# Detection of Intracranial Tumors, Subarachnoid Hemorrhages, and Subdural Hematomas in Primary Care Patients: A Report from ASPN, Part 2

Lorne A. Becker, MD; Larry A. Green, MD; David Beaufait, MD; Jack Kirk, MD; Jack Froom, MD; and William L. Freeman, MD, MPH

*Toronto, Ontario; Denver, Colorado; Hanover, New Hampshire; Stony Brook, New York; and Albuquerque, New Mexico*

*Background.* The initial diagnosis of intracranial tumor, subarachnoid hemorrhage (SAH), and subdural hematoma (SDH) can be difficult. This study was undertaken to determine the incidence and presenting signs and symptoms of these disorders in primary care settings, and to determine whether a more aggressive investigative strategy for patients with headache is justifiable.

*Methods.* Weekly return cards and a chart audit were used to collect data over a 19-month period on every patient who had a new diagnosis of intracranial tumor, SAH, or SDH. Age and sex reports were collected annually.

*Results.* Twenty-five new tumors, 17 SAHs, and 8 SDHs were reported in 58 practices (a rate of 12/100,000 patients per year). Only one half of these patients had headaches, and no abnormalities were found on neurological examination of many. Diagnosis was delayed in only four patients with headache caused by a brain tumor and in three patients with SAHs. Diagnosis was delayed in two of the latter because of false-negative CT scans.

*Conclusions.* Although clinical findings and CT scans are not reliable indicators, clinicians are able to detect the majority of these rare conditions without undue delay by selecting a small subset of patients for further investigation. More extensive use of CT scans appears to be a weak strategy to improve detection of these serious disorders, as increased use would lead to increased health care costs and unintended adverse effects, and provide little benefit.

*Key words.* Tomography, x-ray, computerized; headache; hematoma, subdural; subarachnoid hemorrhage.
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Early detection of intracranial tumor, subarachnoid hemorrhage (SAH), or subdural hematoma (SDH) can be a difficult task in primary care. Prompt recognition is particularly important for patients with SAH who may have a headache but no other clinical findings at the time of the initial examination.[1,2] Early recognition and immediate treatment are associated with better outcomes, but unfortunately, these "warning leaks" are often not identified as SAHs. Patients with intracranial neoplasms or subdural hematomas may also present with headaches that appear to be benign, or with other subtle signs or symptoms, and thus go undetected in their early stages. While headache is considered a relatively common symptom in patients with these disorders,[3] few studies have addressed the incidence or presenting signs and symptoms of intracerebral tumors, SAHs, or SDHs in primary care practices. There is a similar paucity of information concerning the effectiveness of primary care physicians in prompt diagnosis of those patients with a headache caused by a tumor or intracranial bleed.

Several authors[4-6] have suggested that computed

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*From the Department of Family and Community Medicine, University of Toronto, Ontario, Canada (L.A.B.), the Department of Family Medicine, University of Colorado Health Sciences Center, Denver (L.A.G.), the Department of Community and Family Medicine, Dartmouth Medical School, Hanover, New Hampshire (D.B., J.K.), the Department of Family Medicine, State University of New York at Stony Brook, Stony Brook, New York (J.F.), and the Indian Health Service, Albuquerque, New Mexico. Requests for reprints should be addressed to Linda Niebauer, Ambulatory Sentinel Practice Network, 1180 Clermont St, Denver, CO 80220.*


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tomography (CT) scanning of patients with headache represents a cost-effective approach to the diagnosis of intracranial tumors or of SAH. These studies, however, were performed in tertiary care settings, with patients who had passed through a series of referral filters, making it difficult to generalize the findings to primary care settings.[7] In a previous study,[8] we found that primary care physicians use CT selectively, ordering scans only for approximately 3% of patients with headache. We were unable in that study to determine whether this strategy led to significant or harmful delays in diagnosis.

The present study was initiated to determine the incidence in primary care practices of serious intracranial disease such as neoplasms, SAH, or SDH; to study the signs and symptoms with which these patients present to primary care physicians; and to estimate the extent to which a more aggressive investigative strategy for patients with headaches would have led to earlier diagnosis.

