Emergency department evaluation of sudden, severe headache

D.P. BREEN¹, C.W. DUNCAN¹, A.E. POPE², A.J. GRAY³ and R. AL-SHAHI SALMAN¹

From the ¹Department of Clinical Neurosciences, Western General Hospital, ²College of Medicine and Veterinary Medicine, University of Edinburgh, and ³Emergency Department, Royal Infirmary of Edinburgh, Edinburgh, Scotland

Received 6 December 2007 and in revised form 12 February 2008

Summary

Aim: To assess the clinical management of adults presenting with sudden, severe headache.

Methods: We retrospectively reviewed the medical records of consecutive adults presenting with sudden, severe headache to the emergency department (ED) or medical admissions unit at one teaching hospital.

Results: Of 12,025 consecutive attendances over 3 months, 91 adults (0.8%, 95% CI 0.6–0.9%) presented with sudden severe headache. Documentation of time to peak headache intensity and headache duration was complete in only 33% of cases. Brain computed tomography was performed in each of the 29 patients (33%) in whom it appeared indicated for the investigation of headaches peaking within 5 min and lasting more than 1 h, as well as 11 patients (13%) who did not meet these criteria. Lumbar puncture was attempted in every patient for whom it appeared indicated (although it was unsuccessful and abandoned on three of 24 patients), as well as one patient in whom it appeared not to be indicated. When subarachnoid haemorrhage was suspected, 81% of patients had spectrophotometry. Of the patients, 52 (60%) were given a specific diagnosis, 17 (33%) of whom were given a diagnosis despite an apparently insufficient history. A further 12 (14%) could have been diagnosed if the International Headache Society classification had been applied to the documented history. Neurological advice was sought for only 20 patients (23%).

Conclusions: Patients with sudden, severe headache might benefit if EDs used simple protocols, emphasizing the crucial elements of history and examination, appropriate investigation and targeted consultation with neurologists.

Introduction

Differentiating subarachnoid haemorrhage (SAH) from other causes of sudden, severe headache is a diagnostic challenge, but the distinction is important. Thorough clinical assessment and appropriate investigation, leading to earlier diagnosis and treatment, is very likely to improve outcome after aneurysmal SAH (which has ~50% case fatality and leaves one-third of survivors dependant).¹–⁵ The identification of patients with primary headache syndromes (such as migraine, cluster and tension-type headaches) may also lead to their safe and swift discharge without the need for investigation, and target those in need of neurological advice on abortive and prophylactic medication.
Although the Association of British Neurologists (ABN) aspires to the assessment of patients with sudden, severe headache by neurologists,6 the current size of the neurology workforce precludes this, so many patients with sudden severe headache in the UK are managed by acute or general physicians. But the proportion of patients with SAH whose diagnosis was ‘missed’ at an emergency department (ED) visit was 5.4% in a large Canadian study,7 and higher still elsewhere.8–10 Therefore, we sought to assess the clinical assessment and investigation of adults with sudden, severe headache, presenting directly to the ED or medical admissions unit at our hospital.

Methods

One author (A.E.P.) retrospectively screened the medical records of all consecutive, prospectively-recorded presentations to the ED immediate care area (arrival by ambulance or own transport) or medical admissions unit (general practitioner referrals) of the Royal Infirmary of Edinburgh between October 2005 and December 2005 inclusive. All ED patients with acute headache were assessed in the immediate care area, therefore, we did not screen those seen in the minor injuries area. Local practice is for some patients seen by their general practitioner to be referred directly to the on-call neurology service, but they were not included in this audit that focussed on non-specialist management. All patients with sudden, severe headache could be discussed with, and—if necessary—assessed by, the on-call neurology service.

Following the identification of every adult presenting to the ED or medical admissions unit with a sudden, severe headache in clear consciousness and with no history of head trauma, another author (D.P.B.) reviewed relevant medical records and investigation results. Data were collected on patient demographics, clinical history and examination, brain imaging and lumbar puncture (LP), consultation with neurologists, discharge diagnosis and follow-up arrangements.

