for CAP

Not all patients with possible CAP require diagnostic testing to determine the etiology. When diagnostic testing for CAP is considered, the most important question is whether the test result will change management. For example, there are multiple potential benefits of rapid testing for SARS-CoV-2 and influenza, including increased use of and decreased time to administration of antiviral therapy, reduced antibacterial medication use, reduced hospitalization rates, shorter length of hospital stay and lower health care costs, and better infection control practices.[39-42] In contrast, more extensive testing for viruses other than SARS-CoV-2 and influenza has not been shown to affect care.[43-45] Thus, the Infectious Diseases Society of America (IDSA) recommends SARS-CoV-2 and influenza testing for all patients with possible CAP during periods of community transmission or potential exposure to SARS-CoV-2 and influenza (including recent travel to areas with high community transmission); in contrast, IDSA suggests that more extensive testing for viruses other than SARS-CoV-2 and influenza only "be considered in select cases where timely pathogen determination may allow a more directed therapy or discontinuation of unnecessary antibiotics."[46] Except for viral testing, only patients with severe CAP (ie, meeting IDSA/American Thoracic Society [ATS] severity criteria)[3] or risk factors for methicillin-resistant *S aureus* (MRSA) or *Pseudomonas aeruginosa,* or those who do not improve with a course of typical antibacterial medications, should be evaluated for etiology (**Table 2**).[47-52,54-56,58-65] Patients with risk factors for

Table 2. Diagnostic Testing in CAP[a]

Test	Recommendations	Recommended uses	Test performance and limitations	Diagnostic stewardship considerations[47,b]
Recommended in most CAP				
COVID-19 and influenza testing	IDSA recommended if the virus is common in the community (eg, travel to area with community transmission) or if there is potential exposure.[46]	All patients regardless of severity when virus is actively circulating or when the patient has been exposed to these viruses.	When used in ED, influenza testing decreases time to diagnosis, appropriate isolation, time to antiviral initiation, antimicrobial use, chest radiography, admission, and length of stay.[39,42]	
Recommended in severe CAP and for patients with risk factors for MRSA or *Pseudomonas*[c]				
Blood cultures	Recommended in severe CAP, risk factors for MRSA or *Pseudomonas*,[3,46] or empirical treatment of MRSA or *Pseudomonas*.	Severe CAP: patients at elevated risk of MRSA or *Pseudomonas*, including those with history of MRSA or *Pseudomonas* infection or those hospitalized and who received parenteral antibacterial medications in last 90 d. Patients initiating anti-MRSA or anti-*Pseudomonas* therapy.	For patients with low risk of bacteremia, positive results are more likely false positives. In nonsevere CAP, positive blood culture results rarely change management. Yield reduced by prior antibacterial use.	Two sets of blood cultures should be obtained before initiation of antibacterial treatment. Utility may be improved through rapid diagnostics to quickly identify pathogens and contaminants (eg, coagulase-negative *Staphylococci*). Optimal collection practices, such as proper disinfection, sample transport, and training of phlebotomists, can reduce contamination rate.
Respiratory culture and Gram stain	Recommended in severe CAP, risk factors for MRSA or *Pseudomonas*,[3,46] or empirical treatment of MRSA or *Pseudomonas*.	Severe CAP: patients at higher risk of MRSA or *Pseudomonas*, including those with history of MRSA or *Pseudomonas* infection or those hospitalized and who received parenteral antibacterial medications in last 90 d. Patients initiating anti-MRSA or anti-*Pseudomonas* therapy.	Not all patients can produce high-quality sputum (defined as sample with ≥25 leukocytes and <10 squamous epithelial cells per low-power field), which is associated with diagnostic yield.[48] Does not detect viruses and some atypical pathogens. Slow (although may improve with rapid diagnostics). Bacteria colonizing the oropharynx can grow; true bacterial infections may not be detected with cultures alone.[49,50] Gram stains are specific (0.87%-0.99%) but less sensitive (0.59%-0.72%).[51]	Automatic rejection of poor-quality samples. Educate staff on proper collection techniques and need for rapid transport. To improve antibacterial de-escalation, report "no MRSA, no *Pseudomonas*" when oral flora or negative result.[52]
MRSA nasal swab	Recommended in severe CAP and risk factors for MRSA.[3,46]	Severe CAP: patients at elevated risk of MRSA, including those with history of MRSA infection or those hospitalized and who received parenteral antibacterial medications in last 90 d. Patients initiating anti-MRSA antibacterial medications such as vancomycin or linezolid	If negative, then helpful (99% NPV).[53] If positive, then unhelpful (35.4% PPV).[53]	Order when anti-MRSA antibacterial medications ordered. Automatic (or facilitated) anti-MRSA cessation if MRSA nares result returns negative.
Pneumococcal urinary antigen	Recommended in severe CAP only.[3,46]	Patients initiating anti-MRSA/anti-*Pseudomonas* therapy.	Empirical therapy already covers *Streptococcus pneumoniae*; thus, pneumococcal urinary antigen testing changes management only if anti-MRSA or anti-*Pseudomonas* therapy is started.	Consider removing from order sets or other diagnostic stewardship intervention to reduce use ($100 per test or $2400 per positive test result).[54]

