Original Article

Diagnostic Cerebral Angiography in Spontaneous Intracranial Haemorrhage: A Guide for Developing Countries

Ishak Abu Bakar, Ibrahim Lutfi Shuaib, Abdul Rahman Mohd Ariff, Nyi Nyi Naing[1] and Jafri Malin Abdullah,[2]
Department of Radiology, [1]Biostatistics and Research Methodology Unit, and [2]Department of Neurosciences, School of Medical Sciences, Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia.

OBJECTIVE: Spontaneous intracranial haemorrhage constitutes 18–40% of all stroke cases. Indications for cerebral angiography to find underlying potentially treatable vascular abnormalities are not clear. This study determined which intracranial haemorrhage patients need cerebral angiography by correlating computed tomography (CT) findings, age and hypertension history with cerebral angiography findings.
METHODS: A total of 54 patients (8–79 years) with intracranial haemorrhage who underwent both CT examination and six-vessel cerebral angiography were studied over a 2-year period. Cerebral angiography was repeated within 6 weeks if the first angiogram was negative.
RESULTS: Angiography detected vascular lesions in 50% of cases (aneurysm 38.9% and arteriovenous malformation, AVM, 11.1%). In the aneurysm group, angiographic yield was 34.3% whereas in the AVM group, it was 37.9%. Subarachnoid haemorrhage (SAH) combined with other types of haemorrhage (such as intracerebral haemorrhage, ICH) was not significantly correlated with the likelihood of finding a vascular lesion, both aneurysm and AVM ($p = 0.157$). Age less than 50 years had significant correlation ($p = 0.021$) in the AVM group as well as in the aneurysm group ($p < 0.001$). A history of hypertension was associated with both aneurysm ($p = 0.039$) and AVM ($p = 0.008$). No patients with deep intracerebral haematoma had vascular lesions. The presence of an intraventricular haemorrhage (IVH) had significant correlation with aneurysm ($p = 0.008$) but not AVM. There was no significant difference in mean age between patients with and without a vascular lesion ($p = 0.134$).
CONCLUSION: Cerebral angiography is justified in patients with pure SAH ($p = 0.001$). Other factors associated with finding a vascular lesion were a history of hypertension and the presence of IVH. Diagnostic cerebral angiography is indicated for patients with ICH and SAH and IVH with a history of hypertension, regardless of age. [*Asian J Surg* 2005;28(1):1–6]

Key Words: cerebral angiography, developing countries, hypertensive intracranial haemorrhage, indications, surgery

Introduction

Intracranial haemorrhage is named according to its anatomical distribution as intracerebral haemorrhage (ICH), subarachnoid haemorrhage (SAH), intraventricular haemorrhage (IVH), subdural haemorrhage or extradural haemorrhage. Spontaneous intracranial haemorrhage is a non-traumatic haemorrhage. It commonly occurs as ICH, SAH or IVH.[1] Subdural and

Address correspondence and reprint requests to Professor Dr. Jafri Malin Abdullah, Department of Neurosciences, School of Medical Sciences, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan, Malaysia.
E-mail: deptneurosciencesppspusm@yahoo.com • Date of acceptance: 9 October 2003

extradural haemorrhages are commonly due to trauma.

In 1999, Fauziah studied 158 patients admitted to Hospital Universiti Sains Malaysia (HUSM) for symptoms of stroke and revealed that 32.9% were due to spontaneous ICH, 7.6% to SAH and 56.3% to infarction.[2] ICH accounts for 10–32% of all cerebrovascular strokes. A higher incidence of ICH has been noted in Chinese, Japanese and other Asian populations, and the incidence in ASEAN countries varies from 17.2% to 38.6%.[3]

Computed tomography (CT) is the primary investigation for ICH. Cerebral angiography is important if surgery is indicated. Most developing countries such as Malaysia have one cerebral angiogram facility for 4.5 million people. Finding the aetiology of the bleeding is essential in the management of intracranial haemorrhage, particularly for intracranial aneurysm and arteriovenous malformation (AVM), in which surgical or endovascular intervention significantly reduce the re-bleeding risk. Although previous studies have emphasized the safety of the angiography procedure,[4,5] it still carries a 0.07–0.3% risk of permanent stroke and an overall 1.8% risk of systemic complication. This raises the question of what factors determine the most suitable patients to be referred for angiography in developing countries where facilities are limited. The aim of this study was to find out which patients with intracranial haemorrhage need cerebral angiography by correlating CT findings with clinical data.