 Appropriateness of further investigation was determined by comparing against predefined study criteria, orientated towards the identification of SAH. We considered brain imaging to be indicated in cases of: (i) first-ever, sudden, severe headache whose intensity peaked within 5 min and persisted for longer than 1 h; (ii) sudden, severe headache that was not part of the patient’s typical primary headache syndrome whose intensity peaked within 5 min and persisted for longer than 1 h and (iii) when there was a clinical suspicion of a diagnosis other than SAH in which brain imaging was indicated, such as stroke (e.g. cerebral infarction, subdural/extradural/intracerebral haemorrhage, carotid or vertebrobasilar dissection, intracranial venous thrombosis, vasculitis), hydrocephalus, idiopathic intracranial hypertension, intracranial tumour, pituitary apoplexy or infection. Criteria (i) and (ii) were based on a previous study by Linn et al.11 Where the headache was documented as starting ‘suddenly’ without indicating time to peak intensity, we still considered brain imaging to be indicated.

We considered LP to be indicated in cases of sudden, severe headache suspicious of SAH when brain imaging was normal or when there was a suspicion of another diagnosis, which would require LP for confirmation (such as meningitis). Clinical suspicion of other diagnoses was based on case note review [by DPB, with cross-checking by another author (R.A.S.S.) in cases of doubt].

Results

Of 12 025 consecutive presentations to the ED immediate care area or medical admissions unit over 3 months, 91 adults (0.8%, 95% CI 0.6–0.9%) presented with a sudden, severe headache. Data analysis is restricted to the 87 patients (96%) whose medical records could be retrieved; none of the missing four patients had died when checked on the hospital records system. The median age at presentation was 33 years (interquartile range 26–57), and 49 patients (56%) were female.

History

Time to peak headache intensity was quantified for 36 patients (41%), described simply as having started ‘suddenly’ for 33 patients (38%), and not documented for 18 patients (21%) (Figure 1). All patients with confirmed SAH had a headache that peaked either instantaneously or within 5 min, and

![Figure 1. Documentation of time to peak headache intensity.](image-url)
this was statistically significant (Fisher’s exact test: \( P < 0.00001 \)). Headache duration was recorded for 69 patients (79%); 73% of these headaches (including all confirmed SAH) were ongoing at the time of initial assessment. Both of these crucial questions were asked and documented for only 33% of patients. Time of headache onset was documented in only 50 cases (57%). Commonly associated symptoms, regardless of final headache diagnosis, were photophobia (45%), vomiting (41%), visual disturbance (34%), neck stiffness (19%), paraesthesia (18%) and fever (6%).

Of the patients, 19 (22%) had a documented first-ever headache, 37 patients (43%) had a documented past headache history [migraine \( n = 23 \), unspecified \( n = 10 \), cluster headache \( n = 3 \) and trigeminal neuralgia \( n = 1 \)], and a prior headache history was not documented for the remaining 31 patients (35%).

**Examination**

Documentation of complete neurological limb examination (79 patients; 91%) and cranial nerve examination (75 patients; 86%) was reasonable, but fundoscopy was documented as having been performed in only 42 patients (48%).

**Investigations**

Brain computed tomography (CT) was used to investigate each of the 29 patients (33%) in whom it was indicated (based on our study criteria, outlined in the methods section). Eight diagnoses of SAH were made by brain CT, and one other was diagnosed on LP after a normal brain CT. Brain CT was also performed in 11 patients (13%) in whom its use was not orientated towards the investigation of SAH (according to our study criteria): nine of these were normal. Two cases of intracerebral haemorrhage were diagnosed by CT brain scan; both patients had a past headache history and described their headaches as similar to their normal headache type, except that they had not resolved as usual. Their headaches had peaked within ‘5 minutes - 1 hour’ and ‘within hours’.

