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Clinical Article

Value of the quantity and distribution of subarachnoid haemorrhage on CT in the localization of a ruptured cerebral aneurysm

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Summary

Background. Computed tomography (CT) is the "gold standard" for detecting subarachnoid haemorrhage (SAH) and digital subtraction angiography (DSA) for visualising the vascular pathology. We studied retrospectively 180 patients with subarachnoid haemorrhage (SAH) who underwent first non-enhanced computed tomography (CT), then digital subtraction angiography (DSA) and finally operative aneurysm clipping. Our aim was to assess if the location of the ruptured aneurysm could be predicted on the basis of the quantity and distribution of haemorrhage on the initial CT scan.

Methods. 180 patients with SAH were retrospectively studied. All the CT and DSA examinations were performed at the same hospital. CT was performed within 24 hours after the initial haemorrhage. DSA was performed after the CT, within 48 hours after the initial haemorrhage. Two neuroradiologists, blind to the DSA results, analysed and scored independently the quantity and distribution of the haemorrhage and predicted the site of the ruptured aneurysm on the basis of the non-enhanced CT. DSA provided the location of the ruptured aneurysm. All the patients were operated upon, and the location of the ruptured aneurysm was determined.

Findings. The overall reliability value (κ-value) between the two neuroradiologists for locating all ruptured aneurysms was 0.780. The corresponding value for the right MCA was 0.911, that for the left MCA 0.877 and that for the AcoA 0.736. Not all of the κ-values were calculated, either because the location of the rupture was constant or because the number of ruptures in the vessel was too small. Subarachnoid haemorrhage with a parenchymal hematoma is an excellent predictor of the site of the ruptured aneurysm with a statistical significance of $p = 0.003$.

Interpretation. The quantity and pattern of the blood clot on CT within the day of onset of SAH is a reliable and quick tool for locating a ruptured MCA or AcoA aneurysm. It is not, however, reliable for locating other ruptured aneurysms. Subarachnoid haemorrhage with a parenchymal hematoma is an excellent predictor of the site of a ruptured aneurysm.

Keywords: Computed tomography; cerebral aneurysm; subarachnoid haemorrhage; quantity; distribution.

Introduction

Exact determination of the location of a ruptured cerebral aneurysm is important for the planning of treatment. Direct imaging of vessels with 4 vessel digital subtraction angiography (DSA) is the "gold standard" for visualising the aneurysm [11]. The initial CT is the "gold standard" for detecting SAH and for evaluating its quantity and distribution. This information is potentially useful in focusing attention on some particular part of the circulation of the brain and, when DSA shows multiple aneurysms, can aid identification of which one bled. Up to 45% of patients with cerebral aneurysms have multiple aneurysms [4, 13, 14, 17].

During an open operation it is usually easy to decide if an aneurysm has or has not ruptured, but the increasing use of endovascular treatment may be associated with greater uncertainty that the bled aneurysm has been treated. It has been reported that postoperative rebleeding is usually due to a misinterpretation of the location of the ruptured aneurysm in the presence of multiple aneurysms [3, 9]. Prediction of the site of the ruptured aneurysm based on the initial CT has been reported in cases of both single aneurysms and multiple aneurysms [3, 5, 9, 12]. One report recently concluded that unless there is a parenchymal hematoma, the site of the ruptured aneurysm can be determined by CT only if the bleeding has originated from aneurysms in the anterior cerebral artery (ACA) or the anterior communicating artery (AcoA) [4]. Others report that the distribution of haemorrhage predicts the location of the aneurysm in over 80% of cases [2, 8]. DSA, with its sensitivity of 95%, seems to be a good tool for detecting the site of a single ruptured aneurysm [10]. In cases of multiple aneurysms, DSA should find the aneurysms, but its value in detecting the ruptured aneurysm has not been established [3, 10, 16].

We report on the possibility of prediction of the precise location of a ruptured cerebral aneurysm on the basis of the quantity and distribution of subarachnoid haemorrhage on a non-contrast-enhanced CT scan.

