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Sepsis Management in Adults: Pharmacotherapy Focus

Updated April 2026

The chart below summarizes select pharmacotherapeutic interventions in sepsis/septic shock in adults. This information is mostly based on the Surviving Sepsis Campaign guidelines, available at https://sccm.org/survivingsepsiscampaign/guidelines-and-resources/surviving-sepsis-campaign-adult-guidelines#Recommendations. See **footnote a** for information on screening.

Start immediately and complete within 3 hours of recognition of sepsis or septic shock.

A vasopressor might be indicated (e.g., dangerous organ hypoperfusion). See vasopressor row, below.

FLUIDS | For hypoperfusion or shock (MAP <65 mm Hg, SBP <90 mm Hg [or markedly less than baseline], or lactate >4 mmol/L and perhaps >2 mmol/L)[1]

INTERVENTION/INDICATION	ASSOCIATED TESTING OR MONITORING	COMMENTS
• At least 30 mL/kg of IV crystalloid is suggested.[1] • Balanced crystalloids (e.g., LR, Normosol-R, Plasma-Lyte 148) are generally suggested over NS to potentially decrease risk of hyperchloremic metabolic acidosis, acute kidney injury, and perhaps mortality.[1,2,13] • **Albumin** is suggested for patients who have received large volumes of crystalloids (but confers no mortality benefit) or who have cirrhosis.[1] Avoid in TBI.[1] • It is recommended that starches (e.g., hetastarch) **not** be used in resuscitation, and gelatin is suggested against.[1]	• Serum lactate and capillary refill time within one hour.[1] • Dynamic measures (e.g., passive leg raises or fluid challenge with stroke volume or pulse pressure measurement) are suggested over physical exam, or static measures such as CVP alone.[1] • Capillary refill: suggested adjunct to other perfusion measures.[1]	• Individualize initial volume.[1] • The suggested moderate-volume fixed bolus is based on usual practice and volumes used in the ProCESS, ARISE, and ProMISe studies.[1]In one observational study, 4L (moderate volume) was associated with a 2.5% lower mortality than 1.6 L (very low volume) or 6.1 L (very high volume).[1] • Some experts suggest bolusing in • 500 mL increments per response.[9] • If BMI >30 kg/m^2, use IBW or adjusted body weight.[1] • CVP has limited utility to predict a response to a fluid challenge within the range of 8 to 12 mmHg ("normal").[12]

Start immediately (ideally within one hour) of recognition of possible, probable, or definite septic shock, or probable or definite sepsis without shock. For possible sepsis (without shock), consider a short investigation for infection before starting antimicrobials within three hours from time of first suspicion of sepsis.[1]

ANTIMICROBIALS | For patients with septic shock, start within one hour.[1]

INTERVENTION/INDICATION	ASSOCIATED TESTING OR MONITORING	COMMENTS
• Coverage for **MDR** bacteria (e.g., MRSA, MDR gram negatives):suggested for patients at high risk of MDR bacteria: colonization or infection with an MDR bacteria in the last year, extended stay in a hospital where MDR bacteria are prevalent, or extended use of broad-spectrum antibiotics[1] • **Anaerobic** coverage: consider for patients with high risk of anaerobic infection (e.g., abdominal, deep-seated obstetric/gynecological, head and neck, or necrotizing infections; empyema; abscess)[1] • **Antifungals**: consider for patients with high risk of fungal infection (e.g., immunocompromise, extended hospitalization or antibiotic use, abdominal source).[1] • Optimize dosing based on pharmacodynamics and pharmacokinetics (e.g., for beta-lactams prolonged infusion (after bolus) is recommended).[1]	• **Blood cultures**: draw before starting antimicrobials if it will not cause treatment delay.[1] • **Procalcitonin**: use with clinical evaluation to make treatment duration decisions once source is controlled.[1] • **Pathogen-specific rapid diagnostic tests**: suggested for use in a targeted manner in select (not all) patients, with consideration for clinical features and suspected pathogens, in the context of an antimicrobial stewardship program.[1] • Candida biomarkers can be used as a guide to starting or discontinuing empiric antifungal coverage in patients with high risk of fungal infection.[1]	• Mortality benefit of quick initiation is clearest for shock[1]. • Antibiotics can be started in the ambulance or helicopter for definite or probably septic shock if time to hospital assessment is over an hour.[1] • For patients with a low likelihood of infection (without shock), consider postponing antimicrobials and monitoring closely.[1] • De-escalate when possible (i.e., discontinue antibiotics if an alternate diagnosis is strongly suspected, or narrow the spectrum once the organism is identified).[1] • For bacteremia, seven days of antibiotic treatment is as effective as 14 days.[14]

