LP or not LP, that is the question: gold standard or unnecessary procedure in subarachnoid haemorrhage?

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ABSTRACT

Objective To measure the sensitivity of modern CT in patients presenting to the emergency department and evaluated for possible subarachnoid haemorrhage, with particular attention to those presenting within 12 h of ictus.

Design Retrospective cohort study.

Setting Large district general hospital emergency department seeing 73 500 new attendances per year.

Participants Patients presenting to the emergency department and screened for suspected subarachnoid haemorrhage.

Outcome measures Subarachnoid haemorrhage was defined by either the presence of subarachnoid blood on CT, positive CSF spectrophotometry defined by national guidelines or aneurysm identified on subsequent angiography if either of the former were equivocal.

Results 244 patients were screened for subarachnoid haemorrhage during the 24 months between March 2006 and April 2008 (mean age 48.5 years). The sensitivity of CT overall for subarachnoid haemorrhage was 93.8% (95% CI 84% to 98%) increasing to 95% (95% CI 82% to 99%) if performed within 12 h of ictus.

Conclusions While modern CT has a high sensitivity for the diagnosis of acute subarachnoid haemorrhage, particularly within 12 h of ictus, it is still not sufficient to act as the sole diagnostic tool, and patients with a negative CT will require further investigation with a lumbar puncture.

BACKGROUND

Headache remains an important and core presentation to the emergency department and one which highlights the value of the practice of good emergency medicine. Diagnoses may range from the benign and trivial to serious and life threatening. The key to successful management is a detailed and accurate history directing appropriate further investigations.

Subarachnoid haemorrhage (SAH) affects about one in 10 000 patients per year in the UK[1] and is associated with significant morbidity and mortality, not just from the initial insult, but often from the late rupture of further aneurysms. It often affects patients who are otherwise fit and healthy. The classic presentation of SAH is with a 'thunderclap' headache, rupture of an aneurysm leading to a rapid release of blood into the CSF under arterial pressure causing a severe headache, characteristically of very rapid onset reaching maximum intensity within minutes. However, the clinical picture may vary significantly, and patients may present with little or no headache, with syncope, nausea or seizures, and can appear remarkably well.

The initial investigation of choice for patients with suspected SAH remains high-resolution CT. However, the best available evidence still indicates that CT alone is inadequate to act as a sole diagnostic test in patients with suspected SAH, with estimates of sensitivity ranging between 80% and 98%.[2–4] For a condition where missed diagnosis may lead to significant morbidity or even mortality, the diagnostic strategy must be extremely robust. Most protocols mandate that patients with a negative CT should proceed to have a lumbar puncture (LP) at 12 h after ictus to look for bilirubin and oxyhaemoglobin. The combination of CT plus LP gives a robust rule-out for SAH when both are negative.[5] LP however, is not a benign procedure, with post-LP headache seen in up to 38% of patients.[6] This combined with a high rate of patient refusal due to perceived procedural discomfort and the risk of potential CSF infection or abscess development suggests that this is a step that should not be undertaken lightly. Performing a delayed LP frequently makes medical admission necessary and, thus, also entails financial cost, inconvenience for the patient and extra resource usage.

CT scanners used in the original research that established the inadequacy of radiology alone as diagnostic strategy in SAH clearly lacked the sensitivity to detect small but clinically significant bleeds. However, CT technology has progressed significantly in the last two decades. Modern scanners use continuous spiral movement of a scanning tube around the body to produce a volume of information that can be manipulated to identify changes in density with much greater accuracy. More recent research in the USA suggests that the sensitivity of such scanners is vastly improved.[1] Research on this topic in the UK is sparse. Additionally, the timing of scanning from ictus has been neglected, although it is clear that blood becomes progressively less dense and more difficult to detect radiologically with time.[7] McCormack[8] reported that CT alone has 100% sensitivity if performed in patients presenting <6 h from ictus.

The aim of this study was to establish the sensitivity of current CT scanners for detecting SAH within 12 h of ictus in order to evaluate the ongoing need for LP following CT in a large UK emergency department.