(continued)

Table 2. Diagnostic Testing in CAP[a] (continued)

Test	Recommendations	Recommended uses	Test performance and limitations	Diagnostic stewardship considerations[47,b]
Recommended in severe CAP and special uses				
Legionella urine antigen	Recommended in severe CAP or risk factors for *Legionella.*[3,46]	Patients with severe CAP, known exposure, travel, or setting of outbreak.	Detects only *L pneumophila* serogroup 1 antigenuria.	
Procalcitonin	IDSA recommends for severe CAP or to guide antibacterial initiation or discontinuation in combination with viral diagnostics.[46]	If antibacterial treatment is planned regardless of result, do not order. Potential uses: When considering starting antibacterial medications for COVID-19 (has high negative predictive value for bacterial infection). As an additional data point when true diagnostic uncertainty exists (eg, alternative diagnosis). In combination with viral testing to withhold or stop antibacterial medications.	AUC = 0.77 (95% CI, 0.74-0.81) for identifying CAP, defined in most studies as abnormal chest radiograph result. AUC = 0.73 (95% CI, 0.69-0.76) for distinguishing viral from bacterial CAP.[55,56] May be falsely negative early in infection or with atypical bacteria. May be helpful for its NPV (98.3% for ≤0.1 ng/mL) for bacterial coinfection with SARS-CoV-2.[57] One study found it helpful in determining whether to prescribe azithromycin vs levofloxacin in outpatients with CAP.[58]	Procalcitonin is ineffective when protocols not followed[59]; to improve efficacy, consider implementing with antibiotic stewardship support (eg, discussion during face-to-face stewardship rounds).[60]
Expanded respiratory viral testing (other than COVID-19 or influenza)	IDSA recommends for severe CAP or in combination with procalcitonin to guide antibacterial initiation or discontinuation.[46] ATS recommends for severe CAP.[61]	Severe CAP: in combination with procalcitonin if antibacterial medications would be deferred or stopped.	Expensive; limited data on how results should affect management. No demonstrated effect on antibacterial initiation.[62,63] Mixed demonstrated effect on antibacterial duration and discontinuation.[40,41,62,63]	Best when combined with recommendations from antibiotic stewardship personnel. For example, 1 study showed that viral panel results combined with a text or phone call explaining results to clinicians resulted in shorter intravenous antibacterial medication regimens, shorter hospital stay, and lower cost of hospitalization.[64]
Not currently recommended for most CAP				
Invasive lower respiratory tract diagnostic testing	Bronchoscopic sampling, for example.[46]	More practical and clinically warranted for patients undergoing mechanical ventilation (via bronchoscopic or nonbronchoscopic alveolar lavage or tracheal aspirate).	Achieves high level of pathogen identification[65] but no prospective studies demonstrating value.	Rarely indicated in CAP, given need for sedation, procedural risk, and adequacy of empirical regimens.

Abbreviations: ATS, American Thoracic Society; AUC, area under the curve; CAP, community-acquired pneumonia; ED, emergency department; IDSA, Infectious Diseases Society of America; MRSA, methicillin-resistant *Staphylococcus aureus;* NPV, negative predictive value; PPV, positive predictive value.

