Determining the Sensitivity of Computed Tomography Scanning in Early Detection of Subarachnoid Hemorrhage

OBJECTIVE: This study aims to determine the sensitivity of modern computed tomography (CT) scanners in detecting subarachnoid hemorrhage (SAH) and to determine whether there is a continued need for lumbar puncture to exclude the diagnosis.

METHODS: This retrospective study was conducted from January 2000 to December 2005. The study population consisted of all patients referred on suspicion of SAH or with verified SAH. All medical records were reviewed together with results from CT scan, angiography, and cerebral spinal fluid analysis. Clinical history, examination findings, and time from onset of symptoms until CT scan (days) were recorded. Patients with a negative CT scan had a lumbar puncture done.

RESULTS: A total of 499 patients were included. In 203 patients the diagnosis was excluded by a negative CT scan and negative lumbar puncture. Two hundred ninety-six patients were found to have a SAH. The diagnosis in 295 of these patients was based on a positive CT scan. In a single patient, on day 6, the diagnosis was based on a positive lumbar puncture. From day 1 to day 5, CT scanning was found to have a sensitivity of 100%. Overall, CT scanning had a sensitivity of 99.7% (95% confidence interval: 98.1–99.99%).

CONCLUSION: CT scanning is excellent for diagnosing SAH. We demonstrate that in the first days after ictus a negative CT scan is sufficient to exclude SAH. Data do not allow for any specific cutoff point to be made. We suggest leaving out lumbar puncture in the first 3 days after ictus if the results of the CT scan are negative.

KEY WORDS: CT scanning, Lumbar puncture, Subarachnoid hemorrhage

Aneurysmal subarachnoid hemorrhage (SAH) is a potentially devastating disease. Patients who survive the initial hemorrhage are at high risk of rebleeding, which may result in death or permanent neurological deficits. Previous studies show that early detection leads to vastly improved outcomes. It is of the utmost importance, therefore, that an early diagnosis or exclusion of this disease can be made with a high degree of certainty.1,2

Currently, patients suspected of having a SAH have a computed tomography (CT) scan of the head performed. If the CT scan is negative for SAH, these patients have a lumbar puncture done. The detection of xanthochromia in the spinal fluid is currently considered to be the gold standard for diagnosing SAH.3-5

The current guidelines for diagnosing SAH are mainly based on studies done in the 1980s and 1990s. These studies found that CT scanning had an unacceptable rate of false negatives in detecting SAH, and lumbar puncture has therefore remained mandatory for the exclusion of this disease.6-8

Previous studies quote the sensitivity of CT scanning at 93 to 95% within the first 24 hours after onset of symptoms. Three days after onset of symptoms the sensitivity declined to 85%. After one week the sensitivity was only 50%.8

In the time since these studies were conducted the technology behind CT scanning has improved vastly, and it is possible that the accuracy in detecting SAH has improved accordingly. Today high-resolution, multidetector CT scanners are widely available in most hospitals in Western countries.
This retrospective study aims to determine the sensitivity of modern CT scanners in detecting SAH and to determine whether there is a continued need for lumbar puncture to exclude the diagnosis. To our knowledge this is the largest study of its kind in recent years.

MATERIALS AND METHODS

This retrospective study was conducted at the neurosurgical unit at Aalborg University hospital from January 2000 to December 2005. Aalborg Hospital is a major Danish University hospital covering the northern region of Jutland with a population base of approximately 750,000 people.

The study population consisted of all patients referred to our neurosurgical unit on suspicion of SAH or with verified SAH.

The hospital chart database was used to identify all medical records on these patients. The database was also searched for patients having a lumbar tap done during hospital stay. All medical records were reviewed by two experienced members of the neurosurgical staff. The medical records were reviewed together with CT scan, angiography, and results from cerebral spinal fluid analysis. Clinical history, examination findings, and time from onset of symptoms until CT scan (days) were recorded.

All patients had a CT scan of the head performed. If the CT scan was positive for SAH the patients subsequently had angiography studies performed and were allocated to appropriate treatment. Throughout the study period a range of different CT scanners were used at our institution and referring hospitals. The first multidetector CT scanners were introduced in 1998. Ever since, technological advances have been very rapid. Today’s market standard is a 64-slice multidetector CT scanner. Reflecting this development, scanners were gradually replaced and upgraded throughout the study period. All scanners used were considered contemporary standard equipment at the time.

