

Diagnostic test utilization in the emergency department for alert headache patients with possible subarachnoid hemorrhage

Jeffrey J. Perry, MD, MSc; Ian Stiell, MD, MSc; George Wells, PhD; Alena Spacek, MD

ABSTRACT

Objectives: This study evaluated the incidence of subarachnoid hemorrhage (SAH) and the use of computed tomography (CT) and lumbar puncture (LP) in a cohort of emergency department (ED) patients with acute headache.

Methods: Health records from a tertiary care ED were used to identify all patients over 15 years of age who presented with headache over a 10-month period. Patients were excluded if they had been referred with confirmed SAH or if they had recurrent headache, head trauma, decreased level of consciousness or new neurologic deficits. Outcome measures included ED diagnosis, use of CT or LP, and ED length of stay. Analysis included descriptive statistics, 95% confidence intervals (CIs) and analysis of variance for length of stay.

Results: The mean age of the 891 patients was 41.9 years. Ten (1.1%) of the patients had SAH, 313 (35.1%) underwent CT, and 85 (9.5%) underwent LP. Only 9 (2.9%) of the CT scans and 2 (2.4%) of the LPs were positive for SAH. Of the 296 patients with normal CT results, 232 (78.4%) did not undergo subsequent LP. The mean length of stay was 4.0 hours (95% CI, 3.8–4.1) if no diagnostic testing was performed, 5.0 hours (95% CI, 4.7–5.4) if CT was performed and 7.1 hours (95% CI, 6.3–7.9) if LP was performed ($p = 0.001$).

Conclusions: Diagnostic testing was associated with substantially prolonged lengths of stay. CT and LP had low diagnostic yields, which suggests the need for a clinical decision rule to rule out SAH in ED patients with acute headache.

Key words: subarachnoid hemorrhage, headache, clinical decision rule

RÉSUMÉ

Objectifs : La présente étude a évalué l'incidence des hémorragies sous-arachnoïdiennes (HSA) et le recours à la tomodensitométrie et à la ponction lombaire auprès d'une cohorte de patients reçus à l'urgence pour un mal de tête sévère.

Méthodes : Les dossiers de santé provenant d'un département d'urgence (DU) de soins tertiaires furent utilisés pour identifier tous les patients âgés de plus de 15 ans ayant consulté pour un mal de tête sur une période de dix mois. Les patients furent exclus s'ils avaient été envoyés à l'urgence avec un diagnostic confirmé de HSA ou si leurs maux de tête étaient récurrents, s'ils étaient atteints d'un traumatisme crânien, d'une diminution de leur état de conscience ou de nouveaux déficits neurologiques. Les mesures du résultat comprenaient le diagnostic au DU, le recours à la tomodensitométrie ou à la ponction lombaire et la durée du séjour au DU. L'analyse comprenait des statistiques descriptives, des intervalles de confiance (IC) à 95 % et l'analyse de la variance pour la durée du séjour.

Division of Emergency Medicine, Department of Epidemiology and Community Medicine, University of Ottawa, Ottawa, Ont.

Received: Apr. 3, 2002; final submission: May 9, 2002; accepted: May 9, 2002

This article has been peer reviewed.

Résultats : L'âge moyen des 891 patients était de 41,9 ans. Dix d'entre eux (1,1 %) souffraient d'une HSA, 313 (35,1 %) subirent une tomодensitométrie et 85 (9,5 %) subirent une ponction lombaire. Seulement 9 (2,9 %) des tomодensitométries et 2 (2,4 %) des ponctions lombaires donnèrent un résultat de HSA positif. Parmi les 296 patients dont les résultats de la tomодensitométrie étaient normaux, 232 (78,4 %) ne subirent pas de ponction lombaire subséquente. La durée moyenne du séjour était de 4,0 heures (IC 95 % 3,8–4,1) si aucune épreuve diagnostique n'était effectuée, de 5,0 heures (IC 95 % 4,7–5,4) si une tomодensitométrie était effectuée et de 7,1 heures (IC 95 % 6,3–7,9) si une ponction lombaire était effectuée.

