

# Is lumbar puncture still needed in suspected subarachnoid hemorrhage after a negative head computed tomographic scan?

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**Clinical question:**

Is lumbar puncture still needed in suspected subarachnoid hemorrhage with a negative head computed tomographic scan performed within 6 hours of headache onset?

**Article chosen:**

Perry JJ, Stiell IG, Sivilotti ML, et al. Sensitivity of computed tomography performed within six hours of onset of headache for diagnosis of subarachnoid haemorrhage: prospective cohort study. *BMJ* 2011;343:d4277.

**Objective:**

To determine whether lumbar puncture can be safely omitted after a negative head computed tomographic scan in the workup of a suspected subarachnoid hemorrhage.

**Keywords:** computed tomography, lumbar puncture, subarachnoid hemorrhage

**BACKGROUND**

Headache is a frequent complaint encountered in emergency medicine. Although most headaches are benign, subarachnoid hemorrhage is of particular concern. Missing a sentinel hemorrhage delays diagnosis and carries a worse prognosis.<sup>1</sup> The current standard is to perform a lumbar puncture after a negative computed tomographic (CT) scan.<sup>2</sup> Lumbar puncture may be uncomfortable and can be associated with postdural puncture headaches.<sup>3</sup> As for CT, sensitivity declines over time. Previous small studies

reported sensitivity between 93 and 100% for early CT.<sup>4-6</sup>

This study sought to determine the sensitivity of modern CT for identifying subarachnoid hemorrhage in neurologically intact patients specifically when performed within 6 hours of headache onset.

**STUDY DESIGN**

This was a prospective cohort study conducted between November 2000 and December 2009 in 11 university-affiliated tertiary care hospitals in Canada. This report was part of a larger project whose objective was the development of a clinical decision rule for acute headache.<sup>7</sup>

Alert patients over 15 years of age were eligible if they presented with nontraumatic acute headache or syncope associated with headache. Patients were excluded if headache onset was more than 14 days prior to emergency presentation or if they had a history of recurrent headaches or were transferred with a confirmed diagnosis.

**OUTCOMES MEASURED**

The main outcome was the sensitivity of CT for detection of subarachnoid hemorrhage. Patients were considered positive for subarachnoid hemorrhage if subarachnoid blood was identified on a CT scan; if they had visible xanthochromia in the cerebrospinal

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fluid (CSF); or if they had red blood cells ( $> 5 \times 10^6$ ) in the final tube of CSF and an aneurysm identified on a cerebral angiogram. Patients with red blood cells in the CSF without an aneurysm on a cerebral angiogram were deemed negative for subarachnoid hemorrhage. Those with arteriovenous malformation were considered as having a definite alternative cause of headache.

Third-generation scanners were used and interpreted by a local radiologist who was either a neuroradiologist or a general radiologist routinely reporting head CT. Radiologists were blinded to the study objectives but had routine clinical information available. The final report from the radiology staff was used.

Not all patients underwent lumbar puncture. Patients with a negative CT scan not undergoing lumbar puncture were followed for 6 months. Follow-up consisted of phone interviews and hospital record reviews. Finally, records from regional neurosurgical centres and provincial coroner records were searched for patients lost to follow-up.

## RESULTS

A total of 3,132 patients were enrolled, and 2,292 were missed because no data form was completed. Of those enrolled, 240 (7.7%) had subarachnoid hemorrhage.

There were 1,931 patients requiring follow-up. Of those, 1,506 had a phone interview at 6 months and none had a subarachnoid hemorrhage. Most of the remaining patients were known to be alive at least 1 month after their initial visit. Eight were confirmed dead at 6 months, but none from subarachnoid hemorrhage according to death certificates. One patient died suddenly 32 days after the initial visit. His death was presumed cardiac in origin because he died 4 days after a visit for chest pain and had previously suffered a myocardial infarction. Fifty patients, including 13 in the group that underwent CT within 6 hours, were lost to follow-up. None were seen at the regional neurosurgical centre or confirmed

as having died using coroner reports. They were categorized as being free of subarachnoid hemorrhage.