Methods

A cross-sectional study was conducted in patients with spontaneous intracranial haemorrhage admitted to HUSM between 1 October 1998 and 30 April 2001. Both CT and cerebral angiography were performed in all patients. Criteria for inclusion in the study were spontaneous intracranial haemorrhage, cranial CT and digital subtraction cerebral angiography. Patients who had negative angiography initially underwent repeat cerebral angiography within a 6-week period if intracerebral pathology was suspected. Patients were excluded if they had intracranial haemorrhage of traumatic origin, haemorrhage into a tumour diagnosed by CT or magnetic resonance imaging (MRI), unavailable CT scans or angiogram films, or haemorrhage attributed to coagulopathy or blood dyscrasia. All patients gave written informed consent for angiography.

Demographic data and medical history were collected, including age, sex, race and medical illnesses (hypertension, smoking and diabetes mellitus). Hypertension and diabetes mellitus were assumed to be present if the patients or their families had been informed of the diagnosis or if medical documentation indicated their presence. The Glasgow Coma Scale (GCS) was recorded on arrival in the accident and emergency department.

Plain cranial CT was performed using a non-helical CT Somatom HiQ-s (Siemens AG, Erlangen, Germany) or a Somatom Plus 4 (Siemens AG). Slice thickness was chosen according to international protocol format.

Cerebral angiography was performed according to standard protocols using an Advantx LAC/LCV+/LC+ (GE Medical Systems, Milwaukee, WI, USA). The procedures were performed under sedation and local anaesthesia or general anaesthesia. Cerebral vessels were usually cannulated using head-hunter 5F catheters. In all cases, a six-vessel cerebral angiogram was obtained using at least two projections of each of the vessels: anterior–posterior view and lateral view. Iohexol 300 mg/mL was used as the contrast medium.

Two blinded senior radiologists reviewed CT scans and cerebral angiography films. The presence of ICH, SAH, IVH or subdural haemorrhage was recorded from non-enhanced CT scans. ICH was defined by Laissy et al[6] and Steven et al,[7] SAH was defined according to Steven et al[7] and Hijdra et al,[8] IVH was defined according to Steven et al,[7] and subdural haemorrhage was defined according to Orrison and Lewine.[9]

The number and location of aneurysms and the arterial territory of AVMs were recorded from cerebral angiography.[10,11] A positive angiogram was defined as the identification of a vascular abnormality accounting for the haemorrhage. Angiographic yield was defined as the frequency of positive angiography (positive detection of vascular lesions) in a defined patient group.

Statistical analysis

Data were analysed using SPSS version 10 (SPSS Inc, Chicago, IL, USA). Sociodemographic and medical illness data were analysed using descriptive statistics for frequency, percentages for categorical data and mean, median and standard deviation for continuous data. The prevalences of aneurysm and AVM were also determined. McNemar's test was used for correlational statistics and the level of significance was set at 0.05.

Results

Only 18 cases per year were recruited into this study due to the strict CT scan criteria and also to patient reluctance for angiography that is common in developing countries such as Malaysia. Among the 54 patients with spontaneous intracranial haemorrhage for whom both CT scans and cerebral angiographies were available, there were 26 males (48.1%) and 28 females (51.9%) aged 8–79 years (mean, 46.24 ± 14.81 years). A total of 48 patients (88.9%) were Malays and six (11.1%) were Chinese. Twenty-eight (51.9%) patients had pre-existing hypertension, 19 (35.2%) were smokers, and none had diabetes. Thirty-nine (72.2%) patients had a GCS of less than 8/15 (unfavourable) and 15 (27.8%) had a GCS of more than 9/15 (favourable).

There were two cases of spontaneous isolated subdural haematoma. Both had normal angiograms. One patient was a 29-year-old Malay female who was pregnant (third trimester) and the other was a 37-year-old Chinese man.

ICH, SAH and IVH occurred in isolation or in combination with each other. As a result, there were seven possible intracranial haemorrhage types: isolated ICH, SAH and IVH, ICH + SAH, ICH + IVH, SAH + IVH and the combination of all three.

Table 1. Frequency distribution of various types of intracranial haemorrhage

Type of haemorrhage	Frequency, *n* (%)
ICH	12 (22.2)
Pure SAH	10 (18.5)
Pure IVH	3 (5.6)
ICH + SAH	5 (9.3)
ICH + IVH	13 (24.1)
SAH + IVH	7 (13.0)
SAH + IVH + ICH	4 (7.4)
Total	54

ICH = intracerebral haemorrhage; Pure SAH = subarachnoid haemorrhage only; Pure IVH = intraventricular haemorrhage only.