Conclusions : Les épreuves diagnostiques étaient associées à des durées de séjour beaucoup plus longues. La tomодensitométrie et la ponction lombaire avaient un rendement diagnostique faible, ce qui évoque un besoin d'une règle de décision clinique pour écarter le diagnostic de l'HSA chez les patients reçus au DU pour un mal de tête.

Introduction

Subarachnoid hemorrhage (SAH) is a type of hemorrhagic stroke in which blood leaks from a cerebral blood vessel into the subarachnoid space. Most patients present with a history of sudden, severe headache.¹ Nearly half of all patients with SAH have normal vital signs, normal neurologic examination, and little or no neck stiffness.² The diagnosis is confirmed by computed tomography (CT), which shows blood in the basal cisterns, sylvian fissures or ventricles; lumbar puncture (LP), which reveals either xanthochromia (the degradation products of old red blood cells) or persistent red blood cells in the cerebrospinal fluid; cerebral angiography, which demonstrates aneurysm; or autopsy.³

Acute headache accounts for up to 4.5% of all emergency department (ED) visits, but only 1% of these will be SAH.⁴ Diagnosing SAH is often difficult in alert patients with normal neurologic examinations, but these are the patients most likely to benefit from a prompt diagnosis.^{3,5–8} Despite the frequency of headache among ED patients, the indications for investigations are vague. The most common initial investigation for patients with suspected SAH is nonenhanced CT of the head. If the results of such imaging are normal, LP is recommended, as CT misses up to 10% of cases of SAH.^{1,9}

This study evaluated the impact of ED testing strategies on ED resource utilization, as well as the rate of positive test results for SAH in a cohort of ED patients with acute headache compatible with SAH. The primary objective was to characterize diagnostic resource utilization, including ED length of stay and use of CT and LP. The secondary objective was to determine the rate of SAH in this patient group.

Methods

Setting and patients

This historical cohort study was performed between Jan. 1

and Oct. 31, 2000, at the Ottawa Hospital — Civic Campus, a Canadian tertiary care university centre, with an annual emergency department census of 57 000 patient visits. All emergency physicians had certification in emergency medicine through the Royal College of Physicians and Surgeons of Canada or the College of Family Physicians of Canada.

Patients over 15 years of age were eligible for inclusion if they presented to the study ED with headache or syncope, coded according to the World Health Organization's *International Classification of Diseases*, 9th rev (*ICD-9*). Patients were excluded if they had been referred from another centre with a diagnosis of SAH, if they were seen directly by a specialty service, if they had visited the ED 3 or more times in the previous year for a headache, if they had experienced head trauma within 7 days before presentation, if maximal headache severity was not reached within 1 hour from onset, if they had had the headache continuously for more than 14 days, if they had been previously investigated for the same headache with CT or LP (or both), if they had focal neurologic deficits on examination or if they had a Glasgow Coma Scale score of less than 15.

The study protocol was approved by the institutional ethics review board, and patient consent was not required. All personal identifiers were kept confidential and were stored separately from the clinical information.

Data collection

Cases were identified by searching the ED's electronic database for the *ICD-9* codes for headache, SAH or syncope (codes 307.81, 346, 430, 780.2 and 784). Data were extracted from each record of treatment, which included physician, nursing, consultant, triage, ambulance, laboratory and radiology reports. The data (as listed in Table 1) were first recorded on a structured data collection form and then entered into a database with SAS software (SAS Institute, Cary, NC).

Outcome measures

ED length of stay was defined as the time from initial physician assessment until discharge or referral to a specialty service. Utilization of CT and LP was quantified, and the rate of positive test results for SAH was determined.

