PRACTICAL SUMMARIES IN

ACUTE CARE

A Focused Topical Review of the Literature for the Acute Care Practitioner

What antibiotic should be used in a child with suspected meningitis? And when?

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Introduction

Despite advances in health care and access to more sophisticated diagnostic and treatment modalities, acute bacterial meningitis (ABM) remains a significant cause of morbidity and mortality within the pediatric population. Mortality figures range from 10% to 30%, morbidity 5%-40%.[1] Acute care physicians have the responsibility to rapidly identify and appropriately treat a child in whom ABM is suspected.

What is the current definition of *appropriate treatment* for ABM? Over the years, our treatment options have been altered by the development of vaccines, the emergence of antibiotic resistance, and completion of multiple studies. As a result, therapeutic modalities have been—and continue to be—in evolution. It is important to keep abreast of these recent changes so that cases of ABM can be treated quickly and effectively. In this article we will review the most recent literature concerning detection, treatment, and prognosis of one of the more devastating ailments in the pediatric population, and will present guidelines for treatment of ABM based upon the currently available evidence.

ABM's bugs & drugs

Source: Yogev R, et al. Bacterial meningitis in children: Critical review of current concepts. *Drugs* 2005; 65(8):1097-1112.

This article cites two important changes that have significantly altered the management and treatment of ABM. First the development of the *Haemophilus influenza* type b (Hib) vaccine has virtually eliminated Hib as a source of bacterial meningitis in the developed world. Recent reports note that the incidence of invasive Hib has decreased by 97% from 1987 to 1997. As a result, *Streptococcus pneumoniae* has become the most common pathogen beyond the neonatal period. A 1995 Centers for Disease Control and Prevention (CDC) study reported *S pneumoniae* as the most commonly identified agent (47%), along with *Neiserria meningitides* (25%) and Group B *Streptococcus* (12%) in children 3 months or older. Unfortunately, these changes are reflected only in developed countries.

The second major change is the emergence of penicillin and cephalosporin-resistant *S pneumoniae.* Although first reported in the late 1960s, multi-drug resistance is now common worldwide. This study cites a recent multicenter study showing 20% of *S pneumoniae* to be resistant to penicillin and 7% resistant to ceftriaxone. Therefore, the American Academy of Pediatrics (AAP) currently recommends a third-generation cephalosporin plus vancomycin as the standard first-line therapy for ABM beyond the neonatal period. The article details antibacterial therapy recommendations for children with ABM.

• ***Streptococcus pneumoniae:***

Vancomycin should never be used alone. At the time of the study, pneumococcal resistance to vancomycin had not

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been reported. Recently, reports of treatment failure with vancomycin as solo therapy in cases of *S pneumoniae* meningitis have emerged.

Rifampin has shown promise as an alternate drug to vancomycin, however, resistance can develop. Rifampin plus ceftriaxone has shown excellent bactericidal activity, even in cases of cephalosporin-resistant *S pneumoniae.* Rifampin has excellent penetration into the cerebrospinal fluid (CSF), even with adjuvant use of corticosteroids, leading some physicians to use this combination preferentially over vancomycin plus ceftriaxone. More studies are needed before this becomes the standard recommendation.

In vitro studies have shown that moxifloxacin is more effective than cephalosporins against Hib and *S pneumoniae*. In addition, the fluoroquinolones have excellent penetration into the CSF. Again, the drawback is rapid development of resistance. Thus, the FDA does not currently recommend fluoroquinolones for treatment of ABM in children unless standard therapies have failed.

Standard length of therapy for uncomplicated *S pneumoniae meningitis* is 10-14 days, although this is not evidence based. One small study showed no difference in outcome with 4- and 7-day courses of antibiotics. These are promising data for countries with limited resources and antibiotics, but more studies are needed before this therapy can be recommended.

• *Haemophilus influenza* type b:

Third-generation cephalosporins are the recommended first line of therapy.

The current length of therapy is 10 days for uncomplicated Hib meningitis, but data from shorter treatment periods have shown equal efficacy with 7 days. Length of therapy should be tailored to the response of the patient.

In underdeveloped countries, chloramphenicol is still in use, but resistance has become widespread.

• *Neiserria meningitides:*

N meningitides has documented penicillin resistance worldwide. A third-generation cephalosporin or chloramphenicol is the first line of therapy until sensitivities have been established.