[a] Descriptions of diagnostic tests that may be used in CAP, their indications, and considerations to improve diagnostic use are reported with supporting studies.

[b] Diagnostic stewardship involves strategies to modify the process of ordering and performing diagnostic tests and reporting their results to improve the treatment of infections and other conditions.

[c] Severe CAP includes patients requiring intensive care or meeting IDSA/ATS severity criteria.

Box. Commonly Asked Questions About Community-Acquired Pneumonia (CAP)

1. What Diagnostic Evaluation Is Recommended for Patients With Possible CAP?

Patients with possible CAP should undergo chest imaging, typically by chest radiography, and be tested for SARS-CoV-2 and influenza if these viruses are prevalent in the patient's community. Further testing for bacterial infection (eg, respiratory or blood cultures) should be performed only if the patient has severe pneumonia (ie, requires vasopressors, requires mechanical ventilation, or has 3 or more minor severity criteria) or risk factors for methicillin-resistant *Staphylococcus aureus* or *Pseudomonas*.

2. What Are the Most Common Causes of CAP?

Only 38% of patients hospitalized with CAP have a pathogen identified. Of those patients, up to 40% have viruses identified as the likely cause of CAP, with *Streptococcus pneumoniae,* the most common bacterial pathogen, identified in approximately 15%.

3. What Antibiotics Should Be Used to Treat CAP?

When a bacterial cause is suspected, patients in the ambulatory setting and without comorbidities may be treated with amoxicillin 1 g 3 times daily or doxycycline 100 mg twice daily. Patients in the ambulatory setting and with comorbidities could be treated with combination therapy (eg, amoxicillin/clavulanate or a cephalosporin such as cefpodoxime or cefuroxime with azithromycin). Hospitalized patients with suspected bacterial CAP and without risk factors for resistant bacteria can be treated with β-lactam/macrolide combination therapy, such as ceftriaxone combined with azithromycin, for a minimum of 3 days. Patients with severe CAP should receive systemic corticosteroids in addition to empirical antibiotic therapy according to whether they have risk factors for resistant bacteria.

MRSA or *Pseudomonas* include those with a history of MRSA or *Pseudomonas* infection and those with a hospitalization in the past 90 days during which parenteral antibacterial medications were administered.

Treatment

The decision to hospitalize a patient with CAP should be made based on clinical judgment and a clinical decision tool.[3] The Pneumonia Severity Index, which divides patients into 5 risk categories (I-V, where V is worst), was originally developed to predict 30-day mortality. The index assigns points for patient demographic and clinical variables and was endorsed by the 2019 ATS/IDSA guideline as the preferred tool for site-of-care decisions because of its ability to safely reduce hospital admissions for patients with low risk (ie, Pneumonia Severity Index risk categories I-III, which represent more than two-thirds of patients presenting to the emergency department).[3] Because the index can underestimate disease severity, especially for patients aged 50 years or younger, and does not include social determinants of health that may affect the likelihood of successful outpatient treatment (such as homelessness or substance use), clinical judgment should be used when decisions about hospitalization for patients with CAP are made.

Antibacterial Therapy

Empirical antibacterial therapy should be selected according to disease severity and likely pathogen. The 2019 ATS/IDSA guidelines categorized hospitalized patients as having severe pneumonia (ie, patient requiring vasopressors or mechanical ventilation, or with 3 or more minor severity criteria)[3] or nonsevere pneumonia (all other hospitalized patients). For hospitalized patients with nonsevere bacterial CAP, empirical treatment with a β-lactam, such as ceftriaxone, in combination with a macrolide, such as azithromycin, or fluoroquinolone monotherapy (eg, levofloxacin) was recommended (**Box**).[3] Because of potential harms from fluoroquinolone therapy, such as *Clostridioides difficile* infection, antibacterial resistance, and risk of tendon rupture, fluoroquinolone monotherapy is currently recommended only if a β-lactam/macrolide combination is not tolerated (eg, severe penicillin allergy).[46] For many patients, this treatment requires determining whether a penicillin allergy exists because, although 10% of the US population reports a penicillin allergy, less than 1% demonstrate a true allergy to penicillin.[66] Although data are mixed on whether macrolides improve outcomes when added to β-lactam therapy for nonsevere CAP,[67-70] the highest-quality observational and clinical trial evidence suggests that macrolides can improve outcomes, potentially including mortality, for severe CAP.[71,72] The 2024 ACCESS trial reported that compared with placebo, clarithromycin 500 mg twice daily for 7 days reduced a composite end point of respiratory symptom severity and early inflammatory response (68% [91/134] vs 38% [51/133]; $P < .001$).[71] Hospitalized patients with severe CAP should generally receive the same empirical therapy as those with nonsevere CAP (ie, a β-lactam/macrolide combination), with fluoroquinolones such as levofloxacin 750 mg daily or moxifloxacin 400 mg daily replacing macrolides for patients with a contraindication to macrolide therapy.[3] Empirical administration of antianaerobic antibacterial medications, such as metronidazole or clindamycin, can disrupt protective gut commensal bacteria, can increase risk of secondary infections (eg, *C difficile* colitis),[73] and is associated with an estimated 5% to 6% higher mortality.[74,75] Thus, the 2019 ATS/IDSA CAP guidelines recommend against prescribing antimicrobial therapy active against anaerobic bacteria, such as metronidazole or clindamycin.[3]