Data analysis

Descriptive statistics, including means and medians for continuous variables and percentages for dichotomous variables, were generated. Analysis of variance (ANOVA) was performed for ED length of stay. The analyses were performed with SPSS version 10.0 software (SPSS Inc., Chicago, Ill.).

Table 1. Data collected from records of treatment for a 10-month historical cohort study of emergency department (ED) patients with acute headache or syncope

Demographic characteristics

Age, yr

Sex (male or female)

Historical features

Date of arrival in ED, y/m/d

Time of arrival in ED

Mode of arrival (ambulance or ambulatory)

Attending emergency physician (code)

Transfer from another ED

Similar headache in the past

Previous SAH

Family history of SAH

Patient seen in ED for syncope or headache in the past 6 mo

Worst headache the patient has ever had

Recorded severity of pain at peak intensity (0–10)

Recorded time from onset to peak (<1 h or ≥1 h)

Vomiting

Physical findings

Heart rate, beats/min

Temperature, °C

Systolic and diastolic blood pressure, mm Hg

Decreased level of consciousness (GCS score <15)

Transient loss of consciousness

Neck stiffness

Photophobia

Transient motor deficits

Investigations

Time to discharge or referral, whichever was first (ED length of stay)

Patient referred to neurosurgery

CT done

CT positive for SAH

LP done

LP positive for SAH

SAH = subarachnoid hemorrhage; GCS = Glasgow Coma Scale; CT = computed tomography; LP = lumbar puncture

Results

We identified 1957 patient records coded as headache, syncope or SAH. Of these, 891 patients met the study eligibility criteria (Fig. 1). The most common reason for exclusion was absence of headache. Ten (1.1%) of the patients had SAH, approximately one case per month for the study period. This corresponded to an annual incidence of 0.2 per 1000 patient visits at the study site.

Table 2 presents the characteristics of the patients included in the study, although data for many of the variables sought for this study were missing for numerous patients. The mean age of the cohort was 41.9 years, and 592 (66.4%) of the patients were females.

In total, 313 (35.1%) of the patients underwent CT of the head; 9 (2.9%) of these scans were positive for SAH and 8 (2.6%) were positive for other acute processes (6 neoplasms and 2 infarcts). Of the 296 patients who had normal CT results, 232 (78.4%) did not undergo subsequent lumbar puncture. Just 85 (9.5%) of the patients underwent LP, and 2 (2.4%) of these tests were positive for SAH. One of these patients had a positive CT result before the LP; the other had not undergone prior CT and was the only patient who had LP without CT.

Twenty-six (2.9%) of the patients were referred to the neurosurgical service and 33 (3.7%) were admitted.

Only 32 (3.6%) of the 891 patients had potentially dangerous conditions, including 10 patients with SAH, 9

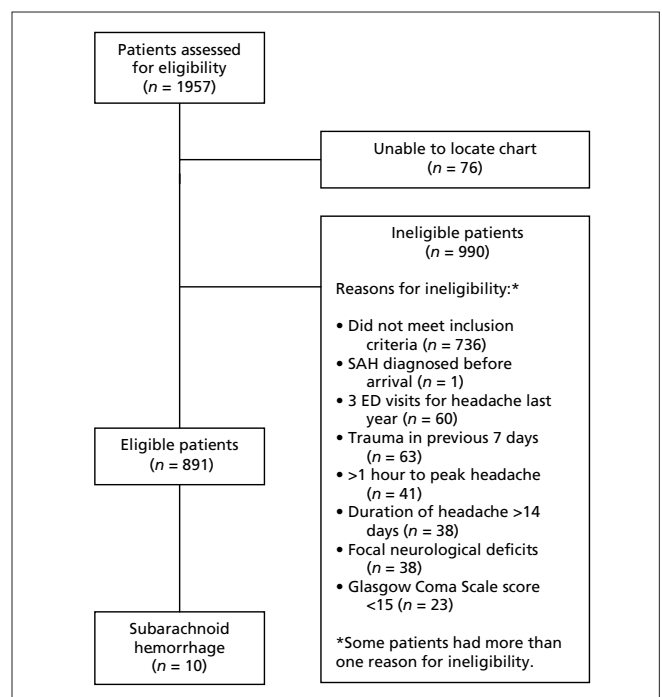


Fig. 1. Flow of patients

(1.0%) with an ischemic event, 6 (0.7%) with a brain tumour, 4 (0.4%) with bacterial meningitis and 3 (0.3%) with temporal arteritis (Table 3). None of the patients who had been seen in the previous 6 months for headache or syncope were subsequently diagnosed as having SAH.