## Methods

Participating clinicians in the Ambulatory Sentinel Practice Network (ASPN) collected data about each patient in their practice who was newly diagnosed as having an intracranial bleed or an intracranial mass lesion (including those patients for whom the ASPN clinician was not personally involved in the episode of care that led to the diagnosis). Intracranial bleed included subdural hematoma, subarachnoid hemorrhage, and other intracranial hemorrhage. Mass lesions included benign, primary, and secondary malignant intracranial tumors, localized intracranial infections such as brain abscess, and other intracranial mass lesions.

Initial data collection was carried out with pocket-sized weekly return cards on which participating physicians noted their specific diagnosis, and indicated whether the patient had ever consulted a physician about headache. Completed return cards were mailed to ASPN weekly. Subsequently, physicians sent documentation (such as a consultant report, hospital discharge summary, or pathology report) to ASPN for each patient they reported as having a newly diagnosed intracranial problem. To preserve confidentiality, patients' names and other identifying data were deleted from these reports and replaced with the patient's ASPN identification number and date of birth. Data collection began on March 17, 1986, and continued until October 4, 1987. During the same period, the same group of ASPN clinicians participated in a study of all patients in their practices for whom a CT scan was ordered as part of the investigation of a patient's headache.[9]

A chart audit for each patient with a newly diagnosed intracranial problem was performed at the end of the recording period by one of the clinicians at the practice site that reported the problem. The audit form developed for the study repeated the question of whether the patient had visited any physician because of headache, and if so, requested specific details concerning the headache evaluation. Information was obtained concerning the severity and symptom characteristics of the headache, presence or absence of papilledema, abnormalities on neurological examination, and presence or absence of other symptoms that could indicate the presence of intracranial problems (such as seizures, loss of consciousness, changes in strength, sensation, or neurological function, changes in headache pattern or severity, or headaches that awakened the patient from sleep). Also included were the date of the first CT scan, and whether this CT scan was ordered by a physician in the ASPN practice reporting the tumor or bleed, or by some other physician.

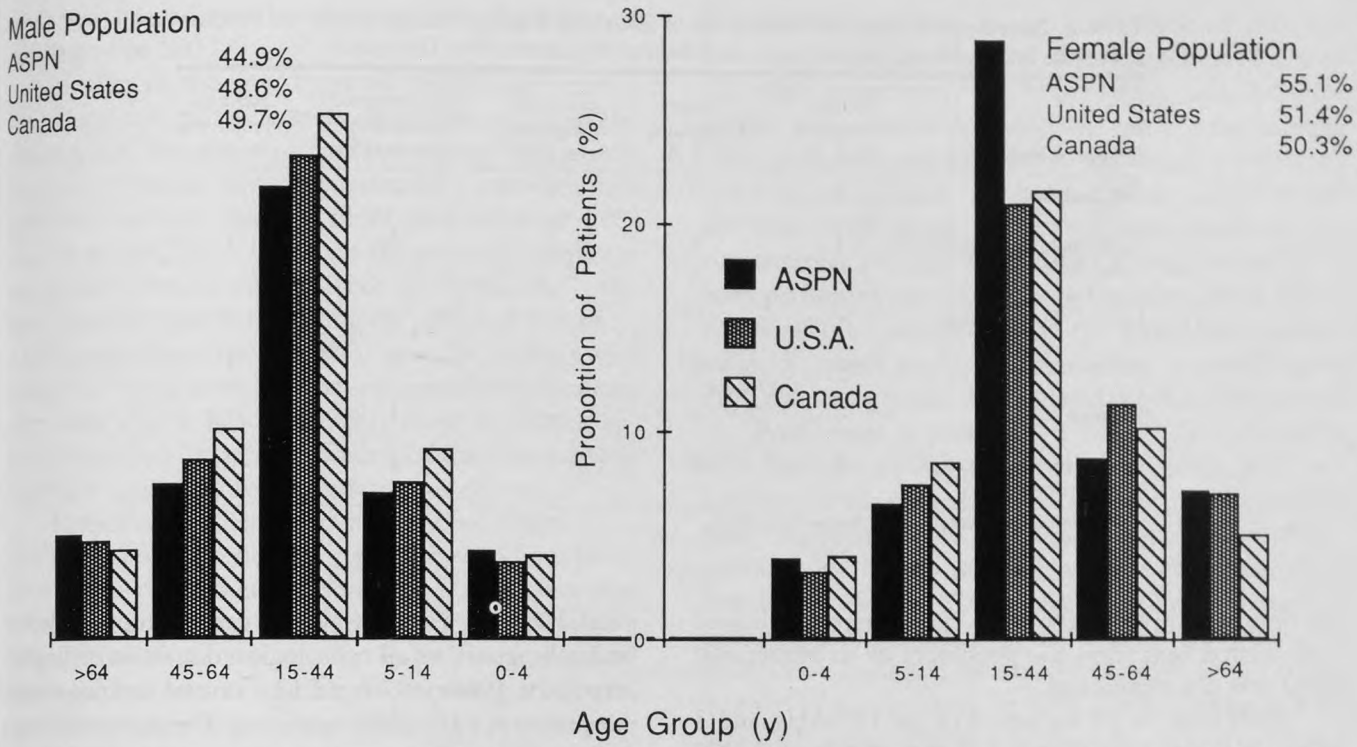
At the end of every calendar year, each ASPN practice provides a report about the sex and year of birth of each patient who has made one or more visits to the practice in the preceding 2 years ("active patient").[10] Data from these individual age and sex reports were aggregated to provide a denominator of patients at risk for estimation of incidence and prevalence rates within the participating ASPN practices.