Most studies recommend 7 days of therapy, although shorter courses of 3-4 days also have been shown to be effective. Again, therapy should be tailored to the response of the individual.

• *Corticosteroids:*

Persistent neurological sequelae are not uncommon in children who survive a case of ABM. In a meta-analysis of clinical trials published between 1988 and 1996, adjuvant use of corticosteroids showed a significant reduction in the number of children with permanent hearing loss following a bout of Hib meningitis. Significant benefit was not seen when corticosteroids were used in cases of pneumococcal meningitis.

Adjuvant steroid use is aimed at reducing the inflammatory response of the CSF in ABM. However, this inflammation may be of benefit because it weakens the blood brain barrier, allowing antibiotics such as vancomycin, to cross into the CSF.

Animal models of meningitis show that CSF vancomycin levels were reduced by 44%-77% when corticosteroids were given concurrently. Most studies citing benefit of corticosteroid use are focused on adult subjects.

Given that Hib meningitis is virtually non-existent in developed nations, and first-line therapy beyond the neonatal period is a third-generation cephalosporin plus vancomycin, corticosteroid use remains controversial.

Commentary

This is an excellent review article highlighting many of the critical issues surrounding ABM in children beyond the neonatal period. The bottom line is: Monotherapy is not recommended until culture sensitivities can verify efficacy of one antibiotic agent.

With the growing number of drug-resistant bacteria flourishing in our population, treatment should start with a third-generation cephalosporin plus vancomycin. Current recommended length of treatment may be excessive, however, the severity of the disease warrants a conservative approach. As stated previously, therapies should always be tailored to individual patient needs.

Bacterial vs aseptic meningitis

Source: Nigrovic LE, et al. Development and validation of a multivariable predictive model to distinguish bacterial

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from aseptic meningitis in children in the post-*Haemophilus influenza* era. *Pediatrics* 2002;110;712-719.

There is a great deal of overlap between the clinical presentations of bacterial and viral meningitis. Therefore, many children with meningitis often receive broad-spectrum antibiotics and admission to the hospital until CSF Gram stain and culture results are finalized.

This retrospective study attempted to develop a scoring system based upon variables and diagnostic tests readily available in the acute setting to distinguish between bacterial and aseptic meningitis. The authors reviewed the data of 696 children admitted for meningitis at Children's Hospital in Boston during an 8-year period. The group was randomized into two groups. Two-thirds comprised the derivation group from which the variables and scoring system were derived. The remaining one-third became the validation group subjected to the new scoring system.

Using two multivariate analysis techniques, they identified the following as independent predictors of ABM: Gram stain results, CSF protein of 80 mg/dL or greater, peripheral absolute neutrophil count (ANC) of 10,000 cells/mm^3 or more, seizure at or before presentation, and CSF ANC of 1000 cells/mm^3 or more. Based upon their data, they cited a positive Gram stain as the strongest independent predictor of ABM—approximately twice the magnitude; the remaining variables carried almost equal weight. Using these data, the authors created the Bacterial Meningitis Score (BMS) with a positive Gram stain result given a score of 2 and a score of 1 given to the remaining variables. The scale ranges from 0 to 6 points. The BMS scoring system then was applied to the validation group data. In the validation group, a BMS of 0 had a negative predictive value for bacterial meningitis of 100%. A BMS of 2 or higher was 87% sensitive in predicting ABM, with a positive predictive value of 87%. When applied to both groups, a BMS of 0 misidentified 2/404 (0.5%) patients who actually had ABM, one of whom had been pretreated with antibiotics before lumbar puncture (LP). Two subset analyses demonstrated similar efficacy of the scoring system when accounting for the anticipated reduction of *Pneumococcal meningitis* after Prevnar administration, and in children younger than 2 months.

Commentary

The tendency to admit and treat all children with an abnormal CSF count and the potential for bacterial meningitis with pending CSF culture results can be an emotional and financial burden to patients, families, and the health care system.

This study provides clinicians with a clinical decision-making tool that may help curtail the number of children who are admitted to the hospital and empirically treated with broad-spectrum antibiotics.

It was a well-designed retrospective study for several reasons. First the authors purposefully chose variables to create their BMS scoring system that were objective, available for analysis on initial presentation, and associated with ABM in previous studies. Also the authors adequately scrutinized their data using separate statistical techniques to substantiate the variables independently. Lastly, in an attempt to overcome the limitations of a retrospective study, they validated their model on a randomly selected subset, on their population as a whole, then on two subdivisions of their population with similar results. The model is applicable in most clinical settings and was demonstrated to distinguish those patients at high risk from those at low risk of ABM.

