# Antibiotics for ventriculitis treatment

- Escherichia coli Pyogenic Ventriculitis in an Infant Following Abdominal Surgery: A Rare Case Report
- Gas, Larvae, Coagulopathy, and a Rare Culprit: Emphysematous Cystitis and Enterococcus raffinosus Ventriculitis Triggered by Strongyloides Hyperinfection Syndrome
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Some new antibiotics are gradually being used in the clinic, but due to the complicated drug-resistant mechanism of carbapenem-resistant Enterobacteriaceae (CRE) and the obstruction of the blood-brain barrier (BBB), the therapeutic effect is still very poor [1)].

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Empiric antibiotics: initiate if ventriculitis is suspected once the appropriate sampling has been obtained

○ If no penicillin allergy:

– vancomycin as a continuous infusion or divided doses (2–3) of 60 mg per kg of body weight per day after a loading dose of 15 mg per kg of body weight, aiming for trough (15–25 mcg/ ml) PLUS – ceftazidime 2 g IV q 8 hrs or cefepime 2 g IV q 8 hrs

○ For penicillin allergy:

– vancomycin as a continuous infusion or divided doses (2–3) of 60 mg per kg of body weight per day after a loading dose of 15 mg per kg of body weight PLUS – meropenem 2 g IV q 8 hrs or aztreonam 2 g IV q 6 hrs

● Switch to more selective agents as appropriate, based on culture and susceptibility when they become available

● Duration of treatment should be individualized to the patient, but as a rule of thumb: treat for 2 weeks if the infection was with S. aureus and S. epidermidis, and 3 weeks if it was gram-negative [2)].

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1)Intraventricular administration of proper antibiotics is a reliable and effective way to treat

ventriculitis associated with ventriculoperitoneal shunts. (2)Vancomycin is the preferred antibiotic for ventriculitis, but other kind(s) of some antibiotics are necessary in a few patients in addition to or instead of vancomycin. (3)The effect of systemic use of antibiotics could not be defined in this series of patients, but this may be used as an adjunct in the practice. (4)There are many problems related to diagnosis and treatment of shunt ventriculitis that should be studied more extensively and deeply [3].

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The emergence of multidrug-resistant pathogens has resulted in difficult-to-treat ventriculitis/meningitis (VM). A meta-analysis aimed to study the role of intraventricular antibiotic administration as an adjunct (IVT plus IV) to the classical intravenous antimicrobial chemotherapy (IV-only) in the management of VM in terms of infection control (Q1), functional outcome (Q2), microbial eradication (Q3), complications (Q4), cost-benefit analysis (Q5), infectious mortality (Q6), and overall mortality (Q7).

The electronic search focused on adult neurosurgical patients, complicated by Gram-negative VM and was limited to studies comparing IVT plus IV to IV-only. The quality of the overall body of evidence was assessed according to the GRADE working group. The pooled estimates for each question were summarized in odds ratios and visualized by forest plots. Every outcome was stratified according to carbapenem-resistance.

Eleven studies with 348 patients fulfilled the eligibility criteria. No evidence existed regarding Q1, Q2, Q4 and Q5 question. For the remaining questions, the overall quality of the best available evidence was low. IVT plus IV treatment was statistically superior to the IV-only therapy in terms of eradication [OR: 10.06 (95% CI: 2.62, 38.65)], infectious mortality [OR: 0.1 (95% CI: 0.03, 0.36)], and overall mortality [OR: 0.22 (95 % CI: 0.08, 0.60)] in the management of carbapenem-resistant pathogens, only.

The combined IVT plus IV treatment has not proved to be superior to the standard IV treatment in the management of VM. Nevertheless, there is weak evidence that IVT treatment may serve as an adjunct in the management of carbapenem-resistant pathogens [4].

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Vancomycin plus an anti-pseudomonal beta-lactam (such as cefepime, ceftazidime, or meropenem) is recommended as empiric therapy for healthcare-associated ventriculitis and meningitis; the choice of empiric beta-lactam agent should be based on local in vitro susceptibility patterns (strong, low).

In seriously ill adult patients with healthcare-associated ventriculitis and meningitis, the vancomycin trough concentration should be maintained at 15–20 µg/mL in those who receive intermittent bolus administration (strong, low).

For patients with healthcare-associated ventriculitis and meningitis who have experienced anaphylaxis to betalactam antimicrobial agents and in whom meropenem is contraindicated, aztreonam or ciprofloxacin is recommended for gram-negative coverage (strong, low).

For patients with healthcare-associated ventriculitis and meningitis who are colonized or infected elsewhere with a highly antimicrobial-resistant pathogen, adjusting the empiric regimen to treat for this pathogen is recommended (strong, low).

For treatment of infection caused by methicillin-susceptible S. aureus, nafcillin or oxacillin is

recommended (strong, moderate). If the patient cannot receive beta-lactam agents, the patient can be desensitized or may receive vancomycin as an alternative agent (weak, moderate).