The sensitivity of CT performed within 6 hours of headache onset was 100% (95% CI 97–100). It dropped to 85.7% (95% CI 78.3–90.9) after 6 hours (Table 1). Of 953 patients who had CT within 6 hours, 121 had confirmed subarachnoid hemorrhage.

One patient had a scan done within 6 hours of headache onset that was initially misinterpreted as being negative by a trainee. The local neuroradiologist later interpreted the scan as positive. The authors considered this case as having being detected by CT.

## COMMENTARY

Considering the consequences of a missed diagnosis, physicians expect a near-perfect sensitivity when ruling out subarachnoid hemorrhage.<sup>8</sup> The main concern is rebleeding, which is highest in the first days and is associated with poor outcomes.<sup>9,10</sup> The present study by Perry and colleagues is the largest prospective study ever undertaken to evaluate the sensitivity of CT.

We must first evaluate for risk of bias. The fact that 2,292 eligible patients were not enrolled is a serious concern. It is, however, reassuring that they had characteristics similar to those of enrolled patients and that sensitivity within 6 hours was also 100% in those patients. Some concerns arise from the reference standard used for comparison because only half of the patients underwent a lumbar puncture. Moreover, sensitivity for xanthochromia using direct observation is below 50%.<sup>11</sup> Spectrophotometric analysis of xanthochromia, being 100% sensitive, would have reduced the possibility of false-negative results.<sup>12</sup> Fortunately, the authors made all efforts possible to ensure an adequate follow-up and had a minimal loss to follow-up. Finally, it is possible that radiologists reading CT scans were aware of the final diagnosis because staff reading was often delayed.

We agree with the authors' conclusion that CT performed more than 6 hours after headache onset has

**Table 1. Sensitivity of computed tomography for subarachnoid hemorrhage**

Time from headache onset to scan	No. of patients	% sensitivity (95% CI)	Negative likelihood ratio (95% CI)
All patients	3,132	92.9 (89.0–95.5)	0.07 (0.05–0.11)
≤ 6 h	953	100 (97.0–100.0)	0.00 (0.00–0.02)
> 6 h	2,179	85.7 (78.3–90.9)	0.14 (0.14–0.17)

inadequate sensitivity to rule out subarachnoid hemorrhage. On the other hand, caution is warranted in acknowledging the 100% sensitivity claimed by the authors for CT performed within 6 hours. The patient with subarachnoid hemorrhage whose scan was retrospectively read as being diagnostic should be considered a false-negative result. It is probable that some cases were missed because not everyone underwent a lumbar puncture. It is uncertain furthermore that all patients lost to follow-up were free of subarachnoid hemorrhage. Although sensitivity using this protocol does not reach 100%, the negative likelihood ratio remains very low. The conservative estimate of the authors, based on the assumption of three false-negative results out of 13 lost to follow-up from 832 negative scans, is plausible: a likelihood ratio of 0.024 (95% CI 0.007 to 0.07).

These results represent the best evidence available. How should we apply them in our clinical practice? Patients with a negative scan done after 6 hours should still undergo a lumbar puncture. As for patients with a negative scan performed within 6 hours, the physician now has tools to engage in informed shared decision making with the patient. The physician must, however, make sure that a third-generation multislice scanner was used. Also, the radiologist interpreting the scanner needs to do so routinely, being either a neuroradiologist or a general radiologist working in a high-volume centre. It would be reasonable to omit lumbar puncture if the patient understands the remote risk of missing a subarachnoid hemorrhage leading to adverse events. Assuming a prevalence of around 7%, the risk of a missed subarachnoid hemorrhage can be conservatively estimated as being around 1 in 500 to 1 in 1,000.

## **CONCLUSION**

Patients with suspected subarachnoid hemorrhage with a negative scan performed after 6 hours of headache onset should still undergo lumbar puncture. For those with a scan performed within 6 hours, caution is advised before uniformly omitting lumbar puncture in such patients. Physicians need to confirm that a modern scanner is used and that the radiologist reading

it is experienced enough. If that is the case, this study informs the discussion about lumbar puncture, which can be held with the patient, on a case-by-case basis.

**Competing interests:** None declared.

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