How Do I Perform a Lumbar Puncture and Analyze the Results to Diagnose Bacterial Meningitis?

EBEM Commentator Contact

Rawle A. Seupaul, MD

From the Department of Emergency Medicine, Indiana University School of Medicine, Indianapolis, IN.

0196-0644/$-see front matter

doi:10.1016/j.annemergmed.2007.04.001

[Ann Emerg Med. 2007;50:85-87.]

RATIONAL CLINICAL EXAMINATION REVIEW SOURCE

This is a rational clinical examination abstract, a regular feature of the *Annals'* Evidence-Based Emergency Medicine (EBEM) series. Each features an abstract of a rational clinical examination review from the *Journal of the American Medical Association* and a commentary by an emergency physician knowledgeable in the subject area.

The source for this rational clinical examination review abstract is: Straus SE, Thorpe KE, Holyroyd-Ledue J. How do I perform a lumbar puncture and analyze the results to diagnose bacterial meningitis? *JAMA.* 2006;296:2012-2022.[1] The *Annals'* EBEM editors assisted in the preparation of the abstract of this rational clinical examination review, as well as the selection of the Evidence-Based Medicine Teaching Points.

OBJECTIVE

To systematically review the evidence concerning techniques to decrease the occurrence of adverse events from diagnostic lumbar puncture, and to determine which analyses of cerebrospinal fluid are most helpful in diagnosing bacterial meningitis in adults.

DATA SOURCES

The authors used a comprehensive search strategy that included the Cochrane Library, MEDLINE (Ovid and PubMed) from 1966 to January 2006, and EMBASE from 1980 to January 2006, without limits on language, and a hand search of bibliographies of articles retrieved.

STUDY SELECTION

For summary analysis of interventions designed to reduce adverse effects of lumbar puncture (headache and backache), only randomized controlled trials of adults aged 18 or older were included. For studies of the accuracy of cerebrospinal fluid analysis for diagnosis of bacterial meningitis, only studies with predominantly adult populations, an appropriate reference standard (cerebrospinal fluid culture or bacterial antigen), and available primary data or summary statistics were used.

DATA EXTRACTION AND ANALYSIS

Two investigators independently appraised study quality using standardized data forms and prespecified minimum quality standards. Pertinent data were extracted, statistical heterogeneity was assessed, and random effects models were used for quantitative data synthesis.

MAIN RESULTS

Overall, 15 trials met inclusion criteria. Five trials with 587 patients found a nonsignificant difference in the occurrence of post–dural puncture headache when an "atraumatic" needle was used versus a standard cutting one (absolute risk reduction=12.3%; 95% confidence interval [CI] –1.72% to 26.2%). Reinsertion of the stylet before needle removal was associated with a statistically significant decrease in the rate of headache (absolute risk reduction=11.3%; 95% CI 6.50% to 16.2%). Four studies with a combined 717 patients revealed no statistically significant difference in headache in subjects who were mobilized versus those undergoing bed rest after lumbar puncture (absolute risk reduction=2.9%; 95% CI –3.4% to 9.3%).

Four studies met inclusion criteria for the predictive ability of cerebrospinal fluid markers for the diagnosis of bacterial meningitis. Three biochemical markers were shown to have statistically significant predictive value: a cerebrospinal fluid-blood glucose ratio less than or equal to 0.4 (positive likelihood ratio=18; 95% CI 12 to 27; negative likelihood ratio=0.31; 95% CI 0.21 to 0.45), cerebrospinal fluid WBC count equal to or greater than 500/μL (positive likelihood ratio=15, 95% CI 10 to 22; negative likelihood ratio=0.30, 95% CI 0.20 to 0.40), and cerebrospinal fluid lactate greater than or equal to 31.53 mg/dL (≥3.5 mmol/L; positive likelihood ratio=21, 95% CI 14 to 32; negative likelihood ratio=0.12, 95% CI 0.07 to 0.23).