In an observational study of 88 605 hospitalized patients with pneumonia, anti-MRSA therapy (ie, vancomycin therapy) in addition to standard CAP therapy was associated with higher 30-day mortality (marginal probability, 11.6% vs 8.6%), kidney injury (population-average adjusted risk ratio [aRR], 1.4; 95% CI, 1.3-1.5), *C difficile* infection (aRR, 1.6; 95% CI, 1.3-1.9), vancomycin-resistant *Enterococcus* infection (aRR, 1.6; 95% CI, 1.0-2.3), and secondary gram-negative rod infections (aRR, 1.5; 95% CI, 1.2-1.8).[76] Absolute rates were not provided in this systematic review. Thus, when deciding whether a patient needs anti-MRSA or antipseudomonal empirical coverage, clinicians should consider potential harm of antibacterial drugs and whether the patient has known risk factors for MRSA or *Pseudomonas*. Multiple studies have attempted to identify risk factors for MRSA or *Pseudomonas*. Although many risk factors have been inconsistent across populations, patients with severe (vs nonsevere) CAP are more likely to have MRSA (5% vs 1%) and *Pseudomonas* (3% vs 1%),[7] as are those with prior MRSA or *Pseudomonas* infection or recent hospitalization with parenteral antibacterial exposure.[3,77] Thus, patients with a history of MRSA or *Pseudomonas* infection should be treated empirically for that pathogen while etiologic

testing results (eg, blood and respiratory culture results) are pending. For MRSA, a negative MRSA nasal swab test result has a high negative predictive value (99%), and anti-MRSA therapy can be discontinued for patients who test negative for MRSA via nasal swab.[53] Patients hospitalized in the 90 days before a CAP diagnosis, during which they received parenteral antibacterial medications, should be empirically treated for MRSA and *Pseudomonas* only if they have severe CAP; otherwise, they can receive standard CAP therapy while etiologic test results are pending.[3]

Few data exist to guide empirical treatment for outpatients[78]; the 2019 ATS/IDSA CAP guidelines recommended amoxicillin 1 g 3 times daily or doxycycline 100 mg twice daily for patients without comorbidities and recommended combination therapy (eg, amoxicillin/clavulanate or cephalosporin [such as cefpodoxime or cefuroxime] and azithromycin) for patients with comorbidities such as chronic lung disease or asplenia (**Table 3**; eTable 2 in the Supplement).[3,79-124] Fluoroquinolone (eg, levofloxacin) monotherapy is not recommended unless the patient cannot tolerate first-line therapy.[46]