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Other Interventions

INTERVENTION/INDICATION		ASSOCIATED TESTING OR MONITORING	COMMENTS
Vasopressors For MAP of <65 mmHg during (for unstable shock) or after fluid resuscitation, started peripherally if central access is not already in place.[1]	• Norepinephrine (usually preferred) or epinephrine.[1] • Consider adding vasopressin if response is inadequate to norepinephrine ~0.3 mcg/kg/min.[1] • Epinephrine can be used as an add-on if vasopressin is unavailable.[1]	• Target MAP of 65 mmHg (60 to 70 mm Hg, or 60 to 65 mm Hg if ≥65 years of age), using invasive monitoring if available.[1] • Also monitor perfusion and CO.[1]	• Norepinephrine may be preferred if tachycardia or tachyarrhythmias is a concern; epinephrine may be preferred if bradycardia, bradyarrhythmias, or cardiac dysfunction is of concern.[1] • Epinephrine can increase lactate production, making it hard to use lactate as a monitoring parameter.[1] • Be aware that dobutamine can cause unwanted vasodilatiion and tachycardia.[1] • Starting norepinephrine before or with fluid resuscitation may reduce fluid needs at six hours, cumulative norepinephrine dose, time to target MAP, ventilator days, and mortality [Evidence level B-2].[10]
Inotropic agents For persistent hypoperfusion and cardiac dysfunction despite adequate volume and MAP.[1]	• Epinephrine is suggested in place of norepinephrine.[1] • Dobutamine can be added to norepinephrine.[1]		
Midodrine For patients with ongoing need for vasopressors.	• Consider 10 mg every 8 hours.[21]	NA	• Most often used in stable patients to assist with vasopressor weaning.[1] Less commonly used to avoid starting vasopressors in mild shock.[1]
VTE Prophylaxis For patients with sepsis or septic shock.[1]	• LMWH (preferred) or UFH is recommended, unless contraindicated.[1] • Use mechanical prophylaxis if pharmacologic prophylaxis is contraindicated.[1]	NA	• Dalteparin (Fragmin) or UFH is preferred if CrCl <30 mL/min.[15] • There is no clear benefit of combining pharmacologic with nonpharmacologic prophylaxis.[1]
Insulin Glucose level ≥180 mg/dL (10 mmol/L).[1]	• Use an insulin infusion in critically ill patients.[6]	• Target glucose 140 to 200 mg/dL (7.8 to 11.1 mmol/L).[6] • Monitor glucose continuously or at least hourly while glucose levels are unstable.[6]	• Glucose targets were chosen to minimize the risk of hypoglycemia.[6]
Sodium bicarbonate Suggested for septic shock with blood pH ≤7.2, and AKIN score 2 or 3.[1]	• Consider sodium bicarbonate 4.2%, 125 to 250 mL over 30 min. Max 1,000 mL within 24 hours.[4]	• Target arterial pH ≥7.3.[4]	• Guidelines suggest against use for lactic acidemia due to hypoperfusion, to improve hemodynamics or to reduce vasopressor needs.[1] • Does not seem to reduce mortality, but is associated with lower use of KRT [Evidence level B-1].[4]
Stress Ulcer Prophylaxis Suggested for patients with risk factors for GI bleed.[1]	• Proton pump inhibitors preferred.[1]	NA	• Proton pump inhibitors pose a higher risk of *Clostridioides difficile* colitis than H2 blockers. Limiting use to 14 days may mitigate risk[16]
Corticosteroids Suggested for septic shock[1]	• Consider hydrocortisone 50 mg IV every six hours (most commonly) or 200 mg/day as a continuous infusion.[1,7] In the largest RCT (ADRENAL), duration was 7 days.[1] • Can also add fludrocortisone • 50 mcg x 7 days or until ICU discharge.[7]	• Cortisol and ACTH are not useful to help determine which septic patients will respond to steroids.[15]	• Corticosteroids have small to moderate benefits on LOS, mortality, shock duration, and organ function.[1,7] • Continuous infusion preferred over boluses to minimize hyperglycemia.[15]
Blood Transfuse when hemoglobin <7 g/dL (or higher in extenuating circumstances [e.g., ACS, hemorrhage, etc]).[11]	NA	• Hemoglobin	• Recommendation based on the TRISS, TRICC, and TRICOP studies.[11]
Vitamin C Suggested **against** in current guidelines.[1]	• 50 mg/kg in 50 mL D5W every six hours for 96 hours has been used.[5]	NA	• No effect on mortality.[1] • Any benefit on duration of vasopressor use is very small.[1]
Methylene blue Sometimes used as rescue therapy for hypotension refractory to vasopressors.[1]	• 1 to 2 mg/kg in 50 mL D5W infused over 5 to 30 minutes.[1,19] May repeat after one hour if needed.[1]	MAP	• Not proven to improve survival.[1] • Increases vascular tone by inhibiting nitric oxide synthase and soluble guanylate cyclase.[1]
Selective decontamination of GI tract Suggested in mechanically ventilated patients with sepsis or septic shock if unit has a low prevalence of antimicrobial resistance.	• Typically, tobramycin, colistin, and amphotericin B or nystatin are administered topically in the oropharynx as a suspension and oral paste every six hours, plus a short-course (e.g., four-days) of a broad spectrum IV antibiotic (e.g., third-generation cephalosporin).[1,17,18] • Suspension and oral paste must be compounded.	• Consider monitoring trough tobramycin levels and reducing the dose if level is >1 mg/L.[20]	• May reduce mortality by reducing ventilator-associated pneumonia and bacteremia.[1] • Does not seem to increase antimicrobial resistance.[1]