## Results

Sixty-two ASPN practices provided data using the weekly return cards. We were unable to use data from four of these practices because they dropped out of the ASPN network before the audit portion of the study was completed. Only the data from the 58 practices that participated in the entire study are included in this report.

During the reporting period, these practices conducted a total of 712,750 patient visits. They provided care for 260,709 active patients, thus this 19-month study represents 412,789 patient years of observation. The estimated age and sex distribution of patients in these practices and those in US and Canadian populations are compared in the Figure.

Although ASPN physicians reported on intracranial mass lesions and hemorrhages of all types, the focus of this report is on intracranial neoplasms, SAHs, and SDHs. A total of 25 new intracranial tumors, 17 new cases of SAHs, and 8 newly diagnosed SDHs were reported during the 19-month recording period (Table 1), representing annual practice incidence rates of 6.1, 4.1, and 1.9 per 100,000 ASPN active patients, respectively.




Comparison of the distribution by age and sex of the Ambulatory Sentinel Practice Network patient population (N = 260,709) with that of the US and Canadian populations.

Only 26 of the 50 patients with an SAH, SDH, or tumor in this study reported a headache. Almost half of the patients with a tumor had no headache, a finding that has been noted by others.[11] Headache was even less common in patients with an SDH, but was present in all of the patients with an SAH who were able to provide a history. However, six patients with an SAH presented with severe neurological dysfunction manifested by coma or collapse, which made it impossible for them to report a headache.

Many of the patients with headache had no abnormalities noted on neurological or fundoscopic examination. This was the case for 9 (75%) of the patients with headache and intracranial neoplasms, 5 (45%) of those with an SAH, and 2 of the 3 patients with an SDH. Among these patients, the history was sometimes suggestive. An additional 3 patients with tumors and 3 with SAHs had symptoms such as new seizures, or changes in function suggesting a neurological problem prior to their diagnosis (Table 2). Three patients (one with a primary malignancy and two with benign tumors) had a change in headache pattern as their only ominous symptom.