Methods and material

We reviewed retrospectively 548 patients who had suffered a subarachnoid haemorrhage caused by a ruptured intracranial aneurysm between the years 1988 and 1999. All of the patients fulfilled the following criteria: all the examinations and operations were performed at the same hospital. Non-contrast-enhanced CT (CT Somatom 2 Siemens, CT Toshiba TCT 80 A, CT Sytec 3000 Plus GE, CT HiSpeed HSA/CTi Plus GE) with 5 mm axial slice thickness in the posterior fossa and 10 mm slice thickness in the suprasellar region was performed as the first examination within 24 hours after the onset of the symptoms of SAH. After confirmation by CT of the presence of subarachnoid haemorrhage, the patients underwent 1- to 4-vessel selective DSA (Angiontron Siemens, Polytron DSA/Neurostar Siemens, Polytron Plus DSA/Bicor HS CF Siemens) to locate precisely the ruptured aneurysm. Altogether, 180 patients with SAH caused by a ruptured aneurysm and confirmed by operation, were chosen for evaluation. All the other patients were excluded.

The CT and DSA images were retrospectively and separately analysed by two neuroradiologists. Each neuroradiologist had 15 years 'total experience and 5 years' experience as a neuroradiologist. The CT images were analysed first, separately from the DSA images. The quantity and distribution of haemorrhage in the various intracranial subarachnoid spaces as well as in the ventricles were analysed on the CT by using the grading scale described by Hijdra [14]. This divides the subarachnoid spaces into 10 different basal cisterns and fissures (Fig. 1). The amount of extravasated blood was graded as follows: 0: no blood; 1: small amount of blood; 2: moderately filled with blood; 3: completely filled with blood. The total amount of subarachnoid blood (sum score) was calculated by summing up the 10 scores. The possible range was 1–30. The amounts of blood in the 4 different ventricles were estimated as follows: 0: no blood; 1: sedimentation of blood in the posterior part; 2: partly filled with blood; 3: completely filled with blood. The total amount of intraventricular blood (sum score) was 0–12. Before the study, the neuroradiologists independently graded 10 patients not included in the present study series, to establish the criteria for estimating the quantity and distribution of haemorrhage. The final determination of the precise location of the ruptured aneurysm was made on the basis of the visual impression and grading scale of the haemorrhage. The aim of analysing the amount and distribution of the haemorrhage by the Hijdra scale was to find an objective way of relating the extent of bleeding to aneurysm location. The precise location of the ruptured aneurysm was designated as follows: ICA = internal carotid artery, ACA = anterior cerebral artery, MCA = middle cerebral artery, AcoA = anterior communicating artery, PcoA = posterior communicating artery, PCA = posterior cerebral artery, BA = basillar artery, PICA = posterior inferior cerebellar artery. DSA was performed to determine the precise location of the aneurysm. All patients has an operation at which the site of the ruptured aneurysm was determined.

The reliability values (κ-values) of each neuroradiologist for each vessel were calculated separately by comparing the neuroradiologist's review of the CT scans to the operative finding, which is considered the "gold standard". The κ-values of the neuroradiologists were compared. A κ-value for each vessel, concerning the level of agreement between the neuroradiologits, was also calculated. The criteria for judging κ-coefficients vary, but the following are proposed as a rough guide. A kappa value of 0.81–1.00 indicates almost perfect reliability, 0.61–0.80 substantial, 0.41–0.60 moderate, 0.21–0.40 fair, 0.00–0.20 slight and less than 0.00 poor reliability [7]. We used the χ^2-test, to test if subarachnoid haemorrhage with a parenchymal hematoma is a good predictor of the site of a ruptured aneurysm. p-values under the threshold 0.05 were considered significant. SPSS 9.0.1. was used for statistical analysis.

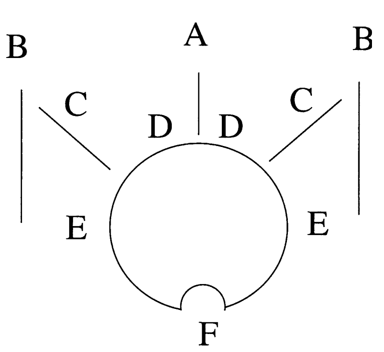


Fig. 1. Division of subarachnoid spaces into 10 different basal cisterns and fissures by Hijdra

Results

The sex, mean age and sites of the ruptured aneurysms of the 180 patients are presented in Table 1. The sites of the ruptured aneurysms as predicted independently by each neuroradiologist are presented in Table 2.