a. **Screening**: Suspect sepsis in acutely ill, high-risk patients.[1] Screening can event be done in the ambulance or helicopter.[1] Tools include SIRS criteria, NEWS, NEW2, or MEWS.[1] One of the EWS variants may be the most clinically useful.[8] qSOFA should not be used alone due to poor sensitivity.[1] A blood lactate level is also suggested.[1]

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Abbreviations: ACTH = adrenocorticotrophic hormone; ACS = acute coronary syndrome; AKIN = Acute Kidney Injury Network; BMI = body mass index; CO = cardiac output; CVP = central venous pressure; EWS = Early Warning Score; GI = gastrointestinal; IBW = ideal body weight; ICU = intensive care unit; KRT = kidney replacement therapy; LMWH = low-molecular-weight heparin; LOS = length of stay; IV = intravenous; LR = Lactated Ringer's; MAP = mean arterial pressure; MDR = multidrug resistant; MEWS = Modified Early Warning Score; MRSA = methicillin-resistant Staphylococcus aureus; NA = not applicable; NEWS = National Early Warning Score; NS = normal saline; SBP = systolic blood pressure; SIRS = systemic inflammatory response syndrome; qSOFA = quick Sequential Organ Failure Assessment; SV = stroke volume; TBI = traumatic brain injury; UFH = unfractionated heparin; VTE = venous thromboembolism

Levels of Evidence

Level	Definition	Study Quality
A	Good-quality patient-oriented evidence.*	1.High-quality randomized controlled trial (RCT) 2.Systematic review (SR)/Meta-analysis of RCTs with consistent findings 3.All-or-none study
B	Inconsistent or limited-quality patient-oriented evidence.*	1.Lower-quality RCT 2.SR/Meta-analysis with low-quality clinical trials or of studies with inconsistent findings 3.Cohort study 4.Case control study
C	Consensus; usual practice; expert opinion; disease-oriented evidence (e.g., physiologic or surrogate endpoints); case series for studies of diagnosis, treatment, prevention, or screening.	