For treatment of infection caused by methicillin-resistant S. aureus, vancomycin is recommended as first-line therapy (strong, moderate), with consideration for an alternative antimicrobial agent if the vancomycin minimal inhibitory concentration (MIC) is ≥1 µg/mL (strong, moderate).

For treatment of infection caused by coagulase-negative staphylococci, the recommended therapy should be similar to that for S. aureus and based on in vitro susceptibility testing (strong, moderate).

If the staphylococcal isolate is susceptible to rifampin, this agent may be considered in combination with other antimicrobial agents for staphylococcal ventriculitis and meningitis (weak, low); rifampin is recommended as part of combination therapy for any patient with intracranial or spinal hardware such as a CSF shunt or drain (strong, low).

For treatment of patients with healthcare-associated ventriculitis and meningitis caused by staphylococci in whom beta-lactam agents or vancomycin cannot be used, linezolid (strong, low), daptomycin (strong, low), or trimethoprim-sulfamethoxazole (strong, low) is recommended, with selection of a specific agent based on in vitro susceptibility testing.

For treatment of infection caused by Propionibacterium acnes, penicillin G is recommended (strong, moderate).

For treatment of infection caused by gram-negative bacilli, therapy should be based on in vitro susceptibility testing with agents that achieve good CNS penetration (strong, moderate).

For treatment of infection caused by gram-negative bacilli susceptible to third-generation cephalosporins, ceftriaxone or cefotaxime is recommended (strong, moderate).

For treatment of infection caused by Pseudomonas species, the recommended therapy is cefepime, ceftazidime, or meropenem (strong, moderate); recommended alternative antimicrobial agents are aztreonam or a fluoroquinolone with in vitro activity (strong, moderate).

For treatment of infection caused by extended-spectrum beta-lactamase–producing gram-negative bacilli, meropenem should be used if this isolate demonstrates in vitro susceptibility (strong, moderate).

For treatment of infection caused by Acinetobacter species, meropenem is recommended (strong, moderate); for strains that demonstrate carbapenem resistance, colistimethate sodium or polymyxin B (either agent administered by the intravenous and intraventricular routes) is recommended (strong, moderate).

Prolonged infusion of meropenem (each dose administered over 3 hours) may be successful in treating resistant gram-negative organisms (weak, low).

For treatment of infection caused by Candida species, based on in vitro susceptibility testing, liposomal amphotericin B, often combined with 5-flucytosine, is recommended (strong, moderate); once the patient shows clinical improvement, therapy can be changed to fluconazole if the isolated species is susceptible (weak, low).

For treatment of infection caused by Aspergillus or Exserohilum species, voriconazole is recommended (strong, low).

VII. What is the Role of Intraventricular Antimicrobial Therapy in Patients with Healthcare-Associated Ventriculitis and Meningitis?

55. Intraventricular antimicrobial therapy should be considered for patients with healthcare-associated ventriculitis and meningitis in which the infection responds poorly to systemic antimicrobial therapy alone (strong, low).

56. When antimicrobial therapy is administered via a ventricular drain, the drain should be clamped for 15–60 minutes to allow the agent to equilibrate throughout the CSF (strong, low).

57. Dosages and intervals of intraventricular antimicrobial therapy should be adjusted based on CSF antimicrobial concentrations to 10–20 times the MIC of the causative microorganism (strong, low), ventricular size (strong, low), and daily output from the ventricular drain (strong, low). VIII. What is the Optimal Duration of Antimicrobial Therapy in Patients with Healthcare-Associated Ventriculitis and Meningitis?

58. Infections caused by a coagulase-negative staphylococcus or P.  acnes with no or minimal CSF pleocytosis, normal CSF glucose, and few clinical symptoms or systemic features should be treated for 10 days (strong, low).

59. Infections caused by a coagulase-negative staphylococcus or P. acnes with significant CSF pleocytosis, CSF hypoglycorrhachia, or clinical symptoms or systemic features should be treated for 10–14 days (strong, low).

60. Infections caused by S. aureus or gram-negative bacilli with or without significant CSF pleocytosis, CSF hypoglycorrhachia, or clinical symptoms or systemic features should be treated for 10–14 days (strong, low); some experts suggest treatment of infection caused by gram-negative bacilli for 21 days (weak, low).

61. In patients with repeatedly positive CSF cultures on appropriate antimicrobial therapy, treatment should be continued for 10–14 after the last positive culture (strong, low).

IX. What is the Role of Catheter Removal in Patients with Cerebrospinal Fluid Shunts or Drains?

62. Complete removal of an infected CSF shunt and replacement with an external ventricular drain combined with intravenous antimicrobial therapy is recommended in patients with infected CSF shunts (strong, moderate).