Middle cerebral aneurysms (MCA)

Fifty-one right MCA aneurysms were identified at operation. Each neuroradiologist located 49 aneurysms correctly, and in 48 patients the correctly located ruptured aneurysms were the same. In one patient, neuroradiologist 1 estimated that an AcoA aneurysm had bled, while neuroradiologist 2 chose a left MCA. In one patient, neuroradiologist 1 misinterpreted the bleeding aneurysm as an AcoA aneurysm, while the estimation of neuroradiologist 2 was correct, and in one patient the roles were reversed.

In the group of 34 left MCA aneurysms, the ruptured aneurysm was located correctly by neuroradiologist 1 in

Table 1. *Sex, mean age and location of the aneurysms of 180 patients with SAH*

	Patients (n = 180)	
Sex		
Male	100	55.6%
Female	80	44.4%
Mean age of		
Male	46 y	(21–72 y)
Female	48 y	(22–74 y)
Aneurysm site		
MCA dex	51	28.3%
MCA sin	34	18.9%
ACA dex	5	2.8%
ACA sin	3	1.7%
PCA dex	–	0.0%
PCA sin	1	0.6%
AcoA	56	31.1%
PcoA dex	5	2.8%
PcoA sin	2	1.1%
AB	3	1.7%
PICA dex	1	0.6%
PICA sin	2	1.1%
ICA dex	12	6.7%
ICA sin	5	2.8%

MCA Middle cerebral artery, *ACA* anterior cerebral artery, *PCA* posterior cerebral artery, *AcoA* anterior communicating artery, *PcoA* posterior communicating artery, *BA* basilar artery, *PICA* posteroinferior cerebral artery, *ICA* internal cerebral artery.

30 patients and by neuroradiologist 2 in 32 patients. In 30 patients, the correctly located ruptured aneurysm was the same for both. In one patient, neuroradiologist 1 estimated the ruptured aneurysm as an AcoA aneurysm and neuroradiologist 2 as a right MCA aneurysm. In one patient, both neuroradiologists located the bleeding aneurysm as an AcoA aneurysm. Neuroradiologist 1 diagnosed the ruptured aneurysm as an AcoA aneurysm in 2 cases.

Anterior communicating aneurysms (AcoA)

Fifty-six AcoA aneurysms were confirmed at operation. Neuroradiologist 1 located 52 and neuroradiologist 2 47 of these correctly. In 45 patients, the correct diagnoses were identical for both observers. In 7 patients, neuroradiologist 2 had made an incorrect location while neuroradiologist 1 had made a correct one, including 2 BA, 1 left MCA, 2 right MCA and 2 right ACA aneurysms. In 2 patients, neuroradiologist 1 located the aneurysm as a right ACA aneurysm, while neuroradiologist 2 made a correct location. In 2 patients, each neuroradiologist located the aneurysms incorrectly as a right MCA aneurysms.

Anterior cerebral aneurysms

Of the 5 right ACA aneurysms only one aneurysm was located correctly by both neuroradiologists. In 3 patients, each neuroradiologist diagnosed the bleeding aneurysm as an AcoA aneurysm, and in one patient neuroradiologist 1 diagnosed the aneurysm as a left ACA aneurysm, while the diagnosise of neuroradiologist 2 was an AcoA aneurysm. Both neuroradiologists located incorrectly each of the 3 left ACA aneurysms. Both neuroradiologists estimated it as an BA aneurysm

Table 2. *Locations of 180 ruptured aneurysms by two neuroradiologist (N_1 | N_2) with respect to locations determined by the gold standard*