*Outcomes that matter to patients (e.g., morbidity, mortality, symptom improvement, quality of life).
[Adapted from Ebell MH, Siwek J, Weiss BD, et al. Strength of Recommendation Taxonomy (SORT): a patient-centered approach to grading evidence in the medical literature. Am Fam Physician 2004;69:548-56. https://www.aafp.org/pubs/afp/issues/2004/0201/p548.html.]

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Vasopressors for Shock

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The first chart below addresses choice of vasopressor for different shock states. For dosing and additional drug information (e.g., pharmacology), see the second chart, below.
Interactive note: Roll over **blue text** to view additional information.

Clinical Scenario	Preferred Vasopressors
Cardiogenic shock	• Initial vasopressor choice depends on whether patient is hypotensive or normotensive.[1] • If hypotensive (e.g., MAP ≤65 mmHg, SBP <90 mmHg, evidence of hypoperfusion):[1] » Start with **norepinephrine**.[1] » Add **doB**utamine or **milrinone** to address low CO.[1] • If blood pressure is preserved, but CO is low:[1] » Start with **doB**utamine or **milrinone**.[1] » Add **norepinephrine** if hypotension develops.[1] • For persistent hypotension, consider vasopressin.[1] • **Special situations**: aortic regurgitation (norepinephrine or epinephrine), aortic stenosis (norepinephrine [phenylephrine if systolic function is preserved]), mitral stenosis (phenylephrine +/- vasopressin).[29]
Septic shock	• **Norepinephrine** (first-line).[4] » If norepinephrine is not available, consider **epinephrine** or **doP**amine.[4] • Consider adding **vasopressin** if MAP target (65 mmHg) not achieved with norepinephrine 0.25 to 0.5 mcg/kg/min.[4] • Consider adding epinephrine for refractory hypotension.[4] • **Angiotensin II** could be used as an adjunct in refractory shock or to limit norepinephrine dose.[4,5] » Based on study population, consider for patients who are hypotensive despite fluid and pressors (e.g., NE, vasopressin, EPI) at a median "NE equivalent" dose of 0.33 mcg/kg/min.[6] • For cardiac dysfunction and hypoperfusion after optimization of volume and MAP, consider **adding doB**utamine to norepinephrine, or **switching to epinephrine alone**.[4] • See our chart, *Sepsis Management in Adults: Pharmacotherapy Focus*, for more information.
Anaphylactic shock	• Epinephrine[3] • Angiotensin II (adjunct[7,8]) » FDA-approved for distributive shock, but most patients in the major clinical trial had septic shock.[6,7]