The mean length of stay was 4.0 hours (95% confidence interval [CI] 3.8–4.1) if no diagnostic testing was performed, 5.0 hours (95% CI 4.7–5.4) if CT was performed and 7.1 hours (95% CI 6.3–7.9) if LP was performed ($p = 0.001$). Performing CT and LP substantially increased ED length of stay (Fig. 2) ($p = 0.001$).

Discussion

This study examined the use of diagnostic tests in ED patients at risk of SAH, and our findings clarify the potential impact of testing strategies on length of stay and patient flow. Our data show that the decision to perform CT and LP in patients with headache adds substantially to ED length of stay — a problem in already overcrowded EDs. Given the high prevalence of benign disorders and the low yield of diagnostic testing in this cohort, it is likely that a more selective approach to testing would reduce costs, shorten length of stay and improve ED flow without putting patients at risk.

We excluded patients with recurrent, gradual-onset, post-traumatic or previously investigated headaches in order to select a cohort of patients at risk for SAH. More than one-third of our study cohort underwent CT, which suggests that physicians viewed them as a high-risk group, but fewer than 10% of all patients (one-quarter of those with negative CT results) subsequently underwent LP, which suggests that physicians were reluctant to perform this test. This reluctance is of concern, given that CT is sensitive enough to diagnose only about 90% of cases of SAH.¹⁰ Nevertheless, even with this low rate of lumbar puncture, positive LP results were rare; thus, it may be possible to improve utilization of both CT and LP for alert patients with acute headache and normal neurologic examination.

The vast majority of these alert patients had benign headaches, including migraines, cluster headaches and tension headaches. The number of serious headaches (caused by SAH, tumour, bacterial meningitis or temporal arteritis) was

small. Thus, most patients required analgesia only, not extensive investigation.

The results of this study are generally consistent with those of similar studies. In particular, Dhopes and associates¹¹ in 1979 and Leicht⁶ in 1980 used retrospective chart reviews to study ED patients with a chief complaint of headache. The baseline characteristics of the patients in these 2 studies were similar to ours, except that Dhopes and associates¹¹ included children. We limited our subjects to patients over the age of 15 because SAH is very rare in children, and our ED sees few pediatric patients. The incidence of serious intracranial problems was lowest (1.5%) in the study by Dhopes and associates,¹¹ which probably relates to the inclusion of children. The incidence of seri-

Table 2. Patient characteristics (n = 891)

Characteristic	Mean or median (and SD or IQR) or no. (and %) of patients
Demographics	
Age, yr	
Mean (and SD)	41.9 (SD 17.0)
Range	15–94
Female	592 (66.4%)
Historical features	
Arrival by ambulance (n = 792)*	122 (15.4%)
Transferred from another ED	52 (5.8%)
Seen in previous 6 mo for headache or syncope	131 (14.7%)
Similar headache quality in past (n = 270)*	211 (78.1%)
Vomiting (n = 538)*	228 (42.4%)
Time from onset to peak, seconds (n = 112)	
Median (and IQR)	1 (IQR 1, 1)
Range	1–1800
Physical findings	
Mean heart rate (and SD), beats/min	83.5 (SD 16.5)
Mean systolic blood pressure (and SD), mm Hg	136.5 (SD 25.8)
Mean diastolic blood pressure (and SD), mm Hg	78.3 (SD 12.9)
Mean temperature (and SD), °C	35.9 (SD 0.8)
Neck stiffness (n = 444)*	16 (3.6%)
Neck pain (n = 181)*	117 (64.6%)
Transient LOC (n = 103)*	42 (40.8%)
Photophobia (n = 402)*	267 (66.4%)
Transient motor deficits (n = 238)*	53 (22.3%)
Investigation	
Time to discharge or referral (ED length of stay)	
Mean (and SD), min	239 (SD 148.3)
Range	17–1438