ICH was present in 34 cases (Table 1) and was classified according to location: lobar (26, 76.5%) or deep and posterior fossa (8, 23.5%).

Most angiographic studies were performed within the first week of the onset of illness (33, 61.1%). Cerebral angiographies were performed between the first and second week in five cases (9.3%), after two weeks in 14 cases (25.9%) and after 1 month in four cases (7.4%). Out of these four patients, two with subdural haematomas had repeat angiograms even though their first angiograms were negative because there was a high suspicion of a vascular anomaly. A total of 27 patients (50.0%) had vascular abnormalities: 21 (38.9%) had aneurysms and six (11.1%) had AVMs (Table 2).

A total of 23 aneurysms were detected in 21 cases (19 with a single aneurysm and 2 with 2 aneurysms). Six of the aneurysms (26.1%) were along the internal carotid artery, seven (30.4%) were along the middle cerebral artery, four (17.4%) were along the anterior cerebral artery, two (8.7%) involved the anterior communicating artery, two (8.7%) involved the basilar artery, one (4.3%) was along the posterior cerebral artery, and one (4.3%) involved the posterior communicating artery.

Of the six AVMs, four were in the anterior cerebral artery territory, one was in the middle cerebral artery territory, and one was in the posterior fossa. No AVMs received more than one artery supply in this small series. All AVMs were less than 5 mm in size.

The presence of pure SAH was associated with a very high rate of aneurysm ($p = 0.001$) (Table 2). Of the 26 cases in which SAH was present, 19 (73.1%) had a vascular lesion, most (18) of which were aneurysms. Eighteen of the 21 aneurysm cases had SAH. Although only two isolated ICH cases had an aneurysm, three of the five cases with SAH + ICH had an aneurysm. One

Table 2. Frequency distributions of computed tomography (CT) findings and the angiographic diagnosis

CT findings	Angiographic diagnosis			Total, *n*
	Normal, *n* (%)	Aneurysm, *n* (%)	AVM, *n* (%)	
ICH	9 (75.0)	2 (16.7)	1 (8.3)	12
Pure SAH	2 (20.0)	8 (80.0)	0	10
Pure IVH	1 (33.3)	0	2 (66.7)	3
ICH + SAH	2 (40.0)	3 (60.0)	0	5
ICH + IVH	10 (76.9)	1 (7.7)	2 (15.4)	13
SAH + IVH	3 (42.9)	4 (57.1)	0	7
SAH + IVH + ICH	0	3 (75.0)	1 (25.0)	4
Total	27 (50.0)	21 (38.9)	6 (11.1)	54

AVM = arteriovenous malformation; ICH = intracerebral haemorrhage; Pure SAH = subarachnoid haemorrhage only; Pure IVH = intraventricular haemorrhage only.

AVM was diagnosed among the four patients with ICH + IVH + SAH.

There were only three isolated cases of IVH, one of which had a normal angiogram and two had AVMs. Both of the AVMs were located in the anterior cerebral artery. Diagnoses in patients with no IVH were normal in 13 cases (48.1%), aneurysm in 13 cases (61.9%), and AVM in one case (16.7%).

In the analysis of location by CT and angiographic diagnosis of aneurysm, significant variables were IVH (p = 0.008), ICH + IVH (p = 0.025), and pre-existing hypertension (p = 0.039) (Table 3). In the analysis of location by CT and angiographic diagnosis of AVM, significant variables were isolated ICH (p = 0.014), pre-existing hypertension (p = 0.008), and age (p = 0.021) (Table 4).