Drug	Dosing (also see footnotes a and b)	Comments/Pharmacology
Angiotensin II (*Giapreza*)	• Note that dosing is in **NANO**grams/kg/min. • See product information for dosing.	• Causes vasoconstriction and aldosterone release.[7] • May reduce mortality in certain patient subsets (e.g., patients with acute kidney injury requiring kidney replacement therapy or higher renin concentrations).[5] • Has not been studied first-line or compared to other add-on pressors. • Consider for distributive shock refractory to vasopressin or epinephrine.[20]
DoButamine	• Initial 2.5 to 5 mcg/kg/min.[13] • Titration 2.5 to 5 mcg/kg/min every 5 to 15 min.[13] • Max 20 mcg/kg/min.[9]	• Clinical effects depend on dose and baseline physiologic state.[4,13] • Less arrhythmogenic than dopamine.[11] • Tolerance may develop, necessitating dosage increase to get the same effect.[12]
DoPamine	• Initial 2 to 5 mcg/kg/min.[2] • Titration 2 to 5 mcg/kg/min every 5 to 15 minutes.[13] • Max 20 mcg/kg/min.[13] • Septic shock (range) 2 mcg/kg/min to 20 mcg/kg/min)	• Associated with higher risk of arrhythmia and death in septic and cardiogenic shock vs. NE.[1,4,9] • Higher risk of tachycardia and arrhythmias compared to doButamine, milrinone, or EPI.[13] • Beta-1 activity may be useful to increase CO, but arrhythmia risk limits use.[4] • Pharmacologic effects are dose-dependent.
Epinephrine	• Initial 0.02 to 0.05 mcg/kg/min.[13] • Titration 0.02 to 0.05 mcg/kg/min every 5 to 15 min.[13] • **Septic shock** (usual dose) 0.1 to 0.3 mcg/kg/min.[28] • **Cardiogenic shock** (usual dose) 0.01 to 0.5 mcg/kg/min.[9] • **Anaphylactic shock** 5 to 15 mcg/min.[14]	• A continuous infusion is recommended for anaphylaxis refractory to two intermittent EPI doses (IM or IV) and fluid resuscitation.[3,10] • Has more beta-agonist activity than norepinephrine.[20] • Pharmacologic effects are dose-dependent. • EPI impairs splanchnic perfusion compared to NE or dopamine.[13] • Increases glucose.[15] • EPI can increase lactate levels.[15] Due to downregulation of beta-1 receptors, EPI effect on lactate diminishes after 12 hours.[15]

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Vasopressors for Shock

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Drug	Dosing (also see footnotes a and b)	Comments/Pharmacology
Midodrine	• Initial 10 mg every 8 hours.[24] • Titration 10 mg/dose.[26] • Max 40 mg every 8 hours.[26] • Decrease by 5 to 10 mg/day if BP stays at goal off vasopressor for 24 hours.[26]	• Alpha-1 agonist.[27] Increases BP.[27] May cause reflex bradycardia.[27] • Used to help discontinue IV vasopressors.
Milrinone	• Usual dose 0.125 to 0.75mcg/kg/min.[9] • Sometimes a 50 mg/kg bolus is given, but may cause hypotension.[9,13]	• Phosphodiesterase-3 inhibitor.[13] Increases CO, decreases SVR.[9] • Reduces SVR, PVR, and PCWP more than doButamine.[9,13] » More likely to cause hypotension than doButamine.[13] • Lower risk of tachycardia and arrythmias than doButamine.[13] • Consider over dobutamine in patients who have recently received a beta-blocker.[13] • Longer half-life than dobutamine, so harder to titrate.[13] • Requires renal dose reduction in kidney impairment.[13]
Norepinephrine	• Initial 0.01 to 0.04 mcg/kg/min.[13] • Titration 0.02 to 0.04 mcg/kg/min every 5 to 15 min.[13] • **Septic shock** (range) 0.02 to 0.19 mcg/kg/min.[16] • **Cardiogenic shock** (usual dose) 0.05 to 0.4 mcg/kg/min.[9]	• **For septic shock**: » Consider adding another pressor when dose nears 0.3 mcg/kg/min.[4,17] » Doses ≥1 mcg/kg/min are associated with higher mortality.[30] • Predominately an alpha agonist.[13] Increases SVR and MAP.[1,4] • Some beta-1 agonist effect, which increases CO.[13] Little effect on HR except at high doses.[4,13] • Lower risk of tachyarrhythmias than doPamine or EPI.[13] • Associated with lower risk of arrhythmia and death in septic and cardiogenic shock compared to **doP**amine.[1,4,9]
Phenylephrine	• Initial 0.1 to 0.3 mcg/kg/min.[13] • Titration 0.1 to 0.4 mcg/kg/min every 5 to 15 min.[13] • Cardiogenic shock (usual dose), 0.1 to 10 mcg/kg/min.[9]	• Alpha-1 agonist.[13] Increases SVR and MAP.[13] • Can reduce CO and HR (due to increased afterload and reflex bradycardia).[1,13,18] • In septic shock, associated with higher mortality than NE.[20] • Consider a max of 1.5 to 2 mcg/kg/min to limit tissue ischemia.[13] • No survival advantage vs NE for septic shock.[19] • Consider for distributive shock refractory to NE, vasopressin, or EPI.[20]
Vasopressin	• **Septic shock**, 0.03 units/min (fixed dose).[4] • **Cardiogenic shock** (usual dose), 0.02 to 0.04 units/min.[9]	• A vasoconstrictor.[20] • In **septic shock**, dose can be increased to 0.06 units/min., but ischemic risk may be > benefit.[4,13,21] • For **septic shock**, consider starting when NE dose reaches 0.25 to 0.5 mcg/kg/min for NE-sparing effect to reduce tachycardia and arrhythmias [Evidence Level A-1].[4,20,21] • Limited data suggest vasopressin use may be associated with lower mortality in septic shock at 90 days.[20] • Reduces risk of atrial fibrillation when used with a catecholamine vasopressor (e.g., NE) in **distributive shock**.[22] • No outcomes data in cardiogenic shock. • Consider the patient's dose and use an appropriate bag size to minimize waste.