METHODS

Design

This study was performed using a retrospective review of patient records from a large city teaching hospital.

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Patients and exclusions

All patients investigated for SAH with either CT alone or CT plus LP at the Royal Devon and Exeter Hospital during the 24 months between 31 March 2006 and 1 April 2008 were identified using three data sources:

1. Radiological coding of SAH (ie, patients with CT head reported as being positive for SAH/subarachnoid blood) n=93
   Exclusions: patients aged less than 18 years (n=2), and those who had sustained traumatic haemorrhages (n=26)
2. LPs performed to exclude SAH (all LP samples processed for xanthachromia performed during the study period were examined, n=222)
   Exclusions: hospital notes were reviewed to exclude those cases in which a diagnosis of SAH was not suspected in the differential diagnosis (n=45, all negative for subarachnoid blood)
3. Medical discharge coding of SAH (to identify any patients missed by (1) and (2) above due to coding or data entry error; this identified two additional patients with SAH).

One of two modern CT scanners using slip-ring technology, and either four or six slices per second, were used; a GE Light Speed 64-slice, or a Siemens Somaton 16-slice with 2.5 mm slices as standard protocol. All final reports were issued by a consultant radiologist (although initial reporting was often by a radiology registrar) and were reported as positive, negative or inconclusive (equivocal) for subarachnoid blood. CSF was analysed by spectrophotometry in accordance with national guidelines[9] to be reported as one of four results: (1) consistent with SAH (positive), (2) no evidence to support SAH (negative), (3) inconclusive, (4) unable to interpret. Those patients in the later two categories (equivocal LPs) were followed-up to identify the result of any further relevant investigation performed to date within the region (notably CT angiography or MR angiography).

Basic demographics and the timing of symptom onset, scanning and LP were documented.

RESULTS

During the 24 months of study review, 244 patients were identified as being investigated for suspected spontaneous SAH by CT alone or CT plus LP; 59% were women, and the mean age was 48.5 years with a range of 18–87. A flow chart illustrating the results of these investigations is shown in figure 1.

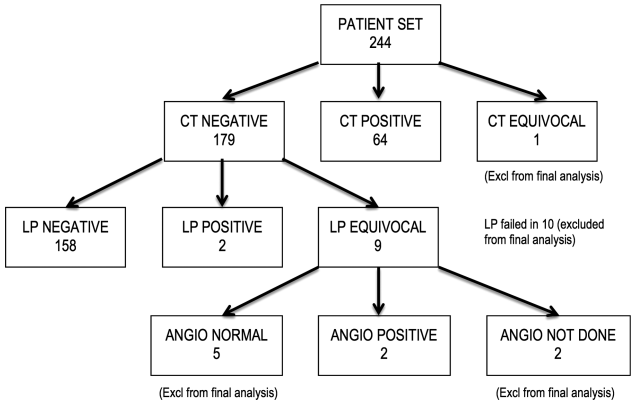

Figure 1 Data summary.

Sixty-four patients had scans that were positive for subarachnoid blood and 179 were negative. Three of the 'positive' results were subsequently labelled with a different diagnosis after further review and reimaging (false positives). One patient had an equivocal scan followed by an equivocal LP and a normal angiogram, and was excluded from further analysis. Of those with a negative scan, 158 had negative LPs. These patients were considered 'true negatives' and not followed-up further. Of the remaining patients with negative scans, two had positive LPs (false negatives), and nine had LPs that were equivocal. In two of the patients with equivocal LPs no further relevant imaging has been performed to date in the region, and they were excluded from further analysis. In the remaining seven, subsequent CT or MR angiography was positive in two cases (false negatives) and negative in five cases (excluded from further analysis as these patients were not 'true negatives' as tested by the gold standard of negative CT and LP). LP failed in 10 patients (due to technical difficulty, insufficient sample or patient refusal). Only three of these 10 had angiography performed subsequently (all negative) and they were all excluded from further analysis for the same reason as described above.