LP was attempted in all 24 patients (28%) in whom it appeared to be indicated based on study criteria, either for suspected SAH \( n = 21 \) or an alternative diagnosis [meningitis \( n = 2 \) and idiopathic intracranial hypertension \( n = 1 \)]. LP was unsuccessful and abandoned in three patients with suspected SAH who were subsequently discharged. The procedure was successful on the first attempt in 10 patients (42%), on the second attempt in four patients (13%), on the third attempt in six patients (19%) and on the fourth attempt in four patients (13%). A normal LP was also performed in one patient in whom it did not appear to be indicated by our criteria. Where LP timing could be ascertained from the notes \( n = 9 \), all procedures were performed >12 h after headache onset, but in many cases took much longer (median time from headache onset = 26 h). Opening pressure was documented in 18 cases (75%). A traumatic tap was documented in five cases (20%). All cerebrospinal fluid (CSF) samples were tested for red cells, white cells, paired glucose and protein. Spectrophotometry was carried out in only 17 cases (81%) where SAH was suspected.

**Consultation with neurology**

Neurological advice was sought in only 20 cases (23%), either following an abnormal CT brain scan \( n = 12 \), following an unsuccessful \( n = 3 \) or traumatic \( n = 1 \) LP, for advice regarding final diagnosis and follow-up \( n = 3 \) or prior to performing any investigations \( n = 1 \).

**Diagnosis and follow-up**

Of the patients, 52 (60%) were discharged with a specific diagnosis, 17 (33%) of whom were given a diagnosis despite an apparently insufficient history. A further 12 patients (14%) could have been diagnosed if the International Headache Society (IHS) classification\(^\text{12}\) had been applied to the documented history. The final IHS diagnoses in our patient population (in order of decreasing frequency) were: migraine, SAH, cluster headache, primary thunderclap headache, systemic viral infection, primary intracerebral haemorrhage, ischaemic stroke and rhinosinusitis. Three-quarters of all patients \( n = 65 \) were discharged without any follow-up arrangements. A smaller proportion was transferred to the neurology ward \( 10 \) patients; 11%), followed-up in the neurology clinic \( 8 \) patients; 9%), or followed-up in the ophthalmology clinic \( 1 \) patient; 1%). Three patients (3%) died whilst in hospital, two as a consequence of their SAH and one following an unrelated pulmonary embolism.

**Discussion**

The key finding of this study was the variation in the documented clinical assessment and investigation of adults with sudden, severe headache (Figure 2). The main focus of the study was the detection of SAH, which is the most important differential diagnosis in this patient group. The two most important questions to document and ask anyone suspected of having SAH are time to peak intensity and headache.
duration, but these were both documented in only one-third of the patients in this study. Thirty-eight percent of the patients’ headaches were described simply as having started ‘suddenly’, but this may not mean ‘instantaneously severe’—the crucial question that helps to distinguish most SAH headaches from mimics (such as migraine) is the time taken for the headache to reach its peak intensity. Despite the importance of a thorough neurological examination,13–16 this was documented in only 48% of our cohort. Fundoscopy was documented least frequently; its conduct by emergency physicians is worthwhile for the detection of frank papilloedema or retinal haemorrhages, although subtle abnormalities are usually only detected during specialist evaluation. LP was unsuccessful and abandoned following normal brain CT in 12% of patients, which was an improvement upon previous findings,17,18 but still ran the unacceptable risk of missing SAH (or other diagnoses such as meningitis) in these patients. The rapid drop in the sensitivity of brain CT for subarachnoid blood (97% at 12 h after headache onset and falling thereafter19) should mandate LP whenever SAH is suspected and brain CT is normal. The assessment of one-fifth of LPs was complicated by a traumatic tap, spectrophotometry was not requested in one-fifth of cases and opening pressure was not documented in one-quarter of all LPs, again reinforcing the need for experience and diligence in the conduct of this procedure. Of course, LP is especially important for patients who present with sudden, severe headache and are suspected of having meningitis.20

Strengths and weaknesses

This study benefited from being representative of the assessment of adults with sudden, severe headache at one teaching hospital ED and medical admissions unit. A large proportion of medical records were available for review, but a weakness was the study’s reliance on only documentation. Having said that, most of the data collected were of sufficient medico-legal importance to warrant their documentation (such as the time to peak headache intensity). The study did not have a protocol other than the criteria on which the appropriateness of investigation was judged, which were orientated to the investigation.