Abbreviations: BP = blood pressure; CO = cardiac output; EPI = epinephrine; HR = heart rate; MAP = mean arterial pressure; NE = norepinephrine; PCWP = pulmonary capillary wedge pressure; PVR = pulmonary vascular resistance; SBP = systolic blood pressure; SVR = systemic vascular resistance

Footnotes:

a. **Goals** of therapy for shock: achieve and maintain adequate tissue perfusion.[9] Consider a MAP target of 65 mmHg in adults based on data from other populations (recommended in septic shock).[4,9] Balance MAP target with vasopressor side effects (e.g., arrhythmias, myocardial ischemia).[9] Some markers to consider include lactate, mixed or central venous oxygen saturation, urine output, serum creatinine, liver function tests, cognitive function, and temperature.[4,9,20] Individualize targets.[9]

b. **Dosing**. Doses are variable and not well-defined for most indications. Assess and correct volume status before using IV vasopressors.[20] To minimize side effects (e.g., myocardial or other organ ischemia, arrhythmias), use vasopressors for the shortest time at the lowest dose necessary to maintain organ function.[13,25]

Vasopressors for Shock

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Levels of Evidence:
In accordance with our goal of providing Evidence-Based information, we are citing the **LEVEL OF EVIDENCE** for the clinical recommendations we publish.

Level	Definition	Study Quality
A	Good-quality patient-oriented evidence.*	1. High-quality randomized controlled trial (RCT) 2. Systematic review (SR)/Meta-analysis of RCTs with consistent findings 3. All-or-none study
B	Inconsistent or limited-quality patient-oriented evidence.*	1. Lower-quality RCT 2. SR/Meta-analysis with low-quality clinical trials or of studies with inconsistent findings 3. Cohort study 4. Case control study
C	Consensus; usual practice; expert opinion; disease-oriented evidence (e.g., physiologic or surrogate endpoints); case series for studies of diagnosis, treatment, prevention, or screening.	

***Outcomes that matter to patients** (e.g., morbidity, mortality, symptom improvement, quality of life).
[Adapted from Ebell MH, Siwek J, Weiss BD, et al. Strength of Recommendation Taxonomy (SORT): a patient-centered approach to grading evidence in the medical literature. Am Fam Physician 2004;69:548-56.
https://www.aafp.org/pubs/afp/issues/2004/0201/p548.html.]

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Hospital-Acquired and Ventilator-Associated Pneumonia: FAQs

The FAQ below addresses common questions pertaining to treatment of hospital-acquired and ventilator-associated pneumonia, with a focus on antibiotic treatment. Unless otherwise referenced, the information is based on 2016 IDSA/ATS guidelines (reference 1) which are available in their entirety at https://www.thoracic.org/statements/resources/tb-opi/hap-vap-guidelines-2016.pdf.