<table>
<tr><th></th><th colspan="13">Location determined by the gold standard</th><th></th></tr>
<tr><th></th><th>MCA dex N1 | N2</th><th>MCA sin N1 | N2</th><th>ACA dex N1 | N2</th><th>ACA sin N1 | N2</th><th>ACP sin N1 | N2</th><th>AcoA N1 | N2</th><th>PcoA dex N1 | N2</th><th>PcoA sin N1 | N2</th><th>AB N1 | N2</th><th>PICA dex N1 | N2</th><th>PICA sin N1 | N2</th><th>ICA dex N1 | N2</th><th>ICA sin N1 | N2</th><th>Total N1 | N2</th></tr>
<tr><td>MCA dex</td><td>49 | 49</td><td>0 | 1</td><td></td><td></td><td></td><td>2 | 4</td><td>2 | 2</td><td></td><td></td><td></td><td></td><td>2 | 4</td><td></td><td>55 | 60</td></tr>
<tr><td>MCA sin</td><td>0 | 1</td><td>30 | 32</td><td></td><td></td><td></td><td>0 | 1</td><td></td><td>0 | 1</td><td></td><td></td><td></td><td>0 | 1</td><td>3 | 2</td><td>33 | 38</td></tr>
<tr><td>ACA dex</td><td></td><td></td><td>1 | 1</td><td>1 | 1</td><td></td><td>2 | 2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>4 | 4</td></tr>
<tr><td>ACA sin</td><td></td><td></td><td>1 | 0</td><td>0 | 0</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1 | 0</td></tr>
<tr><td>ACP sin</td><td></td><td></td><td></td><td></td><td>0 | 0</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>0 | 0</td></tr>
<tr><td>AcoA</td><td>2 | 1</td><td>4 | 1</td><td>3 | 4</td><td>1 | 0</td><td>1 | 1</td><td>52 | 47</td><td></td><td>1 | 0</td><td></td><td>0 | 1</td><td>1 | 0</td><td>4 | 4</td><td>1 | 1</td><td>70 | 60</td></tr>
<tr><td>PcoA dex</td><td></td><td></td><td></td><td></td><td></td><td></td><td>1 | 1</td><td></td><td></td><td></td><td></td><td>0 | 1</td><td></td><td>1 | 2</td></tr>
<tr><td>PcoA sin</td><td></td><td></td><td></td><td>0 | 1</td><td></td><td></td><td>0 | 1</td><td>0 | 0</td><td></td><td></td><td></td><td></td><td>0 | 2</td><td>0 | 4</td></tr>
<tr><td>BA</td><td></td><td></td><td></td><td>1 | 1</td><td></td><td>0 | 2</td><td></td><td>1 | 1</td><td>3 | 3</td><td>1 | 0</td><td>1 | 2</td><td></td><td></td><td>7 | 9</td></tr>
<tr><td>PICA dex</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>0 | 0</td><td></td><td></td><td></td><td>0 | 0</td></tr>
<tr><td>PICA sin</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>0 | 0</td><td></td><td>1 | 0</td><td>1 | 0</td></tr>
<tr><td>ICA dex</td><td></td><td></td><td></td><td></td><td></td><td></td><td>1 | 1</td><td></td><td></td><td></td><td></td><td>6 | 2</td><td></td><td>7 | 3</td></tr>
<tr><td>ICA sin</td><td></td><td></td><td></td><td></td><td></td><td></td><td>1 | 0</td><td></td><td></td><td></td><td></td><td></td><td>0 | 0</td><td>1 | 0</td></tr>
<tr><td>Total</td><td>51</td><td>34</td><td>5</td><td>3</td><td>1</td><td>56</td><td>5</td><td>2</td><td>3</td><td>1</td><td>2</td><td>12</td><td>5</td><td>180</td></tr>
</table>

N_1 Neuroradiologist 1, N_2 neuroradiologist 2.

in one patient and as a right ACA aneurysm in another. In one patient, neuroradiologist 1 diagnosed it as an AcoA aneurysm and neuroradiologist 2 as a right PcoA aneurysm.

Carotid and posterior communicating aneurysm

Twelve aneurysms of the right ICA were diagnosed. One of these was correctly located by both neuroradiologists. Both neuroradiologists located the same 5 aneurysms incorrectly: 3 as an AcoA and 2 as a right MCA aneurysm. In addition, neuroradiologist 1 located 5 aneurysms correctly, while neuroradiologist 2 located them incorrectly as follows: 2 right MCA, one left MCA, one right PcoA and one AcoA aneurysm. Neuroradiologist 2 located one ICA aneurysm correctly, while neuroradiologist 1 located it as an AcoA aneurysm. There were five aneurysms of the left ICA. All were located incorrectly by both neuroradiologists. Each neuroradiologist located 2 as a left MCA and one as an AcoA aneurysm. One was located by neuroradiologist 1 as a left PICA and by neuroradiologist 2 as a left PcoA aneurysm, while the other was located by neuroradiologist 1 as a left MCA and by neuroradiologist 2 as a left PcoA.