Discussion

The angiographic yield in our study population, including all cases of spontaneous intracranial haemorrhage, was 50%: 38.8% of cases were due to aneurysm and 11.2% of cases to AVM. This yield is higher than previously published data, which ranged from 28.2% to 49%.[6,12–14] The prevalence of aneurysm (38.8%) is also higher than that in other studies (16.8–25%).[6,12–14] Analysis within the ICH group showed that, in the presence of SAH, the angiographic yield was 51.4% for AVM and 48.6% for aneurysm. However, in the absence of SAH, the yield was 45.9% for aneurysm and 85.9% for AVM. The difference was statistically significant for AVM but not for aneurysm (p = 0.459), indicating that an AVM was more likely to be detected by cerebral angiography in patients with ICH and SAH than in those with ICH without SAH. Laissy et al found that the combination of ICH and SAH giving rise to a diagnosis of aneurysm had 100% specificity and 100% positive predictive value but 56% sensitivity.[6] The same study found that ICH + SAH + IVH giving rise to aneurysm had 100% specificity and 100% positive predictive value but sensitivity of 40%. Loes et al reported similar findings.[15] In the presence of SAH, angiographic findings were diagnostic in 17 of 22 pa-

Table 3. Association between location by computed tomography and angiographic diagnosis in detecting aneurysm

Computed tomography	Angiographic diagnosis		Test statistic* (p)
	Normal	Aneurysm	
Isolated ICH			
Deep	0	0	†
Lobar	0	2	
Mixed SAH			
Absent	2	0	2.0 (0.157)
Present	2	18	
Mixed IVH			
Absent	2	7	7.0 (0.008)
Present	0	0	
ICH + IVH			
Deep	5	0	5.0 (0.025)
Lobar	5	1	
Pre-existing hypertension			
No	5	5	4.3 (0.039)
Yes	14	5	
Age			
Age < 50	2	14	11.3 (< 0.001)
Age ≥ 50	1	10	

*McNemar's test; †incalculable because the concordant pair is zero. ICH = intracerebral haemorrhage; Mixed SAH = subarachnoid haemorrhage plus others (IVH/ICH); Mixed IVH = intraventricular haemorrhage plus others (except ICH).

Table 4. Association between location by computed tomography and angiographic diagnosis in detecting arteriovenous malformation (AVM)

Computed tomography	Angiographic diagnosis		Test statistic* (p)
	Normal	AVM	
Isolated ICH			
Deep	3	0	6.0 (0.014)
Lobar	6	1	
Mixed SAH			
Absent	1	0	2.0 (0.157)
Present	2	1	
Mixed IVH			
Absent	2	0	†
Present	0	3	
ICH + IVH			
Deep	0	0	†
Lobar	0	2	
Pre-existing hypertension			
No	9	7	7.0 (0.008)
Yes	0	9	
Age			
Age < 50	1	10	5.3 (0.021)
Age ≥ 50	2	14	

*McNemar's test; †incalculable because the concordant pair is zero. ICH = intracerebral haemorrhage; Mixed SAH = subarachnoid haemorrhage plus others (IVH/ICH); Mixed IVH = intraventricular haemorrhage plus others (except ICH).

tients (77%); in its absence, angiography diagnosed vascular lesions in 12 of 45 patients (27%).[15] Griffiths et al also found that SAH with ICH was significant in depicting vascular lesions on cerebral angiography.[13] In the presence of SAH, ICH is associated with findings of aneurysm. The indication for cerebral angiography in the presence of SAH is indisputable and, if initial angiography is negative, careful follow-up by repeat angiogram and/or MRI is essential. In our study, all repeat angiogram patients had no abnormalities after 6 weeks.

In our series, angiographic findings in patients with pure IVH were diagnostic for aneurysm in no cases and for AVM in 83.3% of cases. In patients without IVH, angiographic findings were diagnostic for aneurysm in 47.6% of cases and for AVM in 16.7% of cases. The difference was statistically significant for aneurysm ($p = 0.008$) and there was also a difference in detecting AVM on angiography for patients with isolated ICH ($p = 0.014$). The presence or absence of IVH could be a predictor for detecting aneurysm on cerebral angiography. This finding is in agreement with Griffiths et al, who found that vascular abnormalities are more frequently found in patients under the age of 40 and in cases in which SAH, IVH and extracerebral haemorrhage accompany ICH.[13]

There were three cases of isolated IVH; angiogram was positive in two, both of which were small AVMs (< 5 mm) with feeding vessels from the anterior cerebral artery. The number of cases was too small for statistical analysis. Passero et al analysed 26 cases of primary IVH; angiography revealed vascular lesions in eight (31%).[16] In 10 patients, this was attributed to hypertension, in one patient, it was attributed to a bleeding disorder, and no cause was detected in seven patients. Of these 26 patients, 42% died in hospital, mainly directly from the haemorrhage, followed by the consequences of hydrocephalus.