To our knowledge, no randomized clinical trials have examined whether patients with viral CAP should be treated empirically with antibacterial therapy. In retrospective studies, up to 20% of 1488 hospitalized patients who received antibacterial medications experienced an adverse event,[125] and a single additional day of antibacterial treatment increased the absolute risk of acquiring a resistant organism by 7% (eg, from 10% to 17%).[126] The long-term effects of antibacterial use on a patient's entire microbiome are not fully understood. However, microbiome changes (from antibacterial use or other causes) have been linked to obesity, chronic inflammation, and cancer.[127] For COVID-19, the highest-quality retrospective studies suggested that most patients with CAP did not require antibacterial medications. A systematic review of 3338 patients hospitalized with CAP due to COVID-19 reported that 3.5% had a bacterial coinfection on presentation.[128] If a bacterial coinfection is suspected in a hospitalized patient with COVID-19, procalcitonin testing may be helpful because the negative predictive value of a procalcitonin value less than or equal to 0.1 ng/mL is 98.3%.[57] In contrast, for patients with COVID-19, the positive predictive value of a procalcitonin level greater than 0.5 ng/mL was approximately 9.3% because coinfection with bacteria is uncommon in patients with CAP due to COVID-19. Therefore, for patients unlikely to have a bacterial coinfection, antibacterial therapy should not be initiated based on a positive procalcitonin value alone.[57]

For non–COVID-19 viruses, the decision to treat should be based on severity of the patient's illness and consideration of host biomarkers such as procalcitonin.[46] For example, in the EPIC study, 7% of 462 non-ICU inpatients with CAP and a viral pathogen detected had bacterial codetection compared with 15% of 125 ICU patients with viral CAP. Given these findings, IDSA suggests treating viral CAP with antiviral therapy (if indicated), such as oseltamivir for influenza A and B, and considering deferral of antibacterial treatments if there is low suspicion of bacterial coinfection; for example, if serum procalcitonin level is less than or equal to 0.25 ng/mL.[46] If antibacterial therapy is prescribed, it should supplement disease-specific therapy (eg, steroids, antiviral therapy) and antibacterial medications should be discontinued if a bacterial pathogen is not identified.[46]

De-Escalating Antibacterial Medications

Antibacterial de-escalation includes stopping antibacterial medications, transitioning from empirical to directed therapy, narrowing the spectrum of therapy, or transitioning from intravenous to oral therapy. Clinicians should transition from intravenous to oral antibacterial medications as soon as a patient can ingest oral medications.[129] One retrospective study of 1021 patients reported that default transition to oral medications (ie, an order set with intravenous antibacterial medications for the first dose followed by oral antibacterial medications on subsequent days) for nonsevere CAP was associated with lower intravenous antibacterial duration, shorter total antibacterial duration, and lower costs.[103] Most CAP bacterial pathogens do not have antibacterial resistance. For these patients, potential oral antibacterial regimens include amoxicillin/clavulanate or an oral cephalosporin (eg, cefpodoxime) in addition to a total of 1500 mg of azithromycin (ie, 500 mg daily for 3 days or 500 mg on the first day and then 250 mg daily for 4 days), including any doses received intravenously.[46] A recent study of 7742 patients with sepsis reported that de-escalation from β-lactam therapy to antibiotic treatment with a narrower spectrum (eg, from ceftriaxone to amoxicillin rather than ceftriaxone to amoxicillin/clavulanate) was associated with less development of gram-negative resistance.[102,105] Given this finding, and that most *S pneumoniae* is sensitive to amoxicillin, amoxicillin 1 g orally 3 times a day may also be an appropriate oral antibiotic to select when transitioning from a more broad-spectrum to a more selective antibiotic.

Although the optimal duration of antibacterial therapy in CAP is unknown, a 2021 clinical trial of 310 hospitalized patients with nonsevere CAP who improved quickly (ie, achieved full vital sign stability by hospital day 3, which requires that patients meet all of the following criteria: afebrile [temperature ≤37.8 °C], heart rate <100/min, respiratory rate <24/per min, no hypoxemia [ie, oxygen saturation as measured by pulse oximetry ≥90% or Pao_2 ≥60 mm Hg], and systolic blood pressure ≥90 mm Hg) reported that 3 days of β-lactam antibacterial therapy was noninferior to 8 days of antibacterial therapy for attaining cure at 15 days (77% vs 68%; between-group difference, 9.42%; 95% CI, −0.38% to 20.04%).[46,92] Given potential harms of longer antibacterial duration,[101,126] clinicians should treat patients with the shortest effective duration.[46] Currently, clinical trial evidence supports 3 days of antibacterial medications for outpatients without severe CAP, including for patients treated and discharged from the emergency department without hospital admission. For inpatients with nonsevere CAP, approximately 50% of patients will stabilize by hospital day 3 and should receive antimicrobials for a total of 3 days.[92,94-97] Patients who take more than 3 days to clinically stabilize should generally receive a total of 5 days of antimicrobial treatment.[93] Data are limited on the optimal duration of treating patients who experience complications from pneumonia (eg, empyema) or MRSA or *Pseudomonas* infections, but longer durations of antimicrobials are typically recommended (eg, ≥7 days).[3]