Table 1. Occurrence of Headache in ASPN Patients with Newly Diagnosed Tumors and Intracranial Bleeds

| Diagnosis | With Headache | Without Headache | Total |
|---|---|---|---|
| Benign neoplasm | 5 | 3 | 8 |
| Primary malignancy | 6 | 6 | 12 |
| Secondary malignancy | 1 | 4 | 5 |
| Subarachnoid hemorrhage | 11 | 6* | 17 |
| Subdural hematoma | 3 | 5 | 8 |
| Totals | 26 | 24 | 50 |

**These 6 patients had altered consciousness and were unable to report their symptoms. ASPN denotes Ambulatory Sentinel Practice Network.*

We defined the diagnosis as "delayed" if the interval between the first presentation with a headache and the performance of the first CT scan was greater than 2 weeks in the case of brain tumors or 2 days in the case of SAHs or SDHs. Recognition within these intervals appears to be associated with better outcomes.[12,13] Four patients with brain tumors visited their primary physician with a headache 1 month or more before a diagnostic CT scan was performed. One patient with SDH had a CT scan performed 3 days after the initial visit for a headache. Only one patient with an SAH had a delay of longer than 2 days between the first visit and the performance of a CT scan. False-negative CT scans, however, led to a delayed diagnosis of SAHs for two additional patients. In one case, the patient had suffered repeated SAHs caused by a meningeal arteriovenous malformation that was not detected by CT or MRI. The diagnosis was finally made at

Table 2. Neurological Signs and Symptoms of 26 ASPN Patients with Headache in Whom a Tumor, Subarachnoid Hemorrhage, or Subdural Hematoma Was Diagnosed

| Sign or Symptom | Benign Neoplasm (n = 5) | Primary Malignancy (n = 6) | Secondary Malignancy (n = 1) | Subarachnoid Hemorrhage (n = 11) | Subdural Hematoma (n = 3) |
|---|---|---|---|---|---|
| Papilledema | 1 | 2 | — | — | 1 |
| Abnormal neurological examination | 1 | 1 | 1 | 6 | 1 |
| Loss of consciousness | — | — | — | 5 | 1 |
| Function change | — | 3 | 1 | 5 | 1 |
| Seizures | — | — | — | 1 | — |
| One or more signs or symptoms | 1 | 4 | 1 | 8 | 2 |

*ASPN denotes Ambulatory Sentinel Practice Network.*

the time of autopsy. In the other, the CT report indicated only dilated ventricles; the possibility of an intracranial bleed was not mentioned.

Only 5 of the 25 tumors, 4 of the 17 SAHs, and 3 of the 8 SDHs were reported in the concurrent ASPN study investigating the use of CT for investigation of patients with headache.[9] In most cases, this was because the patient had not consulted the physician about a headache before the diagnosis (24 cases) or had a CT scan ordered by a non-ASPN physician (7 cases). However, there were a few cases of underreporting of CT use in the study. We found 7 cases in which, although a tumor (4 cases) or SAH (3 cases) was reported in the current study and had been discovered by CT in a patient with a headache, the scan had not been reported in the ASPN study of the use of CT scans for headache patients.

## Discussion

Subarachnoid hemorrhages and intracranial neoplasms are relatively rare diagnoses in primary care. Our estimate of 4.1 new cases of SAHs per 100,000 ASPN patients per year is consistent with the low range of estimates from other studies.[14] Some studies have reported higher rates. It has been estimated, however, that only about one half of patients with SAHs ever reach medical attention,[15] and the physicians in this study could not be expected to report these "missed" SAHs. Similar variation is seen in incidence estimates for brain tumors. ASPN's calculated rate (6.1/100,000) is very close to the SEER[16] estimate of 5.6.* Other studies have higher rates, however. For example, the careful study by Brewis and colleagues[17] of all neurological disease in an English city in the 1960s uncovered 12.1 central nervous system neoplasms per 100,000 population. The major difference however, occurs in secondary tumors, many of which are never confirmed except at autopsy. The declining autopsy rate in recent years may be the cause of the lower current rates documented by both ASPN and SEER. Walker et al[18] estimate an annual US incidence rate of 7.7 confirmed intracranial neoplasms per 100,000, a figure slightly higher than our estimate.