All eight patients with deep ICH in our study had a normal angiogram. Three cases of ICH accompanied by IVH showed abnormal angiograms. There were no cases of deep ICH in association with SAH. Primary hypertensive ICH is typically deep in location, mostly involving the basal ganglia and thalamus.[17,18] They may dissect into the ventricles due to close proximity with the ventricle. Seven of our eight patients with deep ICH were hypertensive and older than 51 years, with histories of hypertension.

One study revealed a sensitivity of 96%, a specificity of 100%, a positive predictive value of 100% and a negative predictive value of 91.3% for normal angiography in patients with deep haematoma.[6] Such an analysis could not be performed in the present study as the number of patients was too small. A Chinese study, however, revealed that in patients with thalamic, putaminal or posterior fossa ICH who were young and normotensive, the yield was rather high (48%), while for older hypertensive patients, the yield was 0%.[12] Angiography is still indicated for younger normotensive patients with deep haematomas. Most patients with deep haematomas in our study were older and hypertensive and the yield was similar to that in the Chinese study.[12]

For lobar ICH, the yield was 37.5% for aneurysm and 33.3% for AVM. Three of these patients had aneurysms and three had AVMs. There were 12 normotensive patients who were less than 50 years old and nine hypertensive patients aged above 50 years in the aneurysm group. The angiographic yield was 88.9% for both aneurysm and AVM in both age groups combined. In the younger group, the yield was 87.5% for aneurysm and 90.9% for AVM ($p < 0.001$ and $p = 0.021$, respectively). There was no significant difference in detecting aneurysm or AVM in lobar ICH ($p > 0.05$). The yield for aneurysm detection in older patients was 90.9% for aneurysm and 87.5% for AVM ($p < 0.001$ and $p = 0.021$, respectively). In hypertensive patients aged more than 50 years, the yield was higher than that of the findings from the Chinese study.[12]

Of the 12 patients with isolated ICH, nine had a normal angiogram (3 deep and 6 lobar), aneurysm was detected in two, and AVM was detected in one. In a 28-year-old patient with a history of intravenous drug abuse who presented with altered consciousness (GCS of 11/15) and hemiparesis, CT revealed lobar ICH in the right parietal lobe. Cerebral angiography showed two peripherally located aneurysms, one in the right middle cerebral artery and one in the left anterior cerebral artery; mycotic aneurysm was diagnosed. The area of the haematoma coincided with the right middle cerebral artery aneurysm rupture.

The term "mycotic" aneurysm has been used to describe any aneurysm that develops after infection of the wall of an artery; William Osler first used the term in 1885. Mycotic aneurysm was initially described for fungal infection, but the name is also used with bacterial infection; the terms "infectious aneurysm" and "infectious vascular disease" are preferred. The true incidence of mycotic cerebral aneurysm in intravenous drug users is not known. In a retrospective study of 14 patients with endocarditis-related cerebral aneurysm, nine presented with stroke-like symptoms (hemiparesis); 18 aneurysms were depicted and most (66%) were peripherally located; multiple aneurysms were depicted in four patients.[19] All patients, as in our study, were treated with antibiotics.

The mean age for the cohort of patients with vascular lesions was slightly lower: 42.9 years for those with vascular lesions and 50.7 years for patients without vascular lesions (p = 0.1). Laissy et al reported similar findings.[6]

A few studies have found a significant correlation between patient age and angiographic findings: the older the patient, the more likely they are to have primary ICH.[12,14] Ruiz-Sandoval et al in their retrospective analysis of 200 patients aged less than 40 years with ICH could not find a cause in 15% of cases, while hypertension was assumed to be the cause in 11%, giving a total of 26% primary ICH.[20] Ruptured AVM was seen in 49% of patients and cavernous angioma was detected in 16% of patients. The other 9% consisted of cerebral venous thrombosis (5%) and sympathomimetic drug use (4%).

This signifies that there is a correlation between a history of hypertension and the likelihood of having a normal angiogram or a correlation between the absence of hypertension and the likelihood of having a vascular lesion detected on angiography. Hypertension and amyloid angiopathy are the main causes of primary ICH.[17] Many studies have proven that with the combination of a CT finding of isolated ICH with or without accompanying IVH and hypertension in patients aged over 45 years, vascular causes for the haemorrhage are very unlikely to be depicted on cerebral angiogram.[12–14]

Half of those with lobar ICH had a history of hypertension and 54% of them had a vascular abnormality detected on angiography. The rate of vascular lesion detection was 54%, even with a history of hypertension, so cerebral angiogram is still needed for patients with lobar ICH and a history of hypertension.

