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Things We Do for No Reason™: Computed tomography of the head before lumbar puncture in low-risk adults and children

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The "Things We Do for No Reason" series reviews practices, which have become common parts of hospital care, may provide little value to our patients. Practices reviewed in the TWDFNR series do not represent "black and white" conclusions or clinical practice standards, but are meant as a starting place for research and active discussions among hospitalists and patients. We invite you to be part of that discussion.

CASE PRESENTATION

A 56-year-old man with a history of alcohol use disorder presents to the emergency department with a 4-h history of fever, headache, and photophobia. Before symptoms onset, the patient had otalgia for about 3 days. Physical examination includes a temperature of 102.2°F (38.9°C), blood pressure of 110/87 mmHg, heart rate of 115 beats per minute, and respiratory rate of 18 per minute with an oxygen saturation of 98% on room air. Cardiovascular and pulmonary systems are normal. Neurological exam shows neck stiffness, Glasgow Comas Scale (GCS) of 15/15, and no focal neurological deficits. The hospitalist suspects acute bacterial meningitis (ABM) and decides to order a noncontrast head CT (NCHCT) before performing a diagnostic lumbar puncture (LP) to decrease the risk of brain herniation.

WHY YOU MIGHT THINK OBTAINING A NCHCT BEFORE A LP IS HELPFUL

Performing an NCHCT before LP in patients with a suspicion of ABM can identify patients at high risk for brain herniation and detect alternative diagnoses.[1] Brain herniation occurs in 5% of patients with ABM and accounts for approximately 30% of ABM deaths.[2] Some evidence suggests that LP may increase the risk of brain herniation in patients with meningitis.[2] For example, Rennick and colleagues assessed 445 children with ABM and found 21 episodes of brain herniation in 19 children, a rate of 4.3%.[3] Of these 21 episodes, eight developed herniation within 3 h of the LP. The authors concluded that "the temporal relation between LP and herniation strongly suggests that a LP may cause herniation in some patients."

From a pathophysiological point of view, an LP precipitates brain herniation by lowering the cerebrospinal fluid (CSF) pressure following fluid withdrawal. Patients at increased risk of herniation include those with elevated intracranial pressure (ICP), in particular those with space-occupying intracranial lesions. NCHCT can detect such lesions (brain abscess, cerebral infarction, and obstructive hydrocephalus) and indirect signs of raised ICP (midline shift).

WHY NCHCT BEFORE LP IS NOT USUALLY HELPFUL AND CAN BE HARMFUL

There are three arguments against NCHCT before LP in ABM patients. First, very few patients herniate from LP. Second, NCHCT is not a good test to rule out the possibility of future brain herniation. Third, unnecessary NHCHT can delay antibiotic administration and worsen prognosis.

Herniation from LP is extremely rare

The incidence of ABM-associated LP-induced herniation is difficult to estimate because herniation most often happens as a consequence of

ABM. In the study by Rennick and colleagues, brain herniation occurred in 4/21 patients before LP and in 2/21 without an LP.[3] Six of the eight children who herniated in the three hours following LP had focal neurological symptoms, an indication for NCHCT according to Infectious Diseases Society of America (IDSA) guidelines.[4] Of the two remaining children, one patient's cerebral palsy made the physical exam difficult to interpret and the other had no clinical consequence of the herniation.

In the largest cohort study following adult patients with proven ABM, 47/1533 patients (3%) deteriorated within 8 h following LP and only two (0.1%) deteriorated within 1 h after LP.[5] Researchers assume that when herniation occurs 1–3 h after the LP, it increases the likelihood that the LP caused the herniation. Both patients who deteriorated within 1 h after LP had indications for NCHCT before LP according to IDSA guidelines.[4]

These two studies underline the importance of physical examination for determining the initial risk of brain herniation.

NCHCT is not a good test to rule out future brain herniation

Although NCHCT detects intracranial mass lesions or indirect signs of elevated ICP at the time of the exam, a normal result cannot exclude subsequent brain herniation. Progression of meningeal bacterial invasion and inflammation associated with bacterial lysis due to antibiotic therapy may lead to severe intracranial hypertension resulting in brain herniation despite an initially normal NCHCT.[6] In the study by Rennick and colleagues, 36% of patients with brain herniation had a normal NCHCT.[3] Thus, care teams must closely monitor patients for evolving clinical signs of increased ICP, no matter the result of the initial NCHCT.

Unnecessary NCHCT can delay antibiotics' administration and worsen prognosis

In patients with ABM, the time from onset of symptoms to administration of antibiotics influences prognosis. Performing an NCHCT before LP delays time for antibiotic therapy, which may result in poorer outcomes. Delays occur even though American and European guidelines recommend starting antimicrobial and anti-inflammatory therapies before NCHCT. A Swedish cohort study involving 815 patients showed that less than half of the patients received antibiotic treatment before NCHCT and that NCHCT before LP significantly reduced the proportion of patients treated within two hours of presentation (from 41% to 30%; $p = .005$).[7] Another study compared outcomes of patients with ABM before and after the introduction of new national Swedish guidelines which recommend NCHCT before LP only in patients with severe impaired mental status.[8] Patients managed after introduction of the guidelines had fewer NCHCTs performed, shorter time to antibiotic therapy (1.18 h earlier on average; $p < .01$), lower intrahospital mortality (22/318 (6.9%) versus 46/394 (11.7%); $p < .05$), and decreased sequelae for patients followed 2–6 months after discharge (91/239 (38.1%) versus 144/294 (48.6%); $p < .05$).[9] The study confirmed the lack of clinical benefit and highlighted the potential hazard of routinely performing NCHCT. Although some data show that ultrafast MRI could serve as an alternative to NCHCT,[10] its lack of availability decrease its viability.