Our findings suggest that headaches in patients seen by primary care physicians are rarely caused by brain tumors, SAHs, or SDHs. A previous ASPN study[19] found that there are approximately 4 visits by patients presenting with a new headache per 1000 total visits to the ASPN practices. If this proportion has not changed, ASPN clinicians evaluated approximately 2850 patients with new headaches during the period of data collection for the current study. Only 13 (0.46%) of these patients had a headache caused by a brain tumor, while another 11 (0.39%) had a headache caused by an SAH, and 3 (0.11%) had a headache caused by an SDH. Over one half of these patients had neurological signs or symptoms in addition to their headache. Thus, the rate of serious intracranial disease in patients with a new headache and no neurological findings was 10 per 2850, or 0.35%. These low rates are compatible with results from other studies. Diehr et al[20] found no serious intracranial disease in 726 patients with new headaches who went to a walk-in patient care center, and concluded that the prevalence of such conditions in this population must be less than 0.5%. Data from US national data sets also indicate that physicians providing ambulatory care see many pa-

*SEER is the Surveillance Epidemiology and End Results program of the National Cancer Institute.

tients with headaches,[21] but few new cases of intracranial neoplasm[18] or SAH.[4]

In spite of this low expected yield, some authors have suggested that CT scans should be a part of the investigation for every patient presenting with a new headache.[22] Others have recommended a more selective approach, with the decision of whether to order a CT scan or an MRI scan based on the patient's symptoms and signs.[23] Clinicians in this study clearly used the latter, more selective approach. During the period of this study, ASPN physicians ordered 339 CT scans for patients with headache,[9] while evaluating an estimated 2850 patients seen with a new headache. This selective clinical approach successfully identified most of the patients with headaches caused by serious intracranial disease.

Three studies have investigated the cost-effectiveness of CT scans when ordered for patients who have headaches but no neurological abnormalities. All three appear to be based on the assumption that clinicians will select a subset of headache patients for investigation, since all used expected rates of abnormal CT findings that were much larger than those found among the patients with headache in this study. Carrera et al[6] estimated that the cost per significant abnormality detected would be at least $4363 with selective use of CT for patients with normal neurological examinations, assuming that 5.5% of CT scans for such patients would be abnormal. In a similar study, Baker[5] calculated an expected cost of $8076 per intracranial tumor detected if 2.6% of the patients investigated had an intracranial tumor. Neither Carrera et al nor Baker provided any analysis of the anticipated benefits of a more prompt diagnosis.

Knaus et al[4] performed an analysis of the potential costs and beneficial effects of CT scans for the early detection of SAH. Their model predicted a cost of $24,713 per year of life saved if 0.78% of CT scans performed for patients with headache and no neurological abnormalities revealed an SAH. They further suggest that this cost could be decreased to $1999 per year of life saved if physicians were able to select a subset of headache patients in which 7.8% of CT scans would show an SAH. None of these three studies attempted to include the costs involved in pursuing false-positive findings or the costs associated with providing treatment for the abnormalities detected.

In models such as these, the cost per abnormality detected or the cost per year of life saved varies widely depending on the yield of abnormal CT scans in the subset of patients selected. The ratio of abnormalities to total CT scans for patients with normal neurological examinations in this study were quite close to those anticipated in the cost-effectiveness studies cited above. The ASPN physicians in this study ordered 339 CT scans, and discovered 9 intracranial neoplasms (2.7% of CT scans performed), 5 SAHs (1.5%), and 2 SDHs (0.6%) in patients with a headache but normal findings on neurological examination. A strategy that called for investigation of every new headache may have reduced the delay in diagnosis for five patients. However, we estimate that an additional 2500 CT scans would have been performed had this strategy been employed. These additional CT scans would have had a very low diagnostic yield (approximately 0.2%), leading to much higher marginal costs per case detected and per year of life saved.