Conclusion

Factors that increase the likelihood of finding an aneurysm or AVM on cerebral angiography are the presence of IVH, pure SAH, a history of hypertension, and age less than 50 years. Patients with IVH plus ICH or SAH alone or isolated ICH should be referred to an institution with angiography facilities.

References

1. Russel DS. The pathology of spontaneous intracerebral hemorrhage. *Proc R Soc Med* 1979;47:689–94.
2. Fauziah J. *Prospective Study of First Ever Stroke Patients Admitted to HUSM Between 1997 and 1998.* Hospital Universiti Sains Malaysia, Medical Postgraduate Dissertation, 1999:44–60.
3. Misbach J. Epidemiology of stroke in ASEAN Countries. *Neurol J Southeast Asia* 1997;2:95–6.
4. Waugh JR, Sacharias N. Arteriographic complications in DSA era. *Radiology* 1992;182:243–6.
5. Cloft JH, Joseph GJ, Dion JE. Risk of cerebral angiography in patients with subarachnoid haemorrhage, cerebral aneurysm and arteriovenous malformation; a meta-analysis. *Stroke* 1999;30:317–20.
6. Laissy JP, Normand G, Monroe M, et al. Spontaneous intracerebral hematomas from vascular causes. Predictive value of CT scan compared with angiography. *Neuroradiology* 1991;33:291–5.
7. Steven JM, Murray AD, Saunders D, Lane B. Cranial and intracranial pathology. In: Grainger RG, Allison DJ, Adams A, Dixon AK, eds. *Grainger & Allison's Diagnostic Radiology – A Textbook of Medical Imaging,* 4th edition. London: Churchill Livingstone, 2001:2404–40.
8. Hijdra A, Brouwers PJAM, Vermeulen M, et al. Grading the amount of blood on computed tomograms after subarachnoid haemorrhage. *Stroke* 1990;21:1156–61.
9. Orrison WW, Lewine JD. Neuroimaging in closed head injury. In: Rizzo M, Tranel D, eds. *Head Injury and Postconcussive Syndrome.* New York: Churchill Livingstone, 1996:71–87.
10. Rosenorn J, Eskesen V, Madsen F, et al. Importance of cerebral pan-angiography for detection of multiple aneurysms in patients with aneurysmal subarachnoid haemorrhage. *Acta Neurol Scand* 1993;87: 215–8.
11. Chin LS, Raffel C, Gonzalez-Gomez I, et al. Diffuse arteriovenous malformation: a clinical, radiological, and pathological description. *Neurosurgery* 1992;31:863–9.
12. Zhu XL, Chan MSY, Poon WS. Spontaneous intracranial hemorrhage: which patients need diagnostic cerebral angiography? A prospective study of 206 cases and review of literature. *Stroke* 1997;28:1406–9.
13. Griffiths PD, Beveridge CJ, Gholkar A. Angiography in non-traumatic brain haematoma. An analysis of 100 cases. *Acta Radiol* 1997; 38:797–802.
14. Halpin SFS, Britton JA, Byrne JV, et al. Prospective evaluation of cerebral angiography and computed tomography in cerebral haematoma. *J Neurol Neurosurg Psychiatry* 1994;57:1180–6.
15. Loes DJ, Smoker WR, Biller J, et al. Nontraumatic lobar intracerebral hemorrhage: CT/angiographic correlation. *AJNR Am J Neuroradiol* 1987;8:1027–30.
16. Passero S, Ulivelli M, Reale F. Primary intraventricular haemorrhage in adults. *Acta Neurol Scand* 2002:105:115–9.
17. Qureshi AI, Tuhrim S, Broderick JP, et al. Spontaneous intracerebral haemorrhage. *N Engl J Med* 2001;344:1450–60.
18. Wiggins WS, Moody DM, Toole JF, et al. Clinical and computerized tomographic study of hypertensive intracerebral hemorrhage. *Arch Neurol* 1978;35:832–3.
19. Corr P, Wright M, Handler LC. Endocarditis-related cerebral aneurysm: radiologic changes with treatment. *AJNR Am J Neuroradiol* 1995;16:745–8.
20. Ruiz-Sandoval JL, Cantu C, Barinagarrementeria F. Intracerebral hemorrhage in young people: analysis of risk factors, location, causes, and prognosis. *Stroke* 1999;30:537–41.