63. Removal of an infected CSF drain is recommended (strong, moderate).

64. Removal of an infected intrathecal infusion pump is recommended (strong, moderate).

65. Removal of infected hardware in patients with deep brain stimulation infections is recommended (strong, moderate).

X. How are Patients Monitored for Response to Treatment?

66. Patients with healthcare-associated ventriculitis and meningitis should be monitored for response to treatment based on clinical parameters (strong, low).

67. In patients with healthcare-associated ventriculitis and meningitis and an external drainage device, monitoring of CSF cultures is recommended to ensure that they become negative (strong, low).

68. In patients with no definitive clinical improvement, additional CSF analysis is recommended to ensure that the CSF parameters have improved and the cultures become negative (strong, low).

69. For external CSF drains not being used in the treatment of CSF shunt infection, daily CSF cultures and analysis are not recommended unless clinically indicated (strong, low).

XI. In Patients with Cerebrospinal Fluid Shunts Who Develop Ventriculitis and Meningitis, When can a New Shunt be Reimplanted?

70. In patients with infection caused by coagulase-negative staphylococci or P.  acnes, with no associated CSF abnormalities and with negative CSF cultures for 48 hours after externalization, a new shunt should be reimplanted as soon as the third day after removal (strong, low).

71. In patients with infection caused by a coagulase-negative staphylococcus or P. acnes, with associated CSF abnormalities but negative repeat CSF cultures, a new shunt should be reimplanted after 7 days of antimicrobial therapy (strong, low); if repeat cultures are positive, antimicrobial treatment is recommended until CSF cultures remain negative for 7–10 consecutive days before a new shunt is placed (strong, low).

72. In patients with infection caused by S. aureus or gram-negative bacilli, a new shunt should be reimplanted 10  days after CSF cultures are negative (strong, low).

73. A period off antimicrobial therapy is not recommended to verify clearing of the infection before shunt reimplantation (strong, low).

XII. What is the Best Approach to Prevent Infection in Patients Who are Receiving Cerebrospinal Fluid Shunts?

74. Periprocedural prophylactic antimicrobial administration is recommended for patients undergoing CSF shunt or drain insertion (strong, moderate).

75. Periprocedural prophylactic antimicrobial administration is recommended for patients undergoing placement of external ventricular drains (strong, moderate).

76. Prolonged antimicrobial prophylaxis for the duration of the external ventricular drain is of uncertain benefit and not recommended (strong, moderate).

77. Use of antimicrobial-impregnated CSF shunts and CSF drains is recommended (strong, moderate).

78. In patients with external ventricular drains, fixed interval exchange is not recommended (strong, moderate).

79. Use of a standardized protocol for insertion of CSF shunts and drains is recommended (strong, moderate).

XIII. Is there a Role for Prophylactic Antimicrobial Therapy in Patients Undergoing Neurosurgery or in those with Cerebrospinal fluid fistula?

80. For neurosurgical patients, perioperative antimicrobial agents are recommended to prevent

infections of the incision (strong, high).

81. In patients with basilar skull fractures and a Cerebrospinal fluid fistula, prophylactic antimicrobial agents are not recommended (strong, moderate).

82. In patients with basilar skull fractures and a prolonged CSF leakage (>7 days), an attempt to repair the leak is recommended (strong, low).

83. In patients with basilar skull fractures and a Cerebrospinal fluid fistula, pneumococcal vaccination is recommended (strong, moderate).

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Li C, Zhou P, Liu Y, Zhang L. Treatment of Ventriculitis and Meningitis After Neurosurgery Caused by Carbapenem-Resistant Enterobacteriaceae (CRE): A Challenging Topic. Infect Drug Resist. 2023 Jun 15;16:3807-3818. doi: 10.2147/IDR.S416948. PMID: 37342434; PMCID: PMC10278654.
2)
The management of neurosurgical patients with postoperative bacterial or aseptic meningitis or external ventricular drain-associated ventriculitis. Infection in Neurosurgery Working Party of the British Society for Antimicrobial Chemotherapy. Br J Neurosurg. 2000; 14:7–12
3)
Li XY, Wang ZC, Li YP, Ma ZY, Yang J, Cao EC. [Study on treatment strategy for ventriculitis associated with ventriculoperitoneal shunt for hydrocephalus]. Zhongguo Wei Zhong Bing Ji Jiu Yi Xue. 2005 Sep;17(9):558-60. Chinese. PubMed PMID: 16146606.
4)
Karvouniaris M, Brotis AG, Tsiamalou P, Fountas KN. The Role of Intraventricular Antibiotics in the Treatment of Nosocomial Ventriculitis/Meningitis from Gram-Negative Pathogens: A Systematic Review and Meta-Analysis. World Neurosurg. 2018 Aug 29. pii: S1878-8750(18)31921-1. doi: 10.1016/j.wneu.2018.08.138. [Epub ahead of print] PubMed PMID: 30172065.