Proponents of more liberal use of CT for patients with headache have suggested that diagnostic delay is a huge and frequent problem.[24] Delay in the diagnosis of SAH has been seen as particularly troublesome.[1,2] Approximately 10% to 30% of patients eventually diagnosed as having an SAH have consulted a physician earlier for symptoms that, in retrospect, were believed to have been caused by a "warning leak."[25–28] In our study, 3 of the 17 patients with an SAH (18%) had made such a visit. However, the delay in diagnosis in 2 of the 3 was the result of a false-negative CT scan. The problem of false-negative CT scans in patients with small SAHs has been noted by others. Duffy[29] found that CT sensitivity was only 70% for grade 1 SAH. MRI has an even lower sensitivity for the detection of intracranial bleeds.[30,31] If an SAH is suspected, it is important to perform a lumbar puncture and continue to entertain the diagnosis even if the CT or MRI is negative. Among ASPN patients, delay in diagnosis of brain tumors was a more frequent, although potentially less serious problem. Four patients had an interval of more than 1 month between their initial headache visit and the performance of a CT scan.

While the clinicians in this study identified a group of patients with headaches who were at high risk for tumor or SAH, our data do not clearly indicate what clinical indicators they used in this determination. The neurological examination alone appeared not to be a sufficient indicator of risk. Insistence on the presence of neurological signs or symptoms before ordering a CT scan would have missed a significant fraction of the benign tumors and SAHs detected in this study, and may have played a role in the diagnostic delays that occurred. Thus, we cannot agree with the conclusion of Larson et al[32] that CT is unnecessary for patients with headaches whose neurological examinations are normal.

Overreliance on the symptom of headache as an indicator of serious intracranial disease could also lead to underdiagnosis. Over one half of the patients in this study with a tumor or SDH had no headache. Thus,

physicians must keep these diagnoses in mind even for patients who do not complain of headache.

This study has several limitations. The most serious is the possibility that the event rates we have calculated are in error because of inaccuracies in either the numerator or the denominator used. Numerators could be in error if there was inaccurate reporting by participating physicians of the events of interest. To detect overreporting, all of the events reported on the weekly return cards were verified by chart audit. In addition, we reviewed consultant notes, CT and MRI reports, and hospital discharge summaries provided to ASPN by the participating practices. We used several methods to attempt to avoid underreporting. Participating physicians used the weekly return card for several studies simultaneously, thus they were continuously reminded of the need to record cases of intracranial mass or bleed for the study. Physicians participating in the study were also asked to record all cases occurring in patients in their practice even if the diagnosis was made by a consultant, an emergency room physician, or some other individual. The events of interest in this study are traumatic and cause great hardship for patients and their families. The majority of ASPN physicians practice in rural or suburban settings and care for entire families. It is possible, but unlikely, that they would remain unaware of a missed diagnosis of an intracranial mass or bleed in a patient in their practice.

The use of "active patients" as the denominator may mean that the incidence rates calculated in the study are not strictly comparable with rates calculated using more traditional population denominators.

## Conclusions

Brain tumors and intracranial bleeds are rare causes of headache, but their occasional occurrence and devastating consequences make it impossible to dismiss them from consideration. This study, based in primary care practices, did not identify a large number of patients for whom a clinically significant delay in diagnosis occurred. Instead, it revealed a highly selective clinical approach that correctly identified over 70% of the patients with headaches due to SAH, tumor, or SDH. More extensive use of CT scans in the evaluation of primary care patients appears to be a weak strategy to improve the detection of these serious disorders. The margin for improvement appears small, with potential benefit for approximately 1 patient per 100,000 per year. It is likely, however, that an increased use of CT scans for this purpose would increase health care costs, cause unintended adverse effects, and provide little benefit.

Acknowledgments

**Ambulatory Sentinel Practice Network (ASPN)**

Participating Practices

Canada

*British Columbia*: Valley Medical Group, Maple Ridge. *Quebec*: Centre de Medecine Familiale de Wakefield, Ltd, Wakefield. *Alberta*: Foothills Family Medicine Centre, Black Diamond. *Ontario*: Family Medical Centre, Hamilton; Steve Nantes MD, Kitchener; Peter Whitby MD, Waterloo.