Sick or not sick?

Source: Bonsu BK, et al. A low peripheral blood white blood cell count in infants younger than 90 days increases the odds of acute bacterial meningitis relative to bacteremia. *Acad Emerg Med* 2004;11:1297-1301.

This article attempted to identify whether a high or low peripheral white blood cell (WBC) count could differentiate bacterial meningitis from bacteremia. The authors performed a retrospective review of consecutive infants aged 3 to 89 days, with fevers higher than 38°C, and who had undergone a sepsis work-up. The patient's age, blood culture results, CSF culture result, peripheral WBC counts, and CSF WBC counts were obtained from a review of the medical records. Infants with acute leukemia, and those younger than 48 hours were excluded from the study.

Their analysis demonstrated that infants with bacterial meningitis are seven times more likely to have peripheral WBC counts less than 5000 cells/mm^3 than those with bacteremia, and infants with peripheral WBC counts of 15,000 cells/mm^3 or higher are three times less likely to have bacterial meningitis versus bacteremia. Conversely, infants with peripheral WBC counts between the two extremes were shown to possess an equal chance of having bacterial meningitis versus bacteremia.

Commentary

The authors conceded that no single laboratory test cutoff should be used as a means for making a clinical decision. In an era where there has been increased movement toward treating febrile infants as outpatients, the authors were searching for a laboratory measure that would help determine which well-appearing febrile infants are suitable for discharge home with appropriate cultures, antibiotic therapy, and follow-up.

Although the authors could not define a direct relationship between the WBC count and illness severity, their results do imply that a change in WBC count outside the accepted normal range may correlate with bacteremia. The data obtained beg the age-old question: Does a laboratory test result truly augment a physician's clinical judgment? In patients with WBC counts less than 5000 cells/mm^3 who appear unwell, the low WBC count may be indicative of that patient's inability to mount an

appropriate immune response to their infection. Conversely, an elevated WBC count in an otherwise well-appearing child, may warrant further investigation for occult bacteremia. Laboratory findings should always be viewed as additional data used in conjunction with clinical judgment to enhance patient care. Neither laboratory findings nor clinical impression should be used alone if conflicting patterns are noted on comparison; however, in the context of children 3 months old and younger where physical examination sensitivity decreases, laboratory values may be the strongest factor dictating disposition.

Beyond the cell count and culture

Source: Bonsu BK, et al. Accuracy and test characteristics of ancillary tests of cerebrospinal fluid for predicting acute bacterial meningitis in children with low white blood cell counts in cerebrospinal fluid. *Acad Emerg Med* 2005; 12:303-309.

The purpose of this study was to analyze whether ancillary CSF tests actually aid in diagnosing ABM in children with low CSF WBC counts. The authors retrospectively reviewed CSF data from pediatric patients during a 6-year period who had CSF WBC counts less than 30 cells/mm^3. Because of the low case rate of bacterial meningitis, data were supplemented with CSF samples containing WBC counts less than 30 cells/mm^3 and a known diagnosis of bacterial meningitis. The ancillary tests evaluated included CSF protein (mg/dL) levels, CSF glucose (mg/dL) levels, and CSF percent neutrophils. Areas under the curve (AUC) values were used to determine whether the ancillary test discriminated between ABM and other diagnoses. Sensitivities and specificities were calculated at specific diagnostic thresholds, and likelihood ratios also were calculated for specific test intervals.

Their results showed that all three ancillary tests were able to discriminate between ABM and other diagnoses based on the authors' criteria. However, no single ancillary test showed both high sensitivity and high specificity for diagnosing ABM in cases of low WBC counts in CSF. Likelihood ratios did, however, indicate that a CSF protein level greater than 120 mg/dL, a CSF glucose level less than 20 mg/dL or greater than 120mg/dL and a CSF neutrophils count greater than 75% all increase the risk of ABM in children with CSF WBC counts less than 30 cells/mm^3.