Steroids

For COVID-19 pneumonia associated with hypoxia, clinical trial data, including the 2020 RECOVERY trial, demonstrated that low-dose corticosteroids (ie, dexamethasone 6 mg daily for 10 days) can reduce mortality (28-day mortality of 25.7% without dexamethasone vs

Table 3. Recommended Treatment for CAP[a]

Treatment	Treatment recommendations	Evidence summary[b]	Additional considerations or best practices
Antibacterial therapy			
Empirical therapy	Outpatient: amoxicillin or doxycycline alone. If comorbidities (eg, chronic lung disease or asplenia): amoxicillin/clavulanate or oral cephalosporin (ie, cefpodoxime or cefuroxime) and macrolide or doxycycline (respiratory fluoroquinolone if confirmed allergy). Inpatient, nonsevere: β-lactam (eg, ampicillin + sulbactam or ceftriaxone) + macrolide. Respiratory fluoroquinolone only if confirmed allergy. Inpatient, severe: β-lactam (eg, ampicillin + sulbactam or ceftriaxone) + macrolide. If unable to tolerate macrolide, replace with respiratory fluoroquinolone.	Little evidence supporting superiority of one regimen over another. Outpatient: multiple RCTs have not shown evidence of superiority of one therapy over another.[79] Inpatient CAP: multiple systematic reviews found no difference in clinical outcomes between different regimens.[80-88] Mortality may be higher with β-lactam + fluoroquinolone combination (compared with β-lactam ± macrolide).[81,89] Inpatient, severe: addition of macrolide associated with earlier clinical response and potentially lower mortality.[71,72]	Given risk of resistance and harm with fluoroquinolone use, recommend against empirical fluoroquinolone use when alternative available.[46] Penicillin allergy is overreported and wanes. Patients with a low-risk allergy history (eg, family history only, reaction >10 y ago or unknown, nonallergic symptoms) can be listed as having no allergy or can have an amoxicillin challenge.[90] Best trial evidence supports oral clarithromycin for severe CAP,[71] although it has not been directly compared with azithromycin. Data supporting addition of a macrolide to β-lactam for nonsevere inpatient CAP are mixed.
Anti-MRSA coverage	Outpatient: no anti-MRSA therapy recommended. Inpatient, nonsevere: only if prior respiratory isolation of MRSA or if risk factors and culture results return positive for MRSA. Inpatient, severe: with prior respiratory isolation of MRSA or recent hospitalization with parenteral antibacterial medications. When needed, use vancomycin or linezolid.	In an observational study, higher mortality, kidney injury, *Clostridioides difficile* infection, vancomycin-resistant *Enterococcus* infection, and secondary gram-negative rod infections with anti-MRSA therapy, a finding consistent across subgroups (eg, severity).[76]	Avoid anti-MRSA therapy for most patients. If MRSA coverage added, obtain MRSA via nasal swab and stop therapy if result is negative.
Antipseudomonal (and other potentially multidrug-resistant nonfermenting gram-negative bacilli)	Outpatient: no coverage recommended. Inpatient, nonsevere: only if prior respiratory isolation of *Pseudomonas aeruginosa* or if risk factors and culture result returns positive. Inpatient, severe: with prior respiratory isolation of *P aeruginosa* or recent hospitalization with parenteral antibacterial medications. When needed, cefepime may be preferable to piperacillin-tazobactam.[91] Alternative agents: ceftazidime, imipenem, or meropenem.	In observational cohort studies, use of piperacillin-tazobactam (and other antianaerobic regimens) was associated with higher mortality and longer duration of organ failure.[74,75,91]	Avoid antipseudomonal therapy for most patients. If started, obtain blood and respiratory cultures, and discontinue in 48 h unless positive.
Antibacterial duration	Outpatient: 3 d. Inpatient (including non-ICU severe CAP): 3 d if stable by day 3[92]; 5 d if stable by day 5.[93] At least 7 d if MRSA, *Pseudomonas*. Longer durations for complications (eg, empyema) or unusual pathogens (eg, fungi). ICU CAP: patients admitted to intensive care excluded from duration clinical trials.[92] Stability criteria: 3-d stability requires patients meet all of the following stability criteria by day 3: afebrile (≤37.8 °C), heart rate <100/min, respiratory rate <24/min, no hypoxemia (ie, Spo_2 ≥90% or Pao_2 ≥60 mm Hg), and systolic blood pressure ≥90 mm Hg[92]; 5-d stability requires patients be afebrile plus ≤1 sign of instability by day 5.[92]	Outpatient: 1-d azithromycin has clinical cure similar to that of 7- to 10-d duration.[94,95] Inpatient, nonsevere: 3-5 d (depending on time to stability) noninferior to longer durations.[92,93,96-98] ICU CAP: no studies found.	Prescribe only minimum necessary therapy; observational studies found excessive duration linked to harm[97,99] and appropriately short courses safe up to 1 y later.[100] For hospitalized patients, ≈50% will be stable by day 3. Up to 90% will be stable by day 5.[101] Patients not stable by days 3-5 should be evaluated for alternative diagnoses or noncovered pathogens.
Transition to oral antibacterial medications	Transition to oral antibacterial medications as soon as the patient is improving and able to tolerate oral therapy.[3] Recommended options for patients without an identified organism[46,102]: amoxicillin/clavulanate 500 mg/125 mg orally 3 times a day or 875-2000 mg/125 mg orally twice daily; cefpodoxime 200 mg orally twice daily; cefuroxime 500 mg orally twice daily; amoxicillin 1 g orally 3 times a day; plus total 1500 mg azithromycin (including any parenteral doses).	Automatic transition to oral therapy (in nonsevere CAP) can reduce IV and total antibacterial therapy, cost, and LOS.[46,103,104] Quicker de-escalation (to narrower antibacterial medications [eg, amoxicillin]) may be associated with less development of antibacterial resistance.[105]	IV therapy places patients at risk of IV-related harm while increasing cost of care.

