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Feedback: Computed Tomography and Lumbar Puncture for the Diagnosis of Subarachnoid Hemorrhage: The Importance of Accurate Interpretation

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

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Feedback: Computed Tomography and Lumbar Puncture for the Diagnosis of Subarachnoid Hemorrhage: The Importance of Accurate Interpretation

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To the Editor:

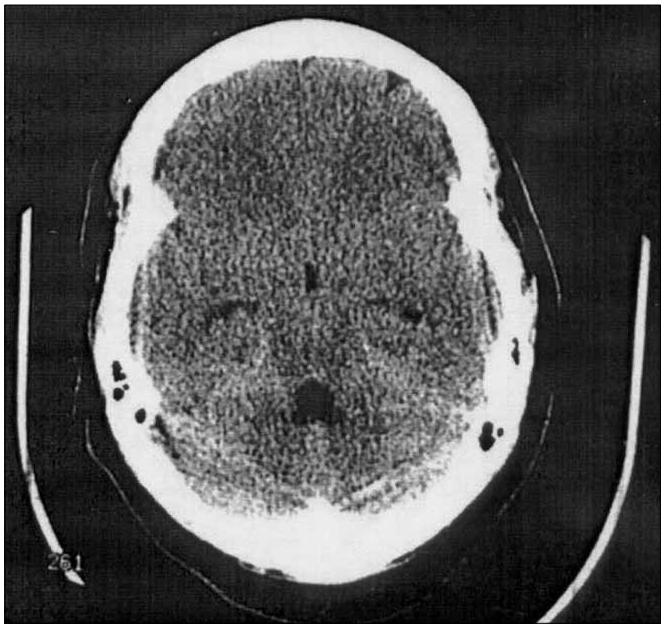
I applaud Dr. Edlow and Dr. Wyer[1,2] for their careful analysis of the medical literature regarding the sensitivity of current generation computed tomographic (CT) scanning in excluding a sentinel leak subarachnoid hemorrhage (SAH). It is important to revisit this issue because the necessity of a lumbar puncture (LP) after negative findings from a CT scan has recently come under question. Singal[3] argues that, in patients with a low (10%) pretest probability of SAH, negative CT scan findings will decrease the posttest probability below a threshold at which it is reasonable to omit an LP (1%). An informal survey by Morgenstern et al[4] found that fewer than 50% of patients with severe headache and negative CT scan findings underwent LPs in a university emergency department.

Edlow and Wyer[1,2] conclude that an LP is needed after negative CT scan findings because the sensitivity of a CT scan is 93% (negative likelihood ratio 0.07) and may be as low as 81% (negative likelihood ratio 0.4). However, the study by Morgenstern et al[4] on which they base their calculations is flawed, causing them to underestimate the sensitivity of CT scanning. Morgenstern et al studied neurologically intact patients who had CT scans within 24 hours of symptom onset. Although they report that 1 (7%) of 15 patients with SAH had negative findings on a CT scan, the CT scan findings were, in fact, not negative (Figure). The CT scan was interpreted as showing hydrocephalus, a finding suggestive of SAH. In the image shown in their report,

there is dilation of the third, fourth, and temporal horns of the lateral ventricles, which is indicative of communicating hydrocephalus. Acute communicating hydrocephalus is seen in either SAH or meningitis. Therefore, none of the patients with SAH presenting within 24 hours of symptom onset had negative CT scan findings, and CT had 100% sensitivity at excluding SAH. However, because only 15 patients with SAH who were scanned within 24 hours of onset were included in the study, the 95% confidence interval (CI) is very large (sensitivity as low as 80%). Morgenstern et al do not prove that CT has less than 100% sensitivity for SAH because all of their patients with SAH had abnormal CT scans, and their sample size was too small to yield meaningful confidence intervals.

The fact that current CT is not 100% sensitive at excluding a sentinel leak SAH, is convincingly demonstrated by Van der Wee et al,[5] who paid meticulous attention to CT technique and interpretation. Two of 119 neurologically intact patients with SAH, who were scanned within 12 hours of onset, had negative CT findings as interpreted by neuroradiology experts (sensitivity 98%, lower 95% CI 94%). In the hypothetical case presented by Edlow and Wyer,[1] this would reduce the posttest likelihood of SAH to close to the proposed 1% threshold under which LP could reasonably be omitted. There are 2 criticisms of the Van der Wee et al study. First, the disease prevalence in the patients studied was high (68%). This could overstate the sensitivity of CT when applied to patients with lower disease prevalence, although the magnitude of the spectrum bias is unknown. Second, CT scans were interpreted by neuroradiology experts, and the results may not be duplicated in other clinical settings. However, one of the study's strengths is that it demonstrated that, even in optimal circumstances, CT can miss an SAH. Despite these quantitative uncertainties, the implications of Van der Wee et al's study are clear in qualitative terms: If SAH remains a diagnostic consideration, truly negative CT scan findings should still be followed by an LP.

Figure (Schwartz).
A 37-year-old woman with a 1-hour history of headache. The CT scan reveals communicating hydrocephalus with dilation of the third, fourth, and temporal horns of the lateral ventricles. Although this finding is indicative of SAH, in this study, the CT scan was considered a false-negative. From Morgenstern LB, Luna-Gonzales H, Huber JC, et al. Worst headache and subarachnoid hemorrhage: prospective, modern computed tomography and spinal fluid analysis. Ann Emerg Med. *1998;32:297-304.*



It is well known that the accuracy of CT scan interpretation depends on the interpreter's expertise. Although it could be argued that accurate CT scan interpretation is of secondary importance because patients with negative CT scan findings will undergo an LP, interpretation of cerebrospinal fluid (CSF) results is sometimes problematic. In approximately 20% of cases, the LP will be bloody because of a traumatic tap, and this can be difficult to distinguish from SAH. Various criteria are used to differentiate a traumatic tap from an SAH, but none are clearly established or foolproof.[6] For example, Van der Wee et al[5] used the presence of xanthochromia measured spectrophotometrically and mandated that the LP be performed at least 12 hours after symptom onset to allow for development of xanthochromia. (His patients were admitted to the hospital to wait until 12 hours had elapsed from the onset of headache.) Morgenstern et al's[4] criteria for SAH were an RBC count of more than 1,000 cells/mm^3 without a decrement of more than 25% from the first and last tube and the presence of xanthochromia by visual inspection. He found that spectrophotometric measurement of xanthochromia was overly sensitive and could not distinguish SAH from a traumatic tap. In a review, Edlow and Caplan[7] state that LP should not be delayed in patients with suspected SAH and that "patients with persistently bloody CSF without xanthochromia should undergo vascular imaging when the level of clinical suspicion of SAH is high." Although these are reasonable conclusions given the available evidence, the terms "persistently bloody" and "high clinical suspicion" are not precisely defined.

The problem of misinterpreting a traumatic tap as an SAH (false-positive CSF interpretations) is not trivial. The patient will require 1 or more cerebral angiograms to

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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In response:

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