Commentary

The authors confirmed the findings of previous studies that mildly abnormal ancillary test results do not aid in predicting ABM in children with CSF WBC counts less than 30 cells/mm^3. They did, however, show that highly abnormal results do increase the odds of ABM. Data from the study by Nigrovic and colleagues indicated that the strongest predictor of ABM is an abnormal Gram stain. Without an abnormal Gram stain, the authors of this study showed that the most significant abnormality regarding risk of ABM was a CSF neutrophil percentage greater than 75%. Although they used a low cutoff for AUC, their cutoff would prevent dismissal of a test that could increase the sensitivity of detecting this rare but devastating disease. This was a small study preventing further sub-analysis of the data; a limitation acknowledged by the authors. Moreover, this study was retrospective, including data from a cohort known to have ABM. The study design and population bias may diminish the external validity and the ability to generalize the authors' findings.

Prognostic factors in pneumococcal meningitis

Source: Wasier AP, et al. Pneumococcal meningitis in a pediatric intensive care unit: Prognostic factors in a series of 49 children. *Pediatr Crit Care Med* 2005;6;568-572.

The authors attempted to identify factors associated with hospital mortality in children admitted to the pediatric intensive care unit (PICU) with pneumococcal meningitis. A retrospective chart review was performed on 49 patients admitted to the PICU during a 14-year period. Patients were included if they had CSF pleocytosis (>10 cells/μL) plus a positive CSF culture and/or blood culture. The following variables were analyzed in this study: Pediatric Risk of Mortality II score (PRISM II score), systolic arterial blood pressure (SBP), Glasgow coma scale (GCS) score, need for mechanical ventilation, presence of seizures, serum laboratory values, CSF laboratory values, and blood cultures. Of these variables, only three were found to be independently associated with hospital mortality: PRISM II score, low peripheral WBC count, and low platelet count.

Commentary

Although well-designed, this study was limited by the sample size and low prevalence of the disease. In addition, the external validity of their conclusions is confounded by the high rates of mortality (49%) and neurologic impairment (48%) seen in their patient population. Most pediatric studies from developed countries report mortality rates of 20% from *S pneumoniae meningitis,* although rates in underdeveloped countries have been known to exceed 35%. Because their study focused on the sickest children (i.e., those requiring PICU care), one would expect to see a predominance of factors known to be associated with sepsis (e.g., low WBC counts and low platelet counts). Interestingly, their univariate analyses showed that mechanical ventilation was also a significant factor associated with morbidity and mortality, but it is unclear why the significance of mechanical ventilation was not reported in their multivariate analysis.

In multiple other studies, intubation and mechanical ventilation have been reported to be one of the strongest markers of disease severity and poor prognostic outcomes. Despite its limitations, this study does successfully highlight three prognostic factors in pneumococcal meningitis: a high PRISM II score, a low peripheral WBC count, and low peripheral platelet counts. Appearance

of such factors should prompt health care providers to consider more aggressive management options in patients with suspected pneumococcal meningitis.

Can a vaccine make a difference?

Source: Haddy RI, et al. Comparison of incidence of invasive *Streptococcus pneumoniae* disease among children before and after introduction of conjugated pneumococcal vaccine. *Pediatr Infect Dis J* 2005;24:320-323.

The goal of this study was to determine if the introduction of the conjugated pneumococcal vaccine has made a significant impact on the incidence of invasive pneumococcal disease in the Louisville, KY area. The heptavalent pneumococcal conjugate vaccine (Prevnar) was introduced in the winter of 1999.

Data were collected on all cases of invasive pneumococcal disease from hospital laboratories for 1997-2002. Invasive pneumococcal disease was defined in this study as positive cultures for *S pneumoniae* in the blood, CSF, or pleural fluid on retrospective data review. The results showed a significant decrease in the incidence of invasive pneumococcal disease during the 2-year period following introduction of the heptavalent vaccine. There were 48 cases in 1999-2000, 37 in 2000-2001, and 12 in 2001-2002. The most common diagnoses in the selected patient population were bacteremia without focus, pneumonia, and meningitis.

Commentary

Although this was a retrospective study, comparison with previous studies revealed similar results in the mean age of the affected patients, the mortality rate, and the overall decline in the number of pneumococcal cases following introduction of Prevnar. To round out their study, it would have been interesting to see data on the total number of cases of invasive *S pneumoniae* disease for several years preceding the introduction of Prevnar to Louisville, KY. Data from this study suggested that most patients with invasive *S pneumoniae* disease do not have an underlying predisposing disorder. This paper successfully reinforces the utility of preventative medicine.