Figure 2. Summary of clinical assessment and investigation of patients with sudden, severe headache.

<table>
<thead>
<tr>
<th>Investigation indicated (n = 29)</th>
<th>Investigation not indicated (n = 58)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT performed (n = 29)</td>
<td>CT performed (n = 11) CT not performed (n = 47)</td>
</tr>
<tr>
<td>LP performed (n = 18)</td>
<td>LP performed (n = 1) LP not performed (n = 57)</td>
</tr>
<tr>
<td>SAH n = 9</td>
<td>n = 1 SAH n = 9</td>
</tr>
</tbody>
</table>

12,025 presentations to ED or medical admissions unit

91 patients with sudden, severe headache (0.8%)

Medical notes retrieved for 87 patients

Documentation of headache history
Time to peak intensity in 36 patients (41%)
Headache duration in 69 patients (79%)
Past headache history in 37 patients (43%)

Investigation indicated (n = 29)

CT performed (n = 29)

LP performed (n = 18) LP not performed (n = 3)

SAH n = 9

Investigation not indicated (n = 58)

CT performed (n = 11) CT not performed (n = 47)

LP performed (n = 1) LP not performed (n = 57)

n = 8
of SAH. Rather, the study was conducted with the specific intention of developing a protocol.

**Comparison with other studies**

Acute headache accounted for 0.8% of all emergency attendances in our study, which is similar to previous studies in the UK (0.5–0.85%), but lower than previous studies in North America (1–2%). Our study builds on previous work done by Locker et al. and describes in more detail the precise deficiencies in the clinical assessment and investigation of patients with sudden, severe headache.

A number of single cohort observational studies and case series have defined warning features ('red flags') that may prompt further investigation (Figure 3). These relate not only to SAH, but also to other potentially serious causes of acute headache described earlier. Whilst patients with 'red flags' will generally require a brain scan, performing a LP in some patients (e.g. those with low pressure headache secondary to intracranial hypotension) may worsen their symptoms and should be avoided by recognition of the diagnosis from the history. Because SAH may present with a longer time to peak than 5 min, those suspected of an atypical SAH presentation should ideally be discussed with the neurologist or neurosurgeon on-call to determine the need for specialist assessment and/or further investigation (Figure 4).

Any new headache that peaks within 5 min and persists for longer than 1 h should be investigated to exclude SAH. Unfortunately, there are no reliable features in the history to differentiate between primary and secondary sudden, severe headaches. SAH can present with mild, sudden onset headache, so the ‘first or worst’ mantra is unreliable.

**Main warning features:**
- New onset or change in headache in a patient who is aged over 50
- Time to peak headache intensity of <5 min
- Focal neurological symptoms (e.g. limb weakness, aura <5 min or >1 h, focal seizure)
- Non-focal neurological symptoms (e.g. cognitive disturbance, generalized seizure)
- Change in headache frequency, characteristics or associated symptoms
- Abnormal neurological examination

**Additional warning features:**
- Headache that changes with posture (e.g. standing up)
- Headache wakening the patient up, or precipitated by physical activity or valsala manoeuvre (e.g. coughing, laughing, straining)
- Patients with risk factors for cerebral venous thrombosis
- Jaw claudication or visual disturbance
- Neck stiffness
- Fever and rash
- New onset headache in patient with a history of HIV infection
- New onset headache in patient with a history of cancer

**Implications for clinical practice**

All patients with suspected SAH should have an unenhanced CT brain scan as soon as possible (immediately if consciousness is impaired). If the scan is normal, national guidelines advise that a LP be performed >12 h from headache onset. Delaying 12 h allows sufficient time for haemoglobin to be degraded into bilirubin, but the clinical benefit of early SAH diagnosis mandates performing the LP soon thereafter.