Table 1 The performance of CT alone versus the gold standard of CT plus LP (with angiography if LP equivocal)

	SAH diagnosed	SAH not diagnosed	Total
CT positive	61 (true positives)	3 (false positives)	64
CT negative	4 (false negatives)	158 (true negatives)	162
Total	65	161	226

LP, lumbar puncture; SAH, subarachnoid haemorrhage.

From the data recorded in table 1, the diagnostic strategy of CT alone to detect SAH irrespective of timing has a sensitivity of 93.8% (95% CI 84% to 98%), specificity of 98% (95% CI 94% to 99.5%), and a negative predictive value of 98% (95% CI 93% to 99%). The negative likelihood ratio is 0.06 (95% CI 0.02 to 0.16) and, thus, in our cohort the patient's probability of having a SAH reduces from 29% pretest to 2% after a negative CT.

Out of the 65 patients (29% of our cohort) found to have had a SAH, timing of symptom onset could be determined in 57 (88%); 40/57 (70%) of these scans were performed within 12 h of symptom onset - two out of these 40 were false negatives (one scan performed at 6.5 h from ictus and the other at 11.5 h). Thus, the diagnostic strategy of CT alone has a sensitivity of 95% (95% CI 82% to 99%) when performed within 12 h of ictus; 31/65 (48%) patients found to have SAH were scanned within 6 h and there were no false negative scans in this group. Of note, 77% of patients with SAH presented out of hours (Monday to Friday 09:00-1700).

DISCUSSION

Headache remains an important emergency department presentation, with SAH representing a small but clinically extremely important subgroup. Patients with SAH may be relatively young, having few or no comorbidities with a high probability of significant adverse sequelae. While SAH accounts for only 5% of the overall mortality from stroke, it accounts for 27% of all stroke-related years of potential life lost before the age of 65 years. Hence, our diagnostic strategy should be extremely robust. This study has shown that despite the significant advances in CT technology in recent years, its diagnostic accuracy for a condition where failure to diagnose may be fatal, is still insufficient for it to act as a gold standard test for the diagnosis of SAH, even in patients presenting within 12 h of ictus.

Other studies

The resurgence of interest in whether CT has improved sufficiently to render LP redundant in diagnosis of SAH was generated by a study by Boesiger and Shiber in 2005. They reported 100% sensitivity in a retrospective study of 177 patients investigated for SAH although their study actually only included six cases of SAH.[6] Further retrospective studies followed but were less encouraging; Byyny *et al*[10] identified 149 patients with SAH presenting over 3 years, 10 of whom had false negative CTs generating a diagnositic sensitivity of 94%. Lourenco carried out a similar study with fewer patients and reported 97% sensitivity.[11] Gee *et al*[12] found a sensitivity of 97.8% in 134 patients with SAH, but pointed out that none of the patients with negative scans required neurosurgical intervention.

Only recently has research really focussed on the effect of timing of imaging from ictus. A retrospective study in 2010 by Cortnum *et al*[13] looked at 499 patients referred to a tertiary neurosurgical centre with suspected or confirmed SAH. Out of 296 patients with confirmed SAH, only one had a negative CT with positive LP, and this patient was scanned 5 days after symptom onset.[13] However, the population studied here does not reflect the real diagnostic challenge to the emergency physician: that is, those patients with acute severe headache, normal conscious level and intact neurology at a hospital without 24 h access to experienced neuroradiologists.

A large prospective multicentre cohort study in America recently addressed this problem.[14] Perry *et al*[14] followed 3132 consecutive patients presenting with acute non-traumatic headache or with syncope and headache. CT scans were ordered at the discretion of the treating clinician. A subgroup of patients scanned within 6 h of ictus was determined a priori. Patients without LP performed after CT, or with inconclusive LP, were followed-up for a minimum of 6 months. Overall sensitivity of CT for SAH was 92.9% (95% CI 89% to 95.5%). In the subgroup scanned within 6 h, sensitivity was 100% (95% CI 97% to 100%). When scans were completed after 6 h, sensitivity fell to 85% (95% CI 78.3% to 90.9%). The authors conclude that despite a small number of patients lost to follow-up and some potentially eligible patients not enrolled because of inaccurate documentation, the findings of this study are enough to negate the need for LP if CT is performed within a modern scanner less than 6 h from ictus, and interpreted by an experienced radiologist.

