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Clinical Review

EMERGENCY MEDICINE MYTHS: COMPUTED TOMOGRAPHY OF THE HEAD PRIOR TO LUMBAR PUNCTURE IN ADULTS WITH SUSPECTED BACTERIAL MENINGITIS – DUE DILIGENCE OR ANTIQUATED PRACTICE?

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□ **Abstract—Background: Various sources purport an association between lumbar puncture and brainstem herniation in patients with intracranial mass effect lesions. Several organizations and texts recommend head computed tomography (CT) prior to lumbar puncture in selected patients. Objective: To review the evidence regarding the utility of obtaining head CT prior to lumbar puncture in adults with suspected bacterial meningitis. Discussion: Observational studies report a risk of post-lumbar puncture brainstem herniation in the presence of intracranial mass effect (1.5%) that is significantly lower than that reported among all patients with bacterial meningitis (up to 13.3%). It is unclear from existing literature whether identifying patients with intracranial mass effect decreases herniation risk. Up to 80% of patients with bacterial meningitis experiencing herniation have no CT abnormalities, and approximately half of patients with intracranial mass effect not undergoing lumbar puncture herniate. Decision rules to selectively perform CT on only those individuals most likely to have intracranial mass effect lesions have not undergone validation. Despite recommendations for immediate antimicrobial therapy prior to imaging, data indicate an association between pre-lumbar puncture CT and antibiotic delays. Recent data demonstrate shortened door-to-antibiotic times and lower mortality from bacterial meningitis after implementation of new national guidelines, which restricted generally accepted CT indications by removing impaired mental status as imaging criterion. Conclusions: Data supporting routine head CT prior to lumbar puncture are limited. Physicians should consider selective CT for those patients at risk for intracranial mass effect lesions based on decision rules or clinical gestalt. Patients undergoing head CT must receive immediate antibiotic therapy. Published by Elsevier Inc.**

□ **Keywords—lumbar puncture; brain computed tomography; bacterial meningitis; brainstem herniation; evidence-based medicine**

INTRODUCTION

Bacterial meningitis is a deadly infection of the meninges. Contemporary estimates of mortality in large datasets from high-income countries range from 15–21% even in patients receiving antibiotic therapy (1,2). Time from presentation to antibiotic receipt is a critically important determinant of patient survival (3–5). Therefore, emergency physicians must actively consider this disease and aggressively administer antibiotics as quickly as possible among patients that they suspect have this deadly condition.

The reference standard diagnostic study for bacterial meningitis is analysis of cerebrospinal fluid (CSF) as

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obtained by lumbar puncture (6). Completion of this procedure to obtain CSF for cultures early in the course of patient care is important to confirm the diagnosis and identify causative organisms to guide antimicrobial therapy (7). However, conventional wisdom holds that there is a potentially catastrophic consequence to the lumbar puncture procedure in certain patients. As stated in *Rosen's Emergency Medicine*, "In most patients with bacterial meningitis, [lumbar puncture (LP)] may be safely performed without antecedent neuroimaging studies. As this may not be the case in other brain diseases, in many circumstances it is advisable to obtain a CT scan of the head before LP is performed" (8). This claim reflects the concern that patients with brain edema or lesions causing intracranial mass effect may experience lumbar puncture-induced brainstem herniation (9).

A discord then exists between the imperative of rapid diagnosis and a rare but potentially fatal complication of the diagnostic procedure. Computed tomography (CT) provides physicians with a tool to identify those patients with brain lesions causing mass effect (10). The use of pre-lumbar puncture head imaging implies two important myths.

THE MYTHS

First, patients with mass effect lesions represent a group at significantly higher risk for brainstem herniation compared with the general population of patients with bacterial meningitis in whom lumbar puncture is uncontroversial. Second, providers may reliably prevent brainstem herniation in patients with intracranial lesions causing mass effect by forgoing lumbar puncture.

WHY IS THIS IMPORTANT?

Brainstem herniation is a devastating event frequently resulting in either death or profound neurologic morbidity (11). Emergency physicians might therefore consider pre-lumbar puncture CT in every patient with suspected bacterial meningitis to be conservative and safe practice. Yet this diagnostic strategy is not without consequence. Head imaging carries with it financial cost and patient exposure to radiation (12,13). More important is the potential for antibiotic delays associated with imaging. The Infectious Diseases Society of America (IDSA) guidelines and Emergency Medicine textbooks including *Rosen's* and *Tintinalli's* all recommend empiric antibiotic administration prior to imaging or lumbar puncture to avoid delays (Figure 1, an evaluation and management of meningitis algorithm) (8,14,15). Yet, despite this consensus, studies nevertheless consistently demonstrate that many patients undergoing head CT prior to lumbar puncture experienced antibiotic delays (4,16–18).

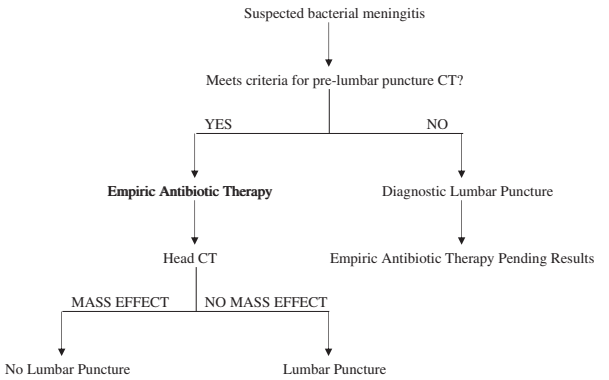

Figure 1. Diagnostic algorithm for adult patients with suspected bacterial meningitis. CT = computed tomography.

The standard practice to minimize these potential imaging consequences is to selectively perform pre-lumbar puncture CT on only those patients most likely to have intracranial lesions causing mass effect. Published decision rule studies, the IDSA guidelines, and the *Rosen's* and *Tintinalli's* texts all offer slightly different criteria for pre-lumbar puncture CT to rule out mass effect lesions (Table 1) (8,14–17). Regardless, this approach is controversial and has been subject to repeated criticism by advocates for fewer head CT scans for these patients (19). More definitive studies resolving this controversy are unlikely to be forthcoming given the rarity of bacterial meningitis and intracranial mass effect lesions and entrenched concerns about performing lumbar punctures in patients with intracranial mass effect lesions. Given the absence of such studies, this review seeks to provide emergency physicians an overview of the relevant existing primary literature so that they may better determine whether their adult patients with suspected bacterial meningitis should undergo head imaging prior to lumbar puncture.

LITERATURE REVIEW

We reviewed the peer-reviewed literature for studies reporting primary data related to the risk of post-lumbar puncture brainstem herniation. To this end we searched the PubMed database from inception through March 15, 2017. We constructed search terms to capture studies of clinical and imaging correlates with brainstem herniation risk and impact studies of alternative imaging strategies (Table 2). We reviewed the abstract of each item identified by the search strategy for possible inclusion into the review. We also reviewed the abstracts of studies cited in the bibliographies of included studies with titles potentially relevant to this review. We excluded nonprimary literature and case reports or series; studies reporting only diagnostic yield for lumbar puncture; studies reporting only nonherniation procedural complications; studies