Patients with a negative CT scan had a lumbar puncture done. Cerebral spinal fluid was sent to the laboratory for cell counts and all samples were analyzed for xanthochromia by spectrophotometry. Lumbar punctures were done no earlier than 12 hours after onset of symptoms.

All complications to lumbar puncture resulting in prolonged hospitalization or readmission were recorded. All data were compiled in a customized database allowing for later analysis.

RESULTS

During the study period, 510 were admitted. Eight patients were excluded because no lumbar puncture was performed because there was no clinical suspicion of SAH. In 2 patients the CT scan revealed an angioreticuloma (capillary hemangioblastoma according to World Health Organization classification). These patients were excluded. In 1 patient a spinal hemorrhage was demonstrated on magnetic resonance imaging. Angiography studies revealed no vascular abnormalities. This patient was excluded.

Four hundred ninety-nine patients were included. In 203 patients the diagnosis was excluded by a negative CT scan and negative lumbar puncture. Two hundred ninety-six patients had a SAH. In 295 of these patients the diagnosis was based on a positive CT scan. In a single patient, on day 6, the diagnosis was based on a positive lumbar puncture.

From day 1 to day 5 CT scanning had a sensitivity of 100% and a specificity of 100%. Overall CT scanning had a sensitivity of 99.7% (95% confidence interval (CI): 98.1–99.99%) and a specificity of 100% (98.2–100%).

Among those patients who had a lumbar puncture done, 4 patients had a viral meningitis. These patients were transferred to the infectious diseases unit.

Fifteen patients experienced post dural puncture headaches, equivalent to 7.4%. Only patients with symptoms severe enough for readmission or prolonged hospitalization were recorded.

DISCUSSION

The majority of patients presented within the first days after onset of symptoms with declining numbers on the following days (see Table 1). This is not surprising given the severity of the symptoms.

As mentioned above CT scanning was found to have a sensitivity of 100% from day 1 to day 5. With declining patient numbers on the later days it is not possible to define an exact “cutoff point.” However, it seems safe to leave out lumbar puncture from day 1 to day 3 if the CT scan is negative. Our numbers suggest that this even allows for a considerable safety margin. To our knowledge this is the largest study of its kind in recent years.

A recent study published by Boesiger and Shiber supports these findings, also quoting the sensitivity of fifth-generation CT scanners evaluating for SAH as 100%. This study is quite small, however, resulting in a wide 95% CI ranging from 61 to 100%.

Some older studies report less convincing results quoting the sensitivity of CT scanners from 95% to 97%. Most of these are also quite small and have not stratified patients according to time from onset of symptoms until CT scanning. It is well known that the sensitivity of CT scanners decreases with time from onset of symptoms as mentioned above. Also, some of these studies depended on older third-generation scanners.

The finding of 4 patients with a viral meningitis reminds us that, if there is any clinical suspicion of a neuroinfection, a lumbar puncture should always be done.

Although lumbar puncture is generally safe, complications are not uncommon. In our study 7.4% of the patients who had a lumbar puncture done experienced severe post dural headaches. This figure is probably an underestimate because only patients with symptoms severe enough for readmission or prolonged hospitalization were recorded. Some studies quote the occurrence of post dural headaches to be as high as 40%.

According to generally accepted guidelines a lumbar puncture should be performed no earlier than 12 hours after onset of symptoms. Apart from patient discomfort due to the procedure, this
also means that many patients have to be hospitalized overnight, taking up resources of the hospital staff.

Subarachnoid hemorrhage from spinal arteriovenous malformations (sAVM) could be considered a problem. In the literature 35 cases of intracranial subarachnoid hemorrhage from sAVM are described. In all these cases SAH was diagnosed on a CT scan. Bleeding from sAVM without intracranial extensions of blood will most likely present with symptoms of back pain, sensory disturbances, and paresis of the extremities.15

As mentioned above it seems to be safe to leave out lumbar puncture from day 1 to day 3 if the results of the CT scan are negative. The CT images should always be evaluated by either a neurosurgeon or a dedicated neuroradiologist if the diagnosis is to be excluded without doing a lumbar puncture. This algorithm should therefore only be used in specialized centers. Patients arriving to hospital later than day 3 should always have a lumbar puncture done if the results of the CT scan are negative. Previous studies show that even the sensitivity of lumbar puncture decreases after day 14. After 3 weeks the sensitivity of lumbar puncture has decreased to 70%, and after 4 weeks the sensitivity is only 40%.16 This means that patients arriving later than day 14 should be evaluated by angiography studies.