Do corticosteroids help? The steroid debate

Source: Feigin R, et al. Use of corticosteroids in bacterial meningitis. *Pediatr Infect Dis J* 2004:23:355-357.

Since the introduction of corticosteroids in 1949, controversy has surrounded their use as adjuvant therapy in cases of ABM. In this article, the authors reviewed multiple studies published during the past five decades in an effort to determine the value of corticosteroid use in the treatment of ABM.

From 1957 to 1969, three controlled studies showed no beneficial effect of steroids in the treatment of bacterial meningitis. Two of the studies even suggested a worse prognosis in those treated with methylprednisolone or hydrocortisone. Almost 20 years later, Lebel and colleagues published reports touting dexamethasone's ability to decrease sensorineural hearing loss after Hib meningitis. Havens' meta-analysis that same year demonstrated conflicting results, pointing out that corticosteroid administration provides no benefit on mortality, risk of neurological abnormality at hospital discharge, or neurological abnormality at follow-up evaluation. A study by Wald and colleagues in 1995 supported previous studies that hearing loss occurs early in the course of ABM. They went on to show that if this deficit is not present on admission, it is unlikely to develop if the patient is treated with antibiotics, with or without the adjuvant use of steroids. In another meta-analysis by McIntyre and colleagues, it was shown that steroids did have benefit with Hib ABM, and may have benefit with ABM caused by *S pneumoniae*, but only if administered early.

Despite the breadth of articles addressing this issue, variations in study design, timing and dosage of steroid administration, and inconsistent evaluation criteria have made most meta-analyses on the topic difficult and inconclusive.

Commentary

After review of several studies published over many decades, the authors concluded that the adjuvant use of corticosteroids does show a benefit: reduction of hearing loss in patients with Hib meningitis. This benefit lost statistical significance when all other organisms were considered. In addition, statistical significance regarding other neurologic sequelae was not achieved. They cited the recommendation by The Committee on Infectious Diseases of the American Academy of Pediatrics that "…dexamethasone therapy should be recommended for treatment of infants and children with *H influenza* type b meningitis and that it should be considered for pneumococcal meningitis in infants and children 6 weeks of age or older."

Secondary to the Hib vaccine's success, cases of Hib ABM are becoming exceedingly rare, and therefore, concomitant steroid use for this disease is less of an issue. Gram stains are the most helpful test in getting a first glimpse of the organism at fault, but timing of results takes from 30 minutes to 1 hour. If recommendations are as above and steroids should be given before or with the first dose of antibiotics, it is difficult to determine if there will be benefit because the causative agent may not be known at the time treatment is rendered. Until we have conclusive evidence supporting the empiric use of corticosteroids during the initial presentation of meningitis in the acute care setting, therapy still will need to be decided on a case-by-case basis.

Let's review

Source: Strange G, et al. Meningitis: Evidence to guide an evolving standard of care. *Pediatr Emerg Med Pract* 2005:2;1-24.

This article examined the most recent literature to provide emergency medicine physicians an evidence-based approach to meningitis. The article illus-

trated several points of interest regarding antibiotic treatments based upon age. In the 1-3 month range, the neonatal causes of ABM are still a concern, but because pneumococcus becomes a possible pathogen, vancomycin should be added to the regimen. Beyond 3 months, the major pathogens are covered by ceftriaxone plus vancomycin.

The authors provided an algorithm delineating a stepwise approach to the management of a child with suspected ABM. The performance of diagnostic tests, including the LP and CT scan, should never delay the administration of antibiotics when there is a high index of suspicion for ABM. The paper cited a study by Coant and colleagues that showed that the clinician has between 1 to 2 hours after the administration of antibiotics before the CSF culture results are influenced. Some studies have suggested even earlier sterilization of the CSF, especially when the organism was meningococcus, however, concern for CSF sterilization should not override the decision to begin prompt antibiotic treatment. Likewise, using computed tomography (CT) scanning should never delay treatment. The article also questioned the need for a CT scan when increased intracranial pressure findings—including papilledema, focal neurological findings, or coma—are not noted on physical examination. While fluid restriction has been practiced in the past for fears of Syndrome of Inappropriate Antidiuretic Hormone (SIADH), this paper cited evidence that initial fluid resuscitation is vital in children presenting with ABM because many are dehydrated and approaching cardiovascular shock. Most experts are now in favor of abandoning fluid restriction.