Unfortunately, providers overprescribe NCHCT before LP even when following the most conservative IDSA guidelines. A 2017 retrospective observational study analyzed physicians' adherence to IDSA guidelines regarding NCHCT in patients presenting to the emergency room with a clinical suspicion of ABM in the Houston area between January 2005 and January 2010. It showed that providers ordered NCHCT for more than 60% of patients with no indication as per IDSA guidelines.[11] Moreover, NCHCT had an impact on clinical management (changing diagnosis suspicion or prompting neurosurgery) in only eight out of 549 patients, and all eight patients had an indication for NCHCT according to the IDSA guidelines. Performing an NCHCT in low-risk patients (i.e., with no clinical indication according to IDSA or ESCMID guidelines) did not change the subsequent management.

WHEN IS NCHCT INDICATED BEFORE LP?

The American and European guidelines currently recommend ordering NCHCT only for adults and children with ≥1 risk factor(s) for an abnormal NCHCT (Table 1).[4,12] A 2001 prospective cohort study of patients with

TABLE 1 Definitions of acute bacterial meningitis patients at high risk for abnormal noncontrast head CT.[a]

Infectious Diseases Society of America	European Society of Clinical Microbiology and Infectious Diseases
Glasgow Coma Scale (GCS) < 15	GCS < 10
Focal neurological deficit	Focal neurological deficit
Severely immunocompromised state (transplant recipient or HIV infection)	Severely immunocompromised state (transplant recipient or HIV infection)
History of new-onset seizure within 1 week	History of new-onset seizure within 1 week
History of intracranial lesion	
Papilledema	

[a]Patients are classified as high risk if ≥1 criteria is met.

suspected ABM identified clinical characteristics associated with an abnormal NCHCT.[13] Clinical characteristics at admission can help to identify patients at risk of having an abnormal NCHCT, but cannot identify who will have a higher risk for subsequent brain herniation. Updated IDSA and European Society of Clinical Microbiology and Infectious Diseases (ESCMID) guidelines differ considerably in their definition of high-risk patients, as shown in Table 1.[4,12] In a Swedish cohort of 815 patients with ABM, 7%, 32%, and 65% of patients had indications for a CT scan before LP according to Swedish, ESCMID, and IDSA guidelines, respectively.[7] Adherence to Swedish guidelines was associated with lower mortality in this study.

WHAT SHOULD WE DO INSTEAD?

Although imperfect, use IDSA and ESCMID to categorize patients at high or low risk for having an abnormal NCHCT. In high-risk patients, administer antibiotics before sending the patient for neuroimaging to shorten the time from presentation to the start of antibiotic therapy. Although administration of antimicrobial therapy before LP decreased CSF culture sensitivity from 66.1% to 48.5% ($p = .004$) in a 2019 study in adults and children with healthcare-associated ventriculitis and meningitis,[14] the care team can still obtain a microbiological diagnosis of ABM via blood cultures or multiplex PCR in the CSF.[15]

RECOMMENDATIONS

1. Clinically evaluate every adult and child presenting with a suspected ABM with a comprehensive neurologic exam for NCHCT indications before pursuing an LP.
2. Classify patients as low or high risk for an abnormal NCHCT based on IDSA or ESCMID criteria.
3. Perform an LP without imaging for low-risk patients.
4. For high-risk patients, initiate antimicrobial and anti-inflammatory therapy as soon as possible (ideally within 15–30 min from arrival at the Emergency Room) and before performing the NCHCT.
5. For high-risk patients, obtain an NCHCT before LP but after the initiation of antimicrobial and anti-inflammatory therapy.
6. Closely monitor all patients for new signs of elevated ICP and impending herniation.

CONCLUSION

Brain herniation is a rare complication of diagnostic LP in ABM patients. NCHCT can identify alternative diagnoses and indirect signs of elevated ICP which can change subsequent management but has a low positive and negative predictive value for eventual brain herniation. Most importantly, ABM prognosis depends on the time to antibiotic therapy, which is often longer for patients undergoing NCHCT before LP. Despite IDSA and ESCMID guidelines updates, many providers still order NCHCT before LP for low-risk patients, delaying treatment initiation and possibly worsening prognosis without having an impact on management. Returning to our 56-year-old patient, he had no indication for NCHCT and should have had immediate diagnostic LP and blood culture followed by empirical treatment initiation.

Do you think this is a low-value practice? Is this truly a "Thing We Do for No Reason"? Let us know what you do in your practice and propose ideas for other "Things We Do for No Reason" topics. Please join in the conversation online at Twitter (#TWDFNR)/ Facebook and don't forget to "Like It" on Facebook or retweet it on Twitter.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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