Clinical Question	Pertinent Information or Suggested Approach
What are HAP and VAP?	ATS/IDSA guidelines define HAP and VAP as follows: • HAP: pneumonia that occurs 48 hours or more after admission, that is not associated with mechanical ventilation, and that was not incubating at the time of admission. • VAP: pneumonia that occurs more than 48 hours after intubation.
Must antibiotics be started immediately in patients with VAP or HAP?	• One strategy in stable patients involves starting antibiotics in patients with a pulmonary infiltrate plus at least two of the following: fever, productive cough, or leukocytosis.[2] This "clinical strategy" may lead to inappropriately broad antimicrobial coverage, longer treatment duration, and increased in-hospital mortality compared to waiting for results of lower respiratory tract sample quantitative culture ("bacteriologic strategy").[2]

What testing is used to inform antibiotic management for a patient with suspected VAP or HAP?	• VAP: non-invasive sampling (i.e., endotracheal aspiration) with semiquantitative cultures is preferred over invasive sampling with quantitative cultures.
	  ○ **If bronchoscopy with quantitative cultures is performed**, it is suggested that antibiotics be withheld if the culture results are below the diagnostic threshold, but keep clinical findings/circumstances in mind.
	• HAP: use of microbiologic studies of samples obtained non-invasively (sputum expectoration or induction, nasotracheal suction [if patient can't cooperate], endotracheal aspiration [in HAP patient who subsequently requires mechanical ventilation]) is preferred over empiric treatment. Invasive sampling might be appropriate in some situations.
	• Blood cultures are appropriate for patients with suspected HAP or VAP.
	• Procalcitonin testing can help support the decision to discontinue antibiotics in conjunction with clinical judgment.[2]
	  ○ Examples: in a patient with suspected viral pneumonia (positive PCR), an elevated procalcitonin supports continuing the antibiotic because it suggests bacterial co-infection, but a low or negative result supports the decision to discontinue the antibiotic. In a patient with a history of heart failure who improves with diuresis, a negative procalcitonin supports antibiotic discontinuation.[2]

Clinical Question	Pertinent Information or Suggested Approach
What organisms should be covered empirically?	• *Pseudomonas aeruginosa*, other gram-negative bacilli, and *Staphylococcus aureus*.
What is the role of the hospital antibiogram in empiric antibiotic selection?	• Choose an empiric regimen based on what organisms are usually associated with HAP and VAP in your institution, and VAP- and HAP-specific antibiograms, when available.
Is empiric coverage for anaerobes suggested?	• Even if aspiration is involved, anaerobic coverage is not routinely needed because gram negative pathogens become the dominant oral flora in most hospital patients within 48 hours.[2]
When is empiric MRSA coverage suggested?	• VAP: treatment in a unit where >10% to 20% of *S. aureus* isolates are MRSA (or prevalence is unknown), and in patients with a risk factor for multidrug-resistant organisms (see next section, below). • HAP: prior antibiotic use within 90 days, treatment in a unit where >20% of *S. aureus* isolates are MRSA (or prevalence is unknown), patient is septic, or patient requires mechanical ventilation for HAP. • A PCR nasal swab for MRSA colonization can help guide the decision to discontinue MRSA coverage, especially in HAP.[2]
What are the risk factors for multidrug-resistant organisms?	• VAP: intravenous antibiotic use within 90 days, septic shock at VAP onset, adult respiratory distress syndrome, acute kidney failure, or hospitalization for five days or more preceding VAP. • HAP: intravenous antibiotic use within 90 days.
When empiric MRSA coverage is needed, what antibiotics are suggested?	• Vancomycin 15 mg/kg (consider a loading dose of 25 to 30 mg/kg for severe illness) every 8 to 12 hours (assuming normal kidney function). Adjust dose based on levels. See our FAQ, *Vancomycin Dosing and Monitoring for Adults*. OR • Linezolid 600 mg IV every 12 hours. • When choosing between agents, consider concomitant use of serotonergic agents (i.e., with linezolid), blood count, kidney function, and cost.