The only left PCA aneurysm was located by both neuroradiologists as an AcoA aneurysm. Five right PcoA aneurysms were diagnosed, one was correctly located by both neuroradiologists and two were located by both neuroradiologists as a right MCA and one as a right ICA aneurysm. One patient was diagnosed by neuroradiologist 1 to have a left ICA and by rater 2 to have a left PcoA aneurysm.

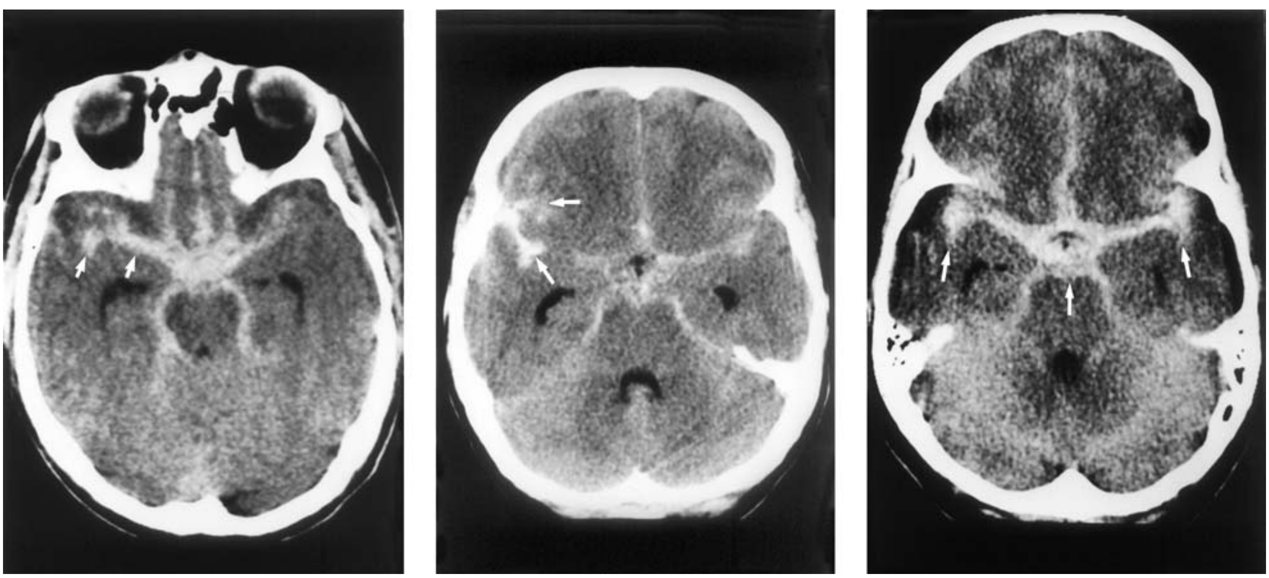
Two left PcoA aneurysms were determined with no correct location. In one case, both neuroradiologists located the bleeding aneurysm as an BA aneurysm. In another case, neuroradiologist 1 located it as an AcoA and neuroradiologist 2 as a left MCA aneurysm.

Posterior circulation aneurysms

All BA aneurysms were correctly located by both neuroradiologists. The only right PICA aneurysm was incorrectly located by both neuroradiologists. Neuroradiologist 1 located it as a BA and neuroradiologist 2 as an AcoA aneurysm. Two left PICA aneurysms were incorrectly located, one by both neuroradiologists as a BA aneurysm and the other by neuroradiologist 1 as an AcoA and by neuroradiologist 2 as a BA aneurysm.

Figure 2 presents the falsely interpreted AcoA, MCA and ICA aneurysms.