Since the conclusion of our study, the algorithm outlined above has been implemented at our institution.

CONCLUSION

CT scanning is excellent for evaluating patients suspected of having a SAH. We show that CT scanning has a sensitivity of 100% from day 1 to day 5. Because of declining patient numbers on the later days, it was not possible to establish an exact “cutoff point.” We suggest leaving out lumbar puncture from day 1 to day 3 if the CT scan is negative, which allows for a considerable safety margin.

Overall CT scanning had a sensitivity of 99.7% (95% CI: 98.1–99.99%) and a specificity of 100% (98.2–100%). A lumbar puncture should always be done if any clinical suspicion of a neuroinfection exists.

Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

REFERENCES

COMMENTS

Cortnum et al present a large retrospective study aimed at evaluating the sensitivity and specificity of modern computed tomography (CT) scanners in accurately diagnosing subarachnoid hemorrhage (SAH), and they re-evaluate the conventional wisdom and previous recommendation to perform lumbar puncture in cases of suspected SAH and a negative CT scan.

This group retrospectively analyzed 499 patients presented to their hospital over a period of 5 years and found only a single case (in which the patient presented on day 6) of positive lumbar puncture and negative CT scan. The CT scanning sensitivity was thus 99.7% and the specificity was 100%. The authors concluded that CT scan is sufficient to diagnose SAH in the first 3 days of presentation and it seems to be safe to leave out lumbar puncture from day 1 to day 3 if the CT scan is negative.

We like this manuscript. The methodology is sound, and the hypothesis addresses an important clinical question. Whereas the real risk of lumbar puncture is small, too often the analysis of a negative CT scan is confounded by spurious data obtained by a traumatic lumbar puncture performed by an inexperienced non-neurosurgeon. This sort of data invariably confounds and complicates the assessment of the case and confuses the patient and family. It seems reasonable to adopt a CT-only policy for the first 3 days following “ictus.” Whether practitioners will actually modify their algorithms is a different matter.

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From a major neurosurgical center in Denmark, the authors report the reliability of CT scanning in the early detection of SAH. Using lumbar puncture as the reference standard, they confirm their hypothesis that modern (fifth generation) CT scanners offer excellent sensitivity and specificity compared with earlier models. They suggest that lumbar puncture is not necessary to exclude SAH in the first 3 days after ictus if the CT scan is negative.

The study consisted of nearly 500 patients who were thought to have SAH. Approximately 200 of the patients had negative CT scans and underwent lumbar puncture. In all of these patients but one, the lumbar puncture was “negative.” The last patient, who presented on post-bleed day 6, had a negative head CT but “positive” lumbar puncture. The remaining 300 patients had positive CT scans. From these data, the authors calculate that CT scanning has a sensitivity of 99.7% and a specificity of 100%, although the latter parameter is essentially tautologous.

The authors do not specify the basis of reporting a “negative” vs “positive” lumbar puncture result, nor do they indicate how they distinguished a traumatic lumbar puncture from true subarachnoid hemorrhage. Presumably, these designations are based on the presence or absence of xanthochromia. However, there may be institutional variability in the way by which xanthochromia is measured. Rather than using quantitative spectrophotometry, some laboratories merely perform visual inspection of the supernatant. Furthermore, as the authors note, xanthochromia takes several hours to appear, so a lumbar puncture performed shortly after the onset of SAH may yield false negative results. Similarly, xanthochromia may disappear at varying rates, and the absence of xanthochromia days after an event can not reliably exclude prior SAH. Also, xanthochromia on lumbar puncture may be the only means of detecting a “sentinel” hemorrhage in the setting of a negative CT. Finally, CT scan interpretation is inescapably subjective. The authors caution that the CT images should always be evaluated by either a neurosurgeon or a dedicated neuroradiologist if the diagnosis of SAH is to be excluded without doing a lumbar puncture.

Despite these limitations, this study provides important data about the reliability of modern CT scanners and is likely to change clinical practice.

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