SD = standard deviation; IQR = interquartile range (presented as 25th percentile, 75th percentile); ED = emergency department; SAH = subarachnoid hemorrhage; LOC = loss of consciousness.

* Data not available for all cases

ous problems was similar in our study (3.6%) to that of Leicht⁶ (5%). On the basis of these results, it appears that the rate of serious intracranial problems has not changed appreciably in the past 2 decades.

Limitations

The main limitation of this study was its retrospective design, which was associated with incomplete information in patients' records. In addition, we failed to locate the charts of 76 potentially eligible patients, and we might have missed other cases if their symptoms were miscoded in the electronic database. Finally, our study cohort undoubtedly included some patients who underwent investigation for reasons other than to rule out SAH, and this might have decreased the diagnostic yields of CT and LP (for SAH).

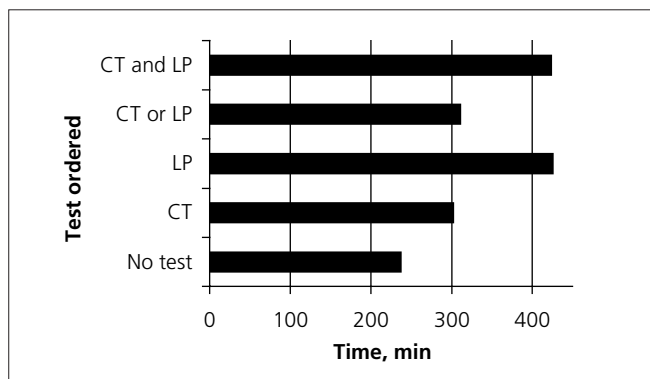


Fig. 2. Mean time spent in emergency department for all patients with acute headache or syncope in whom subarachnoid hemorrhage was not diagnosed.

Table 3. Emergency department diagnosis (n = 891)

Diagnosis	No. (and %) of patients
Migraine headache	389 (43.7)
Other benign headache	295 (33.1)
Viral illness	35 (3.9)
Benign syncope or pre-syncope	20 (2.2)
Subarachnoid hemorrhage	10 (1.1)
Transient ischemic attack or ischemic stroke	9 (1.0)
Trauma or post-trauma	8 (0.9)
Tumour	6 (0.7)
Hypertension	6 (0.7)
Sinusitis	6 (0.7)
Vertigo	5 (0.6)
Bacterial meningitis	4 (0.4)
Temporal arteritis	3 (0.3)
Other or not determined	95 (10.7)

Conclusions

Among ED patients with headache and normal neurologic examination, there is a high prevalence of benign conditions and a low rate of positive tests for SAH. Current testing strategies have substantial negative impacts on cost, ED length of stay and, most likely, patient flow. These factors suggest the need to develop a clinical decision rule to improve diagnostic efficiency in ED patients with acute headache.

Competing interests: None declared.

Acknowledgements: Dr. Perry is a Research Fellow, Ontario Ministry of Health. Dr. Stiell is a Distinguished Investigator of the Canadian Institutes for Health Research. This study was supported by a grant from the Ontario Ministry of Health Emergency Health Services Branch.

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Correspondence to: Dr. Jeffrey J. Perry, Clinical Epidemiology Unit, Ottawa Health Research Institute, F6, Ottawa Hospital — Civic Campus, 1053 Carling Ave., Ottawa ON K1Y 4E9; jperry@ohri.ca