The κ-values of both neuroradiologists for each ruptured vessel are presented in Table 3. For right and left MCA and AcoA aneurysms the κ-values between the two neuroradiologists are alike. For MCA aneurysms



a b c

Fig. 2. A. A ruptured left MCA aneurysm located as an AcoA aneurysm rupture. This single slice shows a central haemorrhage weighted to some extent towards the right site (arrows). B. A ruptured AcoA aneurysm located as a right MCA aneurysm. Haemorrhage weighted towards the right site (arrows). C. A right ICA aneurysm located as an AcoA aneurysm. Symmetrical haemorrhage (arrows)

Table 3. *Reliability values of the neuroradiologists for each ruptured aneurysm*

		κ-values		
	n	N_1*	N_2*	N_1 Vs N_2**
Aneurysm site				
MCA dex	51	0.893	0.831	0.911
MCA sin	34	0.872	0.861	0.877
ACA dex	5	0.203	0.203	0.489
ACA sin	3	– 0.008	–	–
PCA dex	0	–	–	–
PCA sin	1	–	–	–
AcoA	56	0.733	0.720	0.736
PcoA dex	5	0.327	0.274	0.664
PcoA sin	2	–	–	–
AB	3	0.590	0.487	0.739
PICA dex	1	–	–	–
PICA sin	2	–	–	–
ICA dex	12	0.613	0.247	0.386
ICA sin	5	– 0.009	–	–
Overall	180	0.704	0.655	0.780

* κ-values of N_1 and N_2 concern the level of agreement between an individual observer and the gold standard.

** κ-value of N_1 Vs N_2 concerns the level of agreement between the observers.

Not all κ-values were calculated, either because the location of the rupture was constant or because the number of ruptures in the vessel was too small.

N_1 Neuroradiologist 1, *N_2* neuroradiologist 2.

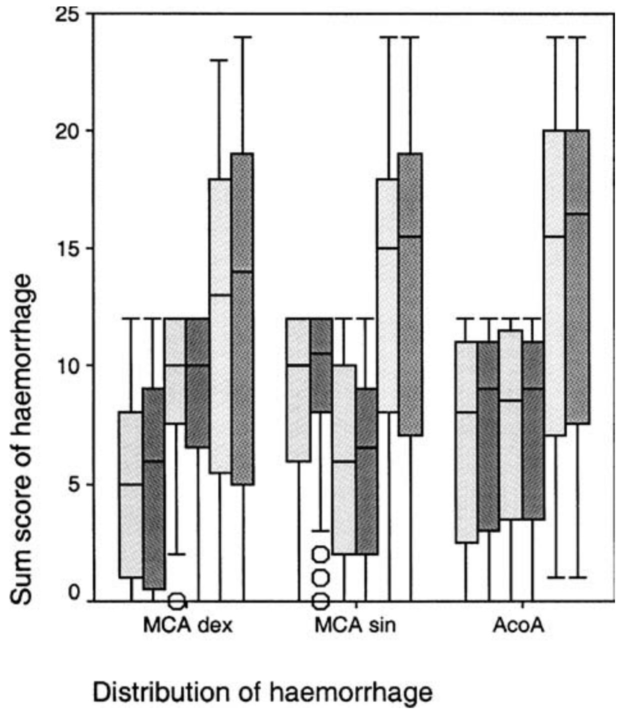


Fig. 3. Sum score and distribution of haemorrhage of right and left MCA and AcoA aneurysm ruptures. *MCA* middle cerebral artery, *AcoA* anterior communicating artery, *N_1* Neuroradiologist 1, *N_2* Neuroradiologist 2. Site of haemorrhage: ▢ Left, N1; ▩ Left, N2; ▢ Right, N1; ▩ Right, N2; ▢ Central, N1; ▩ Central, N2

the κ-values are "almost perfect" and for AcoA aneurysms "substantial". The overall κ-values of both neuroradiologists compared to the gold standard and to each other are "substantial". For right ICA aneurysms the κ-value of neuroradiologist 1 is 0.613 and that of neuroradiologist 2 is 0.247. This is the largest difference in κ-values between the two. For the rest of the vessels, the sample size is very small.