In an attempt to replicate Perry's findings, Backes *et al*[15] retrospectively reviewed patients with a normal conscious level investigated for SAH. However, even when scanned within 6 h and interpreted by a neuroradiologist, SAH secondary to arteriovenous malformation was missed in this study, reducing sensitivity to 98.5% (95% CI 92.1% to 100%).

All 31 of the patients in our cohort scanned within 6 h from ictus were identified by CT alone, although notably one of the false negatives was only 30 min outside this time window. The numbers involved in this study are too small to conclude that a negative scan within 6 h renders LP unnecessary. Additionally, in any observational study it is not possible to prevent the bias resulting from the probability that patients with more 'convincing' symptoms and, thus, possibly bigger bleeds are likely to be scanned more urgently. It also seems relevant to consider how many formally reported scans within 6 h of ictus we can reasonably expect to obtain from neurologically intact, fully conscious patients given current pressures on UK emergency departments. Timely scanning is achievable if the benefit is evident.

Public education, liaison with ambulance services, and improved access to radiology have certainly increased the number of patients with ischaemic stroke scanned within 6 h. However, symptoms of ischaemic stroke are easier to define than those reported in SAH. Additionally, 77% of our patients presented out of hours and, thus, access to consultant radiologists for reporting in this time frame will be problematic for many smaller departments.

Limitations

The inherent weaknesses of using retrospective data make it difficult to establish with certainty the strength of the data produced. While every effort was made to identify those patients evaluated for possible SAH during the study period, the search strategy is flawed by its reliance on data input and coding. Undoubtedly, more patients presented and were screened during the study period than were found. Retrospective design also means that we relied on the clinicians involved to identify and risk-stratify patients presenting with symptoms which may represent SAH. It was not possible to identify and follow-up patients with less severe symptoms who may not have been investigated fully.

Although this may bring into doubt the accuracy of the data, the conclusion should remain firm regardless. That a number of patients with negative CT scans had either positive LP or MRA, suggests that to rely on CT alone would have led to the failure of diagnosis in these patients. Whether there would have been an adverse outcome in these cases without an established diagnosis is unclear.

Nine patients with negative CT underwent unsuccessful LP but failed to have any further definitive investigation. The reasons for this are unclear, although it would seem reasonable to assume that the clinicians involved in the care of these patients were satisfied that no further scrutiny was required. For the purpose of data analysis, if all nine were assumed to have false negative CTs, diagnostic sensitivity would fall to 82% (95% CI 71% to 90%). In addition to highlighting the surprisingly high rate of LP failure, these figures only serve to further enhance the case against the use of CT as a sole diagnositic test for excluding SAH.

A pragmatic design meant that there was no allowance for the grade of clinician reporting the CT, and it was often the case that the initial scan was reported by a registrar, with the final sign-off by the consultant, on occasion, not until the following day. Indeed one of the 61 'true positive' CT scans was initially reported as negative by a radiology registrar and corrected shortly after to positive for SAH by a consultant radiologist.

CT technology continues to evolve (256-slice scanners are now available to some UK emergency departments) and, thus, future research should readdress the issue of sensititvity as such scanners become more widely available.

CONCLUSION

This retrospective review is the first of its kind in the UK. We suggest that a diagnostic strategy of CT alone is inadequate for the exclusion of acute non-traumatic SAH in patients presenting to the emergency department. For the time being, patients with suspected SAH undergoing evaluation with a CT will still need to undergo a LP to ensure the diagnosis is not missed.

Contributors HS: Overall responsibility for content as guarantor, jointly involved in study design; performed data collection, data analysis and write-up. AR: Jointly involved in study design; assisted with data analysis and write-up. JM: Assisted with data collection.

Competing interests None.

Provenance and peer review Not commissioned; internally peer reviewed.

Data sharing statement All data collected is included in the results section of our paper.

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