search for a cerebral aneurysm, an invasive procedure with potential morbidity. Noninvasive imaging studies such as magnetic resonance angiography and CT angiography cannot reliably exclude aneurysms smaller than 5 mm.[8] On the other hand, if there is a concurrent traumatic tap and SAH, CSF results could be mistakenly interpreted as negative for SAH. I am aware of one such patient in whom bloody CSF was mistakenly attributed solely to trauma. The patient was recalled the next day when his CT scan was correctly reread as revealing SAH.

The decision to perform a diagnostic test is governed by the probability that a disease is present and by the risks and benefits of the test and treatment. Because the benefits of detecting a sentinel SAH are very great and the risks of LP are small, there should be a low threshold for performing an LP when the CT scan findings are negative. However, in patients with very low likelihood of SAH, a large number of LPs will be performed to detect 1 SAH. This potentially increases the number of false-positive CSF examinations caused by traumatic LP, and such patients may undergo invasive evaluation with cerebral angiography, a cause of significant morbidity in patients with minimal likelihood of SAH.

Because of the difficulties in evaluating CSF results, correct interpretation of CT scans is important both to take advantage of the full sensitivity of CT at detecting SAH and to reduce the frequency that the diagnosis rests on CSF examination when the CT scan is incorrectly interpreted as negative. Subtle signs of SAH can be identified by knowing the normal CT appearance of the basilar cisterns where aneurysmal SAH is usually found.[9] Because the basilar cisterns are midline structures, comparison of the right and left sides of the brain cannot be relied on to identify SAH. Furthermore, although acute SAH usually appears white on CT images, a small amount of blood mixed with CSF may be isodense to brain tissue, resulting in an absence of the basilar cisterns in their expected location on CT scans. In fact, this is seen in the patient illustrated by Morgenstern et al,[4] in which the basilar cisterns are not visible surrounding the midbrain (Figure). Nonetheless, because these CT signs of blood could be considered equivocal, it is likely that an LP was indicated in this patient to distinguish meningitis from SAH as a cause of her headache and communicating hydrocephalus.

In summary, current CT scanners have good sensitivity (98%; lower 95% CI 94%) at detecting a sentinel SAH in patients with acute severe headache who are neurologically intact, if the scan is performed within 12 hours of symptom onset. However, even if expertly interpreted, CT scanning can still miss aneurysmal SAH, and an LP should be performed in patients with negative CT scan findings if SAH remains a diagnostic consideration. (The 12-hour time limit must be emphasized because CT scan sensitivity decreases significantly after 12 hours.) Accurate CT scan interpretation is important both to maximize the sensitivity of CT and to limit the number of cases in which the diagnosis rests on CSF examination. Interpretation of the CSF examination is problematic if the patient has bloody CSF caused by a traumatic tap, and LP technique must be meticulous to minimize the chances of a traumatic tap. Finally, physicians responsible for the initial interpretation of CT scans in the ED should be familiar with the subtle CT signs of SAH to maximize the information obtained and to avoid misdiagnosis.

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Feedback: Computed Tomography and Lumbar Puncture for the Diagnosis of Subarachnoid Hemorrhage: Evidence, Action, and Error

[Edlow JA, Wyer PC. Feedback: computed tomography and lumbar puncture for the diagnosis of subarachnoid hemorrhage: evidence, action, and error [response]. *Ann Emerg Med.* February 2002;39:192-194.]

In response:

The commentary by Dr. Schwartz,[1] in addition to calling attention to the importance of precise criteria for inter-

pretation of diagnostic tests, raises 2 relevant issues pertaining to the adequacy of cranial computed tomography (CT) in ruling out subarachnoid hemorrhage (SAH) that were not addressed in our original review.[2] Both issues pertain to the process through which a clinical estimate of disease likelihood is modified by a diagnostic test result in a way that influences the actions we recommend on behalf of our patients. Both issues also highlight the ways that evidence-based medicine, as a dimension of clinical thinking, differs from purely academic or research-oriented approach to clinical practice.

Dr. Schwartz points out that the CT scan result that was treated as "false-negative" by Morgenstern et al[3] and in our review[2] was not, in fact, normal. As illustrated by Dr. Schwartz, that scan, done within hours after the onset of headache, revealed a communicating hydrocephalus, a finding known to be consistent with a diagnosis of SAH. It did not show blood. The scan result is therefore ambiguous to the extent that a "positive" scan for SAH had been defined as direct visualization of blood in the subarachnoid space. Morganstern et al do not tell us how this scan was interpreted at the time it was performed. Their protocol called for performance of an LP if the scan did not show intracranial hemorrhage.[3] Finding hydrocephalus only a few hours after onset of headache caused by SAH is distinctly unusual. Certainly, its absence should not be relied on to exclude SAH in patients whose scans do not show blood.

In accepting Morganstern et al's[3] treatment of this scan result as false-negative, we were guided by principles of clinical reasoning. In particular, we followed a principle well known to emergency clinicians caring for potentially critically ill patients: when ambiguity arises, err on the side of patient safety. Exercise of this principle in routine clinical decisionmaking is also known as clinical judgment.