United States

*Alaska*: Resurrection Bay Health Center, Seward. *Colorado*: Crow Family Medical Center at Conifer, Conifer; Marny Eulberg, MD, Denver; Mountain/Plains Family Practice, Denver; Orchard Family Practice, Englewood; Mary Jo Jacobs, MD, Glenwood Springs. *Florida*: James Andersen, MD, Fort Lauderdale; Domingo Gomez, MD, Hialeah; Family Medicine Associates, Miami; South Beach Family Medicine Associates, Miami. *Georgia*: Curtis Hames, MD, Claxton; Titus Taube, MD, Cochran; Frank Don Diego, MD, Palmetto; Al Mooney, MD, Statesboro; Bill Hogan, MD, Thomasville; Tri-County Family Medicine Center, Warrenton. *Louisiana*: Linda Stewart, MD, Baton Rouge. *Massachusetts*: Fitchburg Family Practice Residency Program, Fitchburg; Peter Barker, MD, Swampscott. *Michigan*: Bay de Noc Family Health Center, Escanaba. *Minnesota*: Eagle Medical, Excelsior. *New Hampshire*: David Beaufait, MD, and Mark Parker, MD, Enfield; Richard Douglass, MD, Hillsboro; Manchester Family Health Center, Manchester; Monroe Clinic, Monroe; New London Medical Center, New London. *New York*: Afton Family Health Center, Afton; Central Square Health Services Center, Central Square; Alan S. Cooper, MD, Setauket; Maury Greenberg, MD, Stony Brook. *North Carolina*: Bakersville Community Medical Clinic, Bakersville; Daniel Vinson, MD, Banner Elk; Roanoke Amaranth Community Health Group Inc, Jackson. *Oklahoma*: Madill Medical Associates, Madill. *Oregon*: Dunes Family Health Care, Inc, Reedsport. *Pennsylvania*: Dennis Allen, MD, Hallstead; Highland Physicians, Ltd, Honesdale; Family and Community Health Associates, York. *Tennessee*: Michael Hartsell, MD, Greeneville; Family Medical Center, Lenoir City; Overton County Medical Center, Livingston. *Texas*: Decatur Family Clinic, Decatur; Larry Myers, MD, and Brian Caplan, MD, Mansfield; Isaac Kleinman, MD, Rosenberg. *Vermont*: Community Health Center, Enosburg Falls; The Health Center, Plainfield. *Virginia*: Aylett Medical Center, Aylett; Beaverdam Family Practice, Beaverdam; June Tunstall, MD, Surry; Duane Lawrence, MD, Virginia Beach. *Washington*: Family and Internal Medicine Associates, Anacortes; Cle Elum Family Medicine Center, Cle Elum. *West Virginia*: New River Family Health Center, Scarboro. *Wisconsin*: Group Health of EauClaire, EauClaire; Family Medical Center, Merrill; Kronenwetter Clinic, Mosinee; Doctors Park Family Physicians, Platteville.

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References

1. Ostergaard J. Warning leak in subarachnoid haemorrhage. BMJ 1990; 301:190–1.
2. Johnston SRD, Hammond A, Griffiths L, Greenwood R, Clarke CRA. Subarachnoid hemorrhage—can we do better? J R Soc Med 1989; 82:721–4.
3. Kawamura J, Meyer JS. Headaches due to cerebrovascular disease. Med Clin North Am 1991; 75:617–30.
4. Knaus WA, Wagner DP, Davis DO. CT for headache: cost/benefit for subarachnoid hemorrhage. Am J Roentgenol 1981; 136:537–42.