When performing a LP, it is important to minimize the chance of a traumatic tap, as failure to do so may make interpreting the LP results more difficult and necessitate the need for catheter or CT angiography. LPs should be carried out by doctors with sufficient experience, and adequate training in LP technique should be given to all trainees. It is essential to measure opening pressure in every patient as raised CSF pressure may point to alternative diagnoses such as intracranial venous thrombosis or idiopathic intracranial hypertension. By comparing CSF supernatant with white water against a white background, xanthochromia can be picked up at the bedside. However, samples should also be analysed for bilirubin using spectrophotometry. The presence of bilirubin is highly suggestive of SAH because it is only synthesized in vivo, as opposed to oxyhaemoglobin, which can be released from lysed red blood cells in a traumatic tap or during delayed laboratory transfer. All CSF samples should be delivered to the laboratory by hand and protected from the light. Especially when the tap is traumatic,
Figure 4. Algorithm for emergency evaluation of sudden, severe headache.

* e.g. Nausea, vomiting, photophobia, loss of consciousness, postural variation, seizure, neck stiffness

§ Age >50, headache worse in the morning, cognitive or focal neurological symptoms, change in usual headache character or pattern, HIV infection or cancer, abnormal neurological examination
s spectrophotometry is valuable as red cell clearing (reduction in red cell count in consecutive CSF collecting pots) cannot distinguish SAH from a traumatic tap.42

Neurologists have a significant contribution to make to the diagnosis and management of patients with sudden, severe headache. Interpretation of the history, and further clinical assessment where necessary, can help identify those patients who do not require further investigation. Appropriate training and clinical experience are likely to facilitate recognition of the many disorders in the wide differential diagnosis of sudden, severe headache. For example, by simply making use of the IHS diagnostic criteria and applying it to the documented history, a further 12 patients could have been diagnosed in our study. Lastly, neurologists also have particular expertise in the management of patients with primary headache disorders (such as migraine)—one of the most prevalent neurological diseases—with plenty of opportunity for therapeutic intervention.

Unanswered questions and future research

Our findings and the recommendations of previous studies are encompassed by a proposed algorithm for the emergency evaluation of patients with sudden, severe headache (Figure 4). This algorithm would need to be adapted for evaluation in hospitals with no immediate access to scanning facilities. In the course of this study, we identified two patients with intracerebral haemorrhage whose headaches did not fulfill our study criteria for further investigation (which were orientated to the investigation of SAH), but they did have one of the ‘red flags’ (change in headache pattern), which may prompt further investigation in this patient group (Figure 3). Consequently, our proposed algorithm incorporates these red flags. These patients should also have been discussed with the neurologist on-call.

In cases of suspected meningitis, we advise that patients be managed according to previously published guidelines.20 In immunocompetent adults with no evidence of reduced consciousness (GCS<12 or fluctuating conscious level), no evidence of raised intracranial pressure (papilloedema) and no history of recent seizures, CT is not required when bacterial meningitis is suspected as it may dangerously delay diagnosis and treatment.20,43,44

We plan to monitor the assessment and investigation of patients with sudden, severe headache, using our proposed clinical algorithm in the ED and medical admissions unit of our hospital. We urge others using this or any type of unvalidated algorithm for sudden, severe headache to do the same. We await results from the Ottawa Health Research Institute who are prospectively validating their SAH clinical decision rule.4

Conclusion

Patients with sudden, severe headache might benefit if EDs used simple protocols, emphasizing the crucial elements of history and examination, appropriate investigations and targeted consultation with neurologists.

Acknowledgements

Thanks to Dave Sorensen for his help with data collection and extraction, and the Clinical Effectiveness department at the Royal Infirmary of Edinburgh, NHS Lothian.

Conflict of interest: None declared.

References


42. Heasley DC, Mohamed MA, Yousem DM. Clearing of red blood cells in lumbar puncture does not rule out ruptured