Clinical judgment emphatically pertains to the process of applying information from health care research to patient care. Stroke trials have illustrated graphically how difficult it can be to achieve uniformity in the interpretation of cranial CT scans, even under carefully prepared research conditions.[4] In North America, scans are usually read by general radiologists. We believed that a subtle finding such as hydrocephalus on a cranial CT scan is particularly likely to be missed or misinterpreted in a nonresearch setting when first encounter caretakers are looking for direct evidence of bleeding in a neurologically intact patient with headache. We therefore decided to adhere to the assessment of the scan in question as a "false-negative" study, thereby lowering the estimated performance of CT in identifying patients with SAH.

Similar clinical reasoning led us to reject the apparently superior performance of cranial CT reported by Van der Wee et al.[5] As Dr. Schwartz points out, the patients in that study were stated to be neurologically intact. However, Van der Wee et al admitted all of their study patients to hospital and found 68% of them to be positive for SAH. Because this practice and disease prevalence vary so markedly from what we ourselves are accustomed to, we decided that a much more detailed description of the patient population studied by Van der Wee et al than that provided by the authors would be required for us to be sure that a significant difference in spectrum of disease was not at play.[6] Once again, we exercised the equivalent of clinical judgment in deciding to prefer the results observed by Morganstern et al[3] to those reported by Van der Wee et al. Once again, we elected to err on the side of patient safety in an ambiguous situation.

MAKING ACTION THRESHOLDS EXPLICIT

A second point raised by Dr. Schwartz's commentary has to do with the effect of a diagnostic test result on the decision to activate or not to activate specific diagnostic or management strategies. When specific posttest disease probabilities can be identified, above or below which such strategies are mandated, these are often termed "action thresholds." This concept was introduced in a previous "Skills" article in the *Annals of Emergency Medicine* Evidence-Based Emergency Medicine series.[7] The hypothetical patient around whom our review was centered identified an action threshold of less than 1% probability of SAH.[2] This occurred in a context in which the hypothetical patient had a stated aversion to undergoing a lumbar puncture (LP). Certainly, not all patients manifest such an aversion, nor will all patients be able to respond to such an issue in a numerically precise way. We believe that this aspect of our scenario reflected a reality commonly faced by emergency practitioners. Ten patients, comprising nearly 10% of the study population in the study by Morganstern et al,[3] refused LP outright. Our patient was willing to entertain it, but only if a negative CT findings left the likelihood of SAH above a level that she psychologically perceived to be low.

A 1% action threshold for deferring invasive workup for SAH was suggested by another author[8] cited by Dr. Schwartz. Here again, the threshold was based purely on psychology, differing from our scenario only in that clinician psychology rather than patient psychology was at play.

Can either a patient's or a clinician's intuition be taken as a legitimate basis for defining important clinical action

thresholds? Neither our review nor the clinical scenario we used as a vehicle were intended to propose an action threshold of 1% for general application in connection with the clinical question at issue. Such parameters, to be applicable to broad classes of patients, are best based on established approaches to modeling clinical decision-making.[9-11] Such approaches use objective structured methods for combining patient values or incremental costs of selected strategies with best available evidence on the likely harms and benefits associated with the adoption of those strategies. They allow specific thresholds to be identified in an objective fashion. In this context, the effect of uncertainties and ambiguities in the performance of diagnostic tests, of pretest probabilities, and of the consequences of specific courses of action can also be explored and the effect of those uncertainties on the choice of strategies consistent with objectively stated values determined. Short of such analyses in a particular area, practitioners must continue to exercise clinical judgement in arriving at informed choices for their individual patients.

In closing, we are struck that Dr. Schwartz comes to the same conclusion as did others who have responded to our review,[12,13] and indeed, the same conclusion that we ourselves arrived at: In patients with possible SAH and a negative scan, an LP is warranted. That our review inspired this much discussion and debate in a context in which all involved parties are in agreement with the conclusion encourages us in the conviction that emergency physicians actively seek better conceptual tools and skills in applying scientific knowledge to their daily practice.

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2002 Pediatric Emergency Medicine Subspecialty Examination

The American Board of Emergency Medicine (ABEM) and the American Board of Pediatrics (ABP) will administer the certifying examination in Pediatric Emergency Medicine on November 18, 2002.

The eligibility criteria are available from both board offices.

Physicians who are certified in Emergency Medicine by ABEM must submit an application to ABEM for the credentialing process. Physicians who are certified in General Pediatrics by ABP must submit an application to ABP for the credentialing process. Physicians who are certified by both boards may select the board through which they apply. On successful completion of the examination, certification is awarded by the board through which the physician submitted the application.

Application materials will be available for ABEM diplomates on February 1, 2002, and will be accepted with postmark dates through May 1, 2002. ABP diplomates should contact ABP for application cycle information.

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