Figure 3 presents "box and whisker" plots of both neuroradiologists' graded amount (sum score) and distribution of the haemorrhage associated with rupture of right and left MCA and AcoA aneurysms. In these patients, irrespective of the location of the aneurysm, most haemorrhages are usually in the "central" part and, not unexpectedly with a middle cerebral aneurysm more haemorrhage is present on the side of the rupture than contralaterally and, with an anterior communicating aneurysm, the amount of lateralised haemorrhage is, on an average, equivalent. Because of the small number of other single aneurysms, the amount and distribution of these haemorrhages are not presented.

In 26 patients (14.4%) DSA showed more than one aneurysm. In 19 cases there were 2 and in 7 cases 3 aneurysms. An aneurysm was chosen for the operation on the basis of the distribution of the haemorrhage on the initial CT, the irregularity of the outline of the aneurysm or the existence of the daughter sack of the aneurysm. The neurosurgeon confirmed at operation that the chosen aneurysm was the ruptured one in each patient. In this series there was not a single instance of an unruptured aneurysm operated on instead of the ruptured one, taking the neurosurgeon's opinion as the "gold standard".

62 patients (34.4%) had an intraparenchymal cerebral haematoma (ICH) as well as SAH. The ruptured aneurysms causing an ICH were located in the right MCA (n = 27), left MCA (n = 16), AcoA (n = 14), right ACI (n = 2), left ACI (n = 2) and right ACA (n = 1).

Discussion

Our findings demonstrate the utility of CT in locating the site of a ruptured aneurysm in selected patients. Out of 548 patients with SAH, 180 patients were selected for the study. Through selection, we minimised the variability resulting from different uses of CT and DSA in different hospitals and the time differences between the initial CT and DSA. All the patients selected underwent operation by a neurosurgeon, so that the precise location of the ruptured aneurysm could be determined, by considering the operation as the ''gold standard''.

Because of the method of patient selection, this study may over estimate the reliability of the results by excluding the patients without an aneurysm in DSA. However, the aim of this study was to evaluate how precisely it is possible, if there is a ruptured cerebral aneurysm, to locate it on the basis of the quantity and distribution haemorrhage on the initial CT.

Both neuroradiologists estimated the quantity and distribution of the haemorrhage by the method of Hijdra [1]. This method generally reflects well the distribution and quantity of cisternal and intraventricular haemorrhage. However, the method has some drawbacks because of anatomical and technical reasons. The small amount of SAH in the subarachnoid spaces lying next to the skull base may be misread because the slice thickness of CT causes a partial volume effect. The subarachnoid spaces vary in size between patients of different ages, so that the absolute amount of haemorrhage is difficult to estimate. Also, the calcified falx in the interhemispheric fissure may cause difficulties in grading the SAH. Because of these factors, the general visual impression of the amount and distribution of the haemorrhage has a major influence on the final determination of the location of the ruptured aneurysm.

The distribution of aneurysms varies in different reports [2, 4, 12, 13]. In this study, 47.2% of the aneurysms were on the MCA, 31.1% on the AcoA and 21.7% on the other of intracerebral arteries, which correlates to these reports. Other distributions have been reported [6, 17]. The higher proportion of MCA aneurysms situated on the right side ($n = 51/60.7\%$) versus the left side ($n = 34/39.3\%$) that we found is comparable to the report of van der Jagt [4]. The reason for this site difference is unknown.

The total amount of the haemorrhage did not have an influence on the diagnosis of the site of the ruptured aneurysm. The sum scores of haemorrhage between the neuroradiologists corresponded well with each other. In patients with a MCA or AcoA aneurysm, most haemorrhages are usually in the ''central'' part, and not unexpectedly with a middle cerebral aneurysm, more haemorrhage is present on the side of the rupture than contralaterally, while with an anterior communicating aneurysm the amount of lateral haemorrhages is, on an average, equivalent. The difference in the amount of haemorrhage is small and the visual impression is therefore an important factor for locating the ruptured aneurysm.