(continued)

Table 3. Recommended Treatment for CAP[a] (continued)

Treatment	Treatment recommendations	Evidence summary[b]	Additional considerations or best practices
Other treatment			
Steroids	Outpatient: no steroids. Inpatient, nonsevere: no steroids. Inpatient, severe[c]: steroids (eg, hydrocortisone 200 mg/d)[106] within 24 h of meeting severity criteria.	Outpatient: no studies found. Inpatient, nonsevere: steroids reduce LOS but increase hyperglycemia. No difference in mortality.[107,108] Inpatient, mixed severity: data mixed but benefit driven by more severe subgroups.[109-113] Inpatient, severe: steroids reduce mortality, need for mechanical ventilation,[c] vasopressor use, and hospital or ICU LOS[106,114-120]; adverse events not increased by steroids.[115,121]	Patients may require steroids for other pulmonary (eg, asthma, COPD) or disease indications (eg, COVID-19). Patients with influenza pneumonia were excluded from clinical trials owing to concern steroids could be harmful.
Secondary prevention (no clinical trial data)			
Vaccination[122]	For outpatients, plan for all eligible vaccinations. For inpatients, offer all eligible vaccinations before discharge: pneumococcal conjugate vaccine, influenza, SARS-CoV-2, respiratory syncytial virus.	Vaccination may reduce infection incidence and severity.	
Tobacco use[122]	Screen for and treat tobacco use, including cessation counseling and medications.	Cigarettes increase risk of pneumonia and recurrent pneumonia.[17]	For patients at higher risk of lung cancer, consider recommending lung cancer screening if chest imaging insufficient.
General aspiration risk (dysphagia, alcohol abuse, oral health)[122]	Screen for and treat alcoholism and substance use disorders. Recommend good oral hygiene, including toothbrushing.[123] If dysphagia, consider speech evaluation and therapy.	Patients with alcoholism and other substance use disorders are at higher risk of pneumonia and recurrent pneumonia. Poor oral hygiene is a risk factor for CAP.[17]	
Comorbidity management	Ensure all cardiac (eg, heart failure) and pulmonary (eg, COPD, asthma) comorbidities are treated per guidelines, with goal-directed therapy restarted before discharge.	Patients with COPD treated with inhaled steroids are at higher risk for CAP.[124] Readmission with heart failure common after pneumonia admission; restart any diuretics or goal-directed medical therapy before discharge.[102]	Patients with COPD or asthma who are hospitalized with pneumonia may qualify for controller medication augmentation.