CONCLUSIONS

The use of small-gauge atraumatic needles and reinsertion of the stylet before needle removal reduces the risk of post–lumbar

Table 1. Techniques to decrease the risk of post–lumbar puncture headaches

Techniques	ARR, %	NNT
1. Reinsert the stylet before needle removal	11.3	9
2. Use smaller-gauge needles that are atraumatic	12.3	N/A*

ARR, Absolute risk reduction; *N/A,* not applicable; *NNT,* number needed to treat.
*NNT cannot formally be calculated when the ARR is statistically nonsignificant.

Table 2. Cerebrospinal fluid analysis and likelihood ratios

Test	Positive LR +	Negative LR
Cerebrospinal fluid/blood glucose ratio <0.4	18 (12–27)	0.31 (0.21–0.45)
WBC ≥500/μL	15 (10–22)	0.3 (0.20–0.40)
Lactate ≥31.53 mg/dL	21 (14–32)	0.12 (0.07–0.23)

LR, likelihood ratio.

puncture headache, whereas immobilization does not. In addition to typical serologies, cerebrospinal fluid Gram's stain, and culture, the authors conclude that the following cerebrospinal fluid markers can aid significantly in the diagnosis of bacterial meningitis in adults: cerebrospinal fluid blood glucose ratio less than or equal to 0.4, cerebrospinal fluid WBC count greater than or equal to 500/μL, and a cerebrospinal fluid lactate greater than or equal to 31.53 mg/dL.

Table 3. Calculating results from a therapeutic trial

Simple Equations for Therapeutic Data	
ARR=EER–CER	RR=EER/CER
NNT=1/ARR	RRR=1–RRR

CER, Control event rate; *EER,* experimental event rate; *RR,* relative risk; *RRR,* relative risk reduction.

Rational Clinical Examination Author Contact
Sharon E. Straus, MD, MSc, FRCPC
Toronto General Hospital
Toronto, Ontario, Canada
E-mail sstraus@mtsinai.on.ca

COMMENTARY: CLINICAL IMPLICATION

Diagnostic lumbar puncture is a common procedure performed in the emergency department (ED) for the evaluation of central nervous system infection or cerebral hemorrhage. As with any procedure, there are antecedent risks that should be discussed and minimized whenever possible, and as with any diagnostic test, it is important to understand how helpful the results of cerebrospinal fluid analysis will be in adjusting one's pretest probability. This rational clinical examination installment provides a review of study data that can help emergency medicine practitioners in achieving both of these goals. Using a thorough search strategy to avoid publication bias and well-documented efforts to avoid selection bias, the authors identified 5 studies involving efforts to reduce post–lumbar puncture headaches and 5 studies involving markers for cerebrospinal fluid interpretation.

The first recommendation made by the authors is that small-gauge atraumatic needles be used instead of the standard cutting needles (routinely supplied in ED lumbar puncture trays), despite that there was a statistically nonsignificant absolute risk reduction in post–lumbar puncture headache when atraumatic needles were used. This reduction may have been due to a small sample size in studies meeting inclusion criteria for this review (only studies of diagnostic lumbar punctures were included). In fact, there are randomized trials in spinal anesthesia patients showing statistically significant reductions in headache, supporting the authors' conclusion.[2-4] The review also found that stylet reinsertion was significantly associated with reductions in the incidence of post–lumbar puncture headache (Table 1). Several factors traditionally considered to be associated with post–lumbar puncture headache were *not* shown to affect its occurrence, including bed rest, number of attempts, administration of oral or intravenous fluids, patient positioning, and clinician experience. These data strongly support the assertion that immediate bed rest, a seemingly common post–lumbar puncture measure intended to reduce post–lumbar puncture headache, is unnecessary.

For the diagnosis of bacterial meningitis in adults, 3 diagnostic tests had clinically useful likelihood ratios: cerebrospinal fluid–blood glucose ratio less than or equal to 0.4, cerebrospinal fluid WBC count greater than or equal to 500/μL, and a cerebrospinal fluid lactate level greater than or equal to 31.53 mg/dL (Table 2). Given the magnitude of the positive likelihood ratios of these tests, a positive test result would be considered diagnostic of bacterial meningitis. For example, if the pretest probability for bacterial meningitis were 30% (eg, fever, headache, slight photophobia), the posttest probabilities after obtaining results considered positive for any of these 3 markers would be 89%, 87%, and 90%, respectively. Although the first 2 analyses are routinely conducted in the ED, cerebrospinal fluid lactate testing is not, suggesting the need to investigate the cost and availability of this test.