5. Baker HL. Cranial CT in the investigation of headache: cost effectiveness for brain tumors. J Neuroradiol 1983; 136:91–6.
6. Carrera GF, Gerson DE, Schnur J, McNeil BJ. Computed tomography of the brain in patients with headache or temporal lobe epilepsy: findings and cost effectiveness. J Comput Assist Tomogr 1977; 2:200–3.
7. Sackett DL. Bias in analytic research. J Chronic Dis 1979; 32:51–63.
8. Becker LA, Iverson DC, Reed FM, Calonge N, Miller RS, Freeman WL. A study of headache in North American primary care: report from the Ambulatory Sentinel Practice Network. J R Coll Gen Pract 1987; 37:400–3.
9. Becker LA, Green LA, Beaufait D, Kirk J, Froom J, Freeman WL. Use of CT scans for the investigation of headache: a report from ASPN, Part 1. J Fam Pract 1993; 37:129–34.
10. Green LA. Age/sex registries in primary care research: a report from ASPN. Fam Med 1988; 20(3):185–8.
11. Adams RD, Victor M. Principles of neurology. New York: McGraw-Hill, 1977:574.
12. Adams HP Jr, Sahs AL. Aneurysmal subarachnoid hemorrhage. Mod Concepts Cardiovasc Dis 1981; 50:49–54.
13. Adams HP Jr, Kassell NF, Torner JC, Nibelink DW, Sahs AL. Early management of aneurysmal subarachnoid hemorrhage: a report of the Cooperative Aneurysm Study. J Neurosurg 1981; 54:141–5.
14. Miller CA, Hill SA, Hunt WE. "De novo" aneurysms. Surg Neurol 1985; 24:173–80.
15. Crowell RM. Aneurysms and arteriovenous malformations. Neurol Clin 1985; 3:291–312.
16. Horm JW, Asire AJ, Young JLH Jr, Pollack ES. SEER program: cancer incidence and mortality in the United States 1973–81. Bethesda, Md: Public Health Service, 1984:4. DHHS publication No. (NIH) 85–1837.
17. Brewis M, Poskanzer DC, Rolland C, Miller H. Neurological disease in an English city. Acta Neurol Scand 1966; 42(Suppl 24):1–89.
18. Walker AE, Robins M, Weinfeld FD. Epidemiology of brain tumours: the national survey of intracranial neoplasms. Neurology 1985; 35:219–26.
19. Becker LA, Iverson DC, Reed FM, Calonge N, Miller RS, Freeman WL. Patients with new headache in primary care: a report from ASPN. J Fam Pract 1988; 27:41–7.
20. Diehr P, Wood R, Wolcott B, Slay L, Tompkins RK. On the relationships among headache symptoms. J Chron Dis 1982; 35: 321–31.
21. Cypress B. Headache as the reason for office visits, National Ambulatory Medical Care Survey: US NCHS Advance Data 1981; 67:1–6.
22. Diamond S, Dalessio DJ. The practicing physician's approach to headache. Baltimore: Williams & Wilkins, 1982.
23. NIH Consensus Development Panel. Computed tomographic scanning of the brain. JAMA 1982; 247:1955–8.
24. Bohmfalk GL. Computerized tomographic scans for headache [letter]. JAMA 1980; 244(2):133–4.
25. Adams HP Jr, Jergenson DJ, Kassell NF, Sahs AL. Pitfalls in the recognition of subarachnoid hemorrhage. JAMA 1980; 244: 794–6.
26. Okawara S. Warning signs prior to rupture of an intracranial aneurysm. J Neurosurg 1973; 38:575–80.
27. Verweij RD, Wijdicks EFM, van Gijn J. Warning headache in aneurysmal subarachnoid hemorrhage: a case-control study. Arch Neurol 1988; 45:1019–20.
28. Ostergaard JR. Headache as a warning symptom of impending aneurysmal subarachnoid haemorrhage. Cephalalgia 1991; 11: 53–5.
29. Duffy GP. The "warning leak" in spontaneous subarachnoid haemorrhage. Med J Aust 1983; 1:514–6.
30. Edelman RR, Warach S. Medical progress: magnetic resonance imaging (first of two parts). N Engl J Med 1993; 328:708–15.
31. Prager JM, Mikulis DJ. The radiology of headache. Med Clin North Am 1991; 75:525–44.
32. Larson EB, Omenn GS, Lewis H. Diagnostic evaluation of headache: impact of computerized tomography and cost effectiveness. JAMA 1980; 243:359–62.