The benefit of adjuvant steroid use with Hib meningitis was reiterated; however, the authors were unable to find strong evidence to support its use when *S pneumoniae* and/or *N meningitides* were the suspected pathogens. Because the treatment of ABM should begin as soon as possible, and antibiotics may need to be administered before an LP can be completed and before Gram stain results are available, the authors recommended caution when choosing to administer corticosteroids as adjuvant therapy. However, if the decision is made to use corticosteroids, the authors reemphasized that maximal benefit is seen when steroids are administered before or with the first dose of antibiotics.

Vaccines remain the hope for the future elimination of ABM. The Hib vaccine has made invasive Hib disease almost nonexistent in developed nations. The introduction of the heptavalent pneumococcal vaccine has already been projected to prevent up to 12,000 cases of ABM per year. Current guidelines recommend administration of the quadrivalent meningococcal vaccine in high-risk patients (e.g., those with asplenia or complement deficiencies, and in young adults living in close quarters). Its use in children younger than 2 years however is not recommended secondary to the lack of efficacy and short duration of protection seen in this age group. Children suspected of ABM should be considered candidates for admission to the PICU with disposition customized to the child's condition

Commentary

This review article provides physicians an excellent approach to dealing with a child suspected of having ABM. The authors outlined the first and second-line therapies for suspected ABM based upon age and provided evidence-based guidelines regarding some of the more controversial areas of ABM treatment including time to antibiotics, fluid administration, need for diagnostic modalities, and adjuvant steroid therapy.

Until new evidence points to the contrary, physicians should keep the antibiotic recommendations put forth in this review on hand. While the authors conceded that more research is needed regarding time to sterilization of CSF following antibiotics, it should be noted that the remaining ancillary tests routinely performed on CSF are barely altered with early antibiotic administration.

As demonstrated in the study by Bonsu and colleagues, highly abnormal CSF ancillary tests can be used as additional evidence in diagnosing ABM. Strange and colleagues also touched upon special circumstances not routinely reviewed in meningitis literature (e.g., aseptic meningitis, tuberculous meningitis, co-infection with HIV, patient disposition, and medicolegal considerations), thus rounding out a well-written, comprehensive review of the evolving standard of care for ABM.

Conclusions

In the past two decades, developed nations have made significant strides in the detection, prevention, and treatment of ABM. However, the mortality rates and untoward side effects of this disease remain high in patients who contract it. When evaluating a child with a nondescript febrile illness in the acute setting, physicians have at their disposal a battery of tests that may supplement their clinical suspicion. While no one test can 'hand' them the diagnosis, physicians must interpret findings—such as low CSF WBC counts with a preponderance of neutrophils, low GCS scores, high PRISM II scores, abnormally high CSF protein, and abnormally high or low CSF glucose levels—as possible indicators of the disease. Beyond forming an initial clinical impression, physicians also must act quickly and treat accordingly.

Although antibiotic resistance is on the rise, the most recent recommendations are to treat suspected cases of ABM in neonates with ampicillin plus cefotaxime, with the addition of vancomycin for children 4-12 weeks of age. In children 3 months old or older, ampicillin is dropped and ceftriaxone plus vancomycin substituted for cefotaxime plus vancomycin. Adjuvant tests, such as a CT scan, should only be used when physical examination findings suggest increased intracranial pressure. While the LP is an invaluable diagnostic test, its acquisition should not delay treatment.

The use of adjunct therapies (e.g., steroids) remains controversial. Steroid administration should be based upon the suspected pathogen. Thus far, evidence has only shown benefit when the etiologic agent is Hib and the benefit pertains to hearing loss only. Adult models

Table 1. ABM: Common Organisms and Antibiotic Recommendations

AGE GROUP	POTENTIAL ORGANISMS	ANTIBIOTIC RECOMMENDATIONS
Birth to 4 weeks	**Common:** Group B *Streptococcus* Gram-negative enteric bacilli (*Escherichia coli*) **Uncommon:** *Listeria monocytogenes* *Enterobacter* spp.	Ampicillin and gentamicin OR Ampicillin and cefotaxime
4 weeks to 3 months	**Common:** *Streptococcus pneumoniae* *Neisseria meningitides* *Hemophilus influenzae* type b **Uncommon:** Group B *Streptococcus* Gram-negative enteric bacilli (*E coli, Klebsiella* spp, *Enterobacter* spp, and *Salmonella*) *Listeria monocytogenes*	Ampicillin and cefotaxime AND Vancomycin
3 months to 2 years	*Streptococcus pneumoniae* *Neisseria meningitides* *Hemophilus influenzae* type b	Ceftriaxone AND Vancomycin
2 years to 18 years	*Streptococcus pneumoniae* *Neisseria meningitides*	Ceftriaxone AND Vancomycin