Clinical Question	Pertinent Information or Suggested Approach
Which antibiotics cover methicillin-sensitive *S. aureus* (MSSA)?	• Although oxacillin, nafcillin, and cefazolin are preferred for empiric coverage of MSSA, they are not usually used empirically because other antibiotics typically used empirically to provide gram-negative coverage also cover MSSA. Piperacillin/tazobactam, cefepime, levofloxacin, imipenem, or meropenem should cover MSSA.
What empiric antibiotic regimens are suggested for VAP?	• Choose one of the following (doses are for **normal kidney and liver function**; **extended infusions** may be appropriate for beta-lactams, except aztreonam) to cover gram negatives (including *Pseudomonas*) and MSSA: o piperacillin-tazobactam 4.5 g IV every 6 hours. o cefepime 2 g IV every 8 hours. o levofloxacin 750 mg IV every 24 hours. o meropenem 1 g IV every 8 hours. o imipenem 500 mg IV every 8 hours (patients <70 kg may require smaller dose due to seizure risk). • If MRSA coverage (vancomycin or linezolid) is added (see indications, above), this allows for a few more options for gram-negative/pseudomonal coverage: ceftazidime 2 g IV every 8 hours, ciprofloxacin 400 mg IV every 8 hours, or aztreonam 2 g IV every 8 hours. o Note: these three agents do not cover *S. aureus*. • Use of **two antipseudomonals** from different antimicrobial classes are recommended in suspected VAP patients with a risk factor for multidrug resistance (see above), patients treated in units where >10% of gram-negatives are resistant to one of the antibiotics considered for monotherapy, patients treated in units where antibiogram data are unavailable, or in patients with structural lung disease (e.g., bronchiectasis, cystic fibrosis).
What empiric antibiotic regimens are suggested for HAP?	• Choose one of the following (doses are for **normal kidney and liver function**; **extended infusions** may be appropriate for beta-lactams, except aztreonam) to cover gram-negatives (including *Pseudomonas*) and MSSA: o piperacillin-tazobactam 4.5 g IV every 6 hours. o cefepime 2 g IV every 8 hours. o levofloxacin 750 mg IV every 24 hours. o meropenem 1 g IV every 8 hours. o imipenem 500 mg IV every 8 hours (patients <70 kg may require smaller dose due to seizure risk). • If MRSA coverage (vancomycin or linezolid) is added (see indications, above), this allows for a few more options for gram-negative/pseudomonal coverage: ceftazidime 2 g IV every 8 hours, ciprofloxacin 400 mg IV every 8 hours, or aztreonam 2 g IV every 8 hours. o Note that these three agents do not cover *S. aureus*. • Use of **two antipseudomonals** from different antimicrobial classes (avoiding use of two beta-lactams) are recommended in suspected HAP patients at high risk of mortality (sepsis; requires mechanical ventilation for HAP), structural lung disease (e.g., bronchiectasis, cystic fibrosis), or IV antibiotic use within 90 days, especially if a high-quality gram stain shows predominant, numerous gram-negative rods).

Clinical Question	Pertinent Information or Suggested Approach
For how long should antibiotics be continued in VAP or HAP?	• Seven days total.

Abbreviations: ATS = American Thoracic Society; HAP = hospital-acquired pneumonia; IDSA = Infectious Diseases Society of America; IV = intravenously; MRSA = methicillin-resistant *Staphylococcus aureus*; MSSA = methicillin-sensitive *Staphylococcus aureus*; PCR = polymerase chain reaction; VAP = ventilator-associated pneumonia.

Users of this resource are cautioned to use their own professional judgment and consult any other necessary or appropriate sources prior to making clinical judgments based on the content of this document. Our editors have researched the information with input from experts, government agencies, and national organizations. Information and internet links in this article were current as of the date of publication.

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