Abbreviations: CAP, community-acquired pneumonia; COPD, chronic obstructive pulmonary disease; ICU, intensive care unit; IV, intravenous; LOS, length of stay; MRSA, methicillin-resistant *Staphylococcus aureus;* RCT, randomized clinical trial; Spo_2, oxygen saturation as measured by pulse oximetry.

[a] Recommended treatment and considerations for best practice, with supporting evidence, are provided by disease severity. American Thoracic Society/Infectious Diseases Society of America criteria were used to distinguish severe from nonsevere inpatient pneumonia unless otherwise stated.

[b] See eTable 2 in the Supplement for a detailed literature review included in the evidence summary.

[c] The CAPE COD clinical trial defined severe pneumonia by the presence of at least 1 of the following: (1) mechanical ventilation; (2) high-flow nasal cannula with a ratio of Pao_2 to the fraction of inspired oxygen (Fio_2) of less than 300, with Fio_2 greater than or equal to 50%; (3) Pao_2:Fio_2 ratio less than 300 for patients wearing a nonrebreathing mask; or (4) Pulmonary Severity Index score greater than 130 (ie, group V severity).[106]

22.9% with it), particularly among patients undergoing invasive mechanical ventilation (28-day mortality of 41.4% without dexamethasone vs 29.3% with it).[130,131]

For non–COVID-19 severe CAP,[132] clinical trial evidence, including the 2023 CAPE COD trial, suggested that early (ie, within 24 hours of meeting severity criteria) administration of steroids (defined as ≤400 mg hydrocortisone equivalent daily) can reduce 28-day mortality by up to 5.6% (absolute difference, from 11.9% to 6.2%), need for mechanical ventilation, vasopressor use, and length of stay.[106,109,114,115]

Nonsevere CAP (without alternative indications) appears not to benefit from corticosteroids, largely because outcomes are better in this group, and the risks of adverse effects from steroids outweigh potential benefits.[107,133,134]

Secondary Prevention

Patients with a history of CAP have higher rates of subsequent CAP (aOR, 1.86; 95% CI, 1.53-3.81)[17] and should be counseled about smoking and alcohol cessation and relevant vaccination. Relevant vaccines include pneumococcal conjugate vaccine and those for influenza, SARS-CoV-2, and respiratory syncytial virus. Patients should also be counseled about good oral hygiene (ie, daily toothbrushing and dental care to reduce microbial burden)[123] and should be treated according to guidelines for underlying cardiac and pulmonary conditions (Table 3).[122,135] Patients with history of aspiration should be referred for speech or swallow therapy and counseled on behavioral strategies to reduce aspiration. For example, eating with small bites, fully chewing each bite, consuming small frequent meals, and sitting upright during and for 30 minutes after meals can reduce aspiration rates.

Limitations

This review has several limitations. First, not all aspects of CAP were discussed. Second, the literature search may have missed relevant articles. Third, a formal quality assessment of published literature was not performed.

Conclusions

Community-acquired pneumonia is the most common infectious cause of morbidity and mortality in the US. Viruses are the most common pathogens detected in CAP, whereas *S pneumoniae* remains the most common bacterial pathogen. First-line therapy varies by disease severity and by the most likely etiology. Patients with CAP with suspected bacterial cause who do not have comorbidities and are not hospitalized may be treated with amoxicillin 1 g 3 times daily or doxycycline 100 mg twice daily. Patients with CAP with suspected bacterial cause and comorbidities who are not hospitalized should receive combination therapy (eg, amoxicillin/clavulanate, cephalosporin and azithromycin). Hospitalized patients with suspected bacterial CAP and without risk factors for resistant bacteria can be treated with β-lactam/macrolide combination therapy, such as ceftriaxone combined with azithromycin, for a minimum of 3 days.

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