TAKE-HOME MESSAGE

Strong evidence supports the conclusion that stylet reinsertion before needle removal reduces the incidence of post–lumbar puncture headache (number needed to treat=9), whereas weaker evidence suggests that small-gauge atraumatic needles may do so as well. Cerebrospinal fluid pleocytosis of greater than 500 cells per high-powered field, a cerebrospinal fluid:serum glucose ratio less than or equal to 0.4, and a cerebrospinal fluid lactate level greater than or equal to 31.53

mg/dL may all be considered positively diagnostic for bacterial meningitis.

EBBM Commentator Contact
Rawle A. Seupaul, MD
Indiana University School of Medicine
Indianapolis, IN
E-mail rseupaul@iupui.edu

EBEM TEACHING POINT

Effect measures. The reported results for the therapeutic data in this review are described in terms of the absolute risk reduction and number needed to treat instead of the relative risk and relative risk reduction. Although the absolute risk reduction is the difference in outcome (mortality in the example below) between the control group and the experimental group, the relative risk reduction is the *proportional* reduction in outcome between the control and experimental groups. The former is a more powerful and meaningful method of reporting effect sizes. In general, the relative risk or relative risk reduction tends to inflate the impact of study results and can be used to magnify small changes in absolute benefit or harm (the calculation of these results is summarized in Table 3). This form of data reporting is commonly used in business marketing. An illustration of this effect can be found in the Figure, comparing 2 similar trials in which the effect between 2 drugs on mortality is compared to control populations.

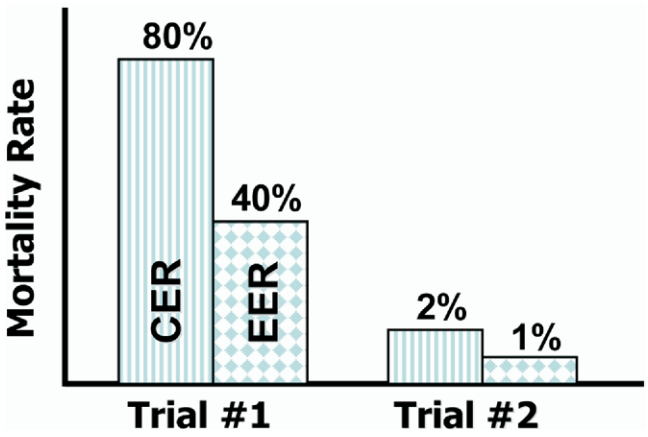

Figure. In this example, 2 similar trials are displayed, with resultant mortality data. In both cases, the relative risk and relative risk reduction are the same for both trials (50%). Each author can conclude that the mortality has been reduced by 50%; however, the trial absolute risk reductions are 40% and 1%, respectively, which results in a number needed to treat of 3 for trial 1 and 100 for trial 2.

REFERENCES

1. Straus SE, Thorpe KE, Holroyd-Leduc J. How do I perform a lumbar puncture and analyze the results to diagnose bacterial meningitis? *JAMA*. 2006;296:2012-2022.
2. Buettner J, Wresch KP, Klose R. Postdural puncture headache: comparison of 25-gauge Whitacre and Quincke needles. *Reg Anesth*. 1993;18:166-169.
3. Halpern S, Preston R. Postdural puncture headache and spinal needle design. Meta-analyses. *Anesthesiology*. 1994;81:1376-1383.
4. Tourtellotte WW, Henderson WG, Tucker RP, et al. A randomized, double-blind clinical trial comparing the 22 versus 26 gauge needle in the production of the post-lumbar puncture syndrome in normal individuals. *Headache*. 1972;12:73-78.