have demonstrated the utility of steroids with other causes of meningitis, but more research is needed to make these data applicable to the pediatric population. Steroid administration is not without risk, and concomitant use can decrease CSF penetration of vancomycin. The recommendations at this time are to administer steroids when the etiologic agent is known to be Hib and steroids should be considered when the agent is thought to be *Streptococcus pneumoniae* in children older than 6 weeks.

ABM in children can present insidiously and progress rapidly, leading to death or significant neurologic complications. Physicians must continue to have a low threshold for performing an LP and for treating patients empirically with antibiotics, even if the diagnosis of ABM is not immediately clear.

Attempt to obtain the appropriate cultures, but do not delay the administration of antibiotic therapy. There have been promising data demonstrating the utility of scoring systems (e.g., BMS) allowing us to risk stratify and perhaps avoid unnecessary admissions. When evaluating a child with a fever, ABM should always be considered by any clinician; ancillary tests then can be prioritized based upon the clinical picture.

With this vigilance, we can hopefully prevent the progression and widespread devastation caused by many cases of ABM. Advances in vaccines and detection techniques have changed the incidence and outcomes of this disease significantly in just two decades, with newer vaccines showing similar trends. As acute care physicians, it is our duty to stay abreast of the most recent literature available to adapt and change with the current recommendations.

Reference

1. Strange GR, et al. Meningitis: Evidence to guide an evolving standard of care. *Pediatr Emerg Med Pract* 2005;2:2.

Future Issues

• What is the best diagnostic test for nephrolithiasis?

• Is an LP necessary in SAH with new generation scanners?

• Ultrasound evaluation for pneumothorax

• Pelvic x-rays for trauma patients

CME OBJECTIVES

Upon completing this program, participants will be able to:

- Summarize the most recent significant studies in emergency medicine/acute care related to a single topic;
- Discuss up-to-date information about new drugs, techniques, equipment, trials, studies, books, teaching aids, and other information pertinent to the stated topic;
- Evaluate the credibility of published data and recommendations about the stated topic.

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Physicians participate in this continuing medical education program by reading the articles, using the provided references for further research, and studying the CME questions. Participants should select what they believe to be the correct answers, then refer to the list of correct answers to test their knowledge. To clarify confusion surrounding any questions answered incorrectly, please consult the source material.

After completing this activity, participants must complete the evaluation form provided at the end of each semester (May and November) and return it in the reply envelope provided to receive a credit letter. When an evaluation form is received, a credit letter will be mailed to the participant.

CME QUESTIONS

36. The best antibiotic regimen for suspected acute bacterial meningitis in a child older than 4 weeks is:

a. a first-generation cephalosporin and ampicillin.
b. vancomycin alone.
c. vancomycin and rifampin.
d. ceftriaxone and vancomycin.

37. Which of the following symptoms is an absolute indication for CT scan prior to an LP in patients with acute bacterial meningitis?

a. Fever
b. Evidence of sinusitis
c. Lethargy
d. Nausea and vomiting
e. Focal neurologic deficits

38. The most significant event that has led to a change in the most common pathogen of ABM in developed nations is:

a. the Hib vaccine
b. the pentavalent pneumococcal vaccine
c. increased antibiotic resistance
d. post-exposure prophylaxis

39. Which of the following test results might raise your suspicion of acute bacterial meningitis in a child with a fever?

a. A CSF protein count of 50 mg/dL
b. A CSF WBC count of < 30 cells/mm^3, > 75% neutrophils
c. A peripheral WBC count of > 30 cells/mm3, > 75% lymphocytes
d. A CSF glucose level of 100mg/dL

40. In addition to the most common pathogens of childhood ABM, which of the following etiologic agents also should be covered in a 3-week-old infant?

a. *Streptococcus pneumoniae*
b. *Staphylococcus aureus*
c. *Neisseria meningitides*
d. *Listeria monocytogenes*

Answers: 36. d; 37. e; 38. a; 39. b; 40. d