In this study, the initial CT proved to be a reliable method for locating ruptured MCA and AcoA aneurysms causing SAH on the basis of the quantity and distribution of subarachnoid haemorrhage. We found substantial or almost perfect reliability, which differs from the conclusions of previous reports that CT helps to predict the site of rupture in only a minority of cases [12]. The recent publication by van der Jagt [4] concluded that the site of a ruptured aneurysm in the absence of a parenchymal hematoma, can be identified by CT only when the bleeding originates from an ACA or an anterior AcoA aneurysm. Latchaw [8] and Hillman [2], however, showed that the distribution of haemorrhage predicts the location of the aneurysm in over 80% of cases. According to the present study, when a MCA aneurysm bleeds towards the central part of the brain or an AcoA aneurysm bleeds towards the lateral parts, there is a possibility of misinterpretion of the location of the ruptured aneurysm, as one or the other neuroradiologist did in 15 (10.6%) cases out of the 141 ruptured MCA or AcoA aneurysms. It is also possible to misinterpret the site on the CT images, as both neuroradiologists did in two haemorrhages originating from MCA aneurysms.

It appears that, for aneurysms other than MCA and AcoA, it is not possible to locate the ruptured aneurysm accurately on the basis of the initial CT. This is because of the location of these aneurysms at the basal parts of the brain. However, the number of these aneurysms is also too low to warrant reliable conclusions in this respect.

Subarachnoid haemorrhage with a parenchymal hematoma has been shown to be an excellent predictor of the site of a ruptured aneurysm [2, 4, 12], but it is present in only 15–20% of cases [2, 4]. We found an ICH with SAH in 34.4% of cases, and it was a good predictor for evaluating the location of the ruptured aneurysm, with a statistical significance of $p = 0.003$.

Conclusion

Initial CT appears to be a reliable method for locating the ruptured MCA and AcoA aneurysms causing SAH with substantial or almost perfect reliability. However, the direction of the blood jet from a ruptured MCA or AcoA aneurysm may cause difficulties in locating precisely the site of the ruptured aneurysm. Diagnosis of the precise location of other ruptured aneurysms does not seem to be reliable on the basis of the amount and distribution of the SAH. A subarchnoid haemorrhage with a parenchymal hematoma is an excellent predictor of the site of a ruptured aneurysm.

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Comments

The authors of this manuscript report on the value of the distribution and quantity of subarachnoid hemorrhage on CT for the prediction of the site of rupture of an aneurysm. As the authors state, the ultimate aim to determine the probable location of the aneurysm which has bled is of real importance. In case of multiple aneurysms, DSA, and even the neurosurgeon's view will be liable to some errors of judgment which of the visible aneurysms was the cause of the SAH. Fortunately, in many instances the bleeding into the subarachnoid space is more or less confined to the site of the aneurysm, and this study demonstrates that for aneurysms in the most usual locations, the distribution of the SAH is accurate in predicting the major intracerebral vessel where the ruptured aneurysm resides. Alas, for less common locations, the study shows that the neuroradiologist will choose a convenient location on the basis of common knowledge of the distribution frequency.

Although 180 patients have been screened, the authors do not report on any patient with multiple aneurysms were the proposed scoring technique would have proved its real value. Furthermore it is not mentioned that multiple aneurysms can also occur on the same vessel, and then this technique of gross estimation is evidently of little value.

The study is interesting in itself though, it confirms that CT is a very sensitive technique for the detection of SAH, and an attempt can be made to predict the site of the ruptured aneurysm. But this prediction is only an indication and never a substitute for DSA and can help to direct attention to the site of rupture. DSA remains the gold standard for locating and depicting the ruptured aneurysm. In cases of multiple aneurysms, the one that has ruptured, will almost always show some irregularities, some kind of bleb indicating the pseudoaneurysm. Furthermore, in the case of multiple aneurysms, the possibility to treat all or the onces most likely to cause bleeding by endovascular methods has revolutionized our general approach of the pathology.

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This study addresses the important topic of a localisation of aneurysms based on CT scans. It has been carefully performed with 2 rigorous assessments by 2 Neuroradiologists who are blinded to the angiographic results and scored the data independently. Their conclusions are valid and supported by the data and correctly conclude that anterior-communicating artery and middle cerebral artery aneurysms can be predicted on the basis of the CT. However, other aneurysms around the Circle of Willis were not predicted well.

When there was an intraparenchymal haemorrhage then CT scanning was an excellent predictor with a P value of 0.003. This study certainly suggests that the precise location of the ruptured aneurysm can be addressed on CT which is probably the preferred method.

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