

The Usefulness of 3D-CT Angiography as a Screening Tool for Vascular Abnormalities in Spontaneous ICH Patients

Ho Jin Lee, M.D., Min Ho Kong, M.D., Hyun Jong Hong, M.D.,
Dong Soo Kang, M.D., Kwan Young Song, M.D.

Department of Neurosurgery, Seoul Medical Center, Seoul, Korea

Objective : We investigated the incidence of the vascular abnormalities associated with spontaneous intracerebral hemorrhage (ICH) using three-dimensional computed tomographic angiography (3D-CTA).

Methods : We prospectively assessed consecutive 76 patients with spontaneous intracerebral hemorrhage (ICH) who underwent 3D-CTA between June 2003 and May 2005. The patients with a recent history of trauma or mainly subarachnoid hemorrhage were excluded. We investigated relationship between vascular abnormality and ICH location. The findings of 3D-CTA were classified as one of three patterns with ICH; type A (without evidence of vascular abnormality), type B (with no vascular abnormality as the source of hemorrhage, but with incidental vascular abnormality), and type C (presence of a vascular abnormality as the source of hemorrhage).

Results : Sites of ICH were lobar 26, basal ganglia 23, thalamus 17, posterior fossa 6 and dominant intraventricular hemorrhage (IVH) 4. Among 76 patients, sixteen (21.1%) vascular abnormalities were noted excluding 13 cases of stenocclusive disease. Sixteen cases included 6 cases of cerebral aneurysms (7.9%), 5 moyamoya diseases (6.6%), 4 arteriovenous malformations (5.3%) and 1 dural sinus thrombosis (1.3%). Lobar ICH (30.8%) had a higher vascular abnormalities than other types, and younger age (<40) group had a higher incidence of vascular abnormalities than old age group. The patterns of 3D-CTA include sixty cases (79.0%) of type A, 6 cases (7.8%) of type B and 10 cases (13.2%) of type C. The vascular abnormalities were found in 8 (13.5%) of 59 hypertensive patients and 8 (47.0%) of 17 non-hypertensive patients ($p=0.006$).

Conclusion : 3D-CT angiography is considered a useful screening tool for ICH patients with suspected cerebrovascular abnormalities and should be considered in such clinical settings, especially in lobar type and in non-hypertensive younger patients.

KEY WORDS : Computed tomographic angiography · Intracerebral hemorrhage · Vascular abnormality · Screening.

Introduction

The term spontaneous intracerebral hemorrhage (ICH) refers to all varieties of bleeding into the cerebral parenchyma in which 'trauma or other exogenous' factors do not play an essential part²⁴. It constitutes a major neurosurgical problem. Its incidence varies from 10 to 32% of all cerebrovascular strokes in USA¹⁹, and from 27.3% to 47.6% in Korea^{12,18}.

Spontaneous ICH is caused more often by hypertension per se than by vascular abnormality secondarily^{2,3}. Clinically,

therefore, through investigations to detect any possible associated vascular abnormalities have not been routinely performed on the past. Conventional angiography remains the golden standard for diagnosis of vascular abnormality. But it is invasive, difficult in acutely ill patients, and carries definite risks¹. Recently three-dimensional computerized tomographic angiography (3D-CTA) has shown to be promise as a highly sensitive and less invasive modality for determining the source of hemorrhage^{8,23,29}. In this study, we have tried to screen any associated vascular abnormalities in spontaneous ICH using 3D-CTA.

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• Address for reprints : Min Ho Kong, M.D., Department of Neurosurgery, Seoul Medical Center, 171-1 Samseong-dong, Gangnam-gu, Seoul 135-090, Korea Tel : +82-2-3430-0645, Fax : +82-2-557-8207, E-mail : joenam0@yahoo.co.kr

Materials and Methods

This study is based on 90 cases of spontaneous ICH patients who visited our hospital during the period from June 2003 to May 2005. We prospectively assessed 90 consecutive patients in whom ICH had been diagnosed and who met the following inclusion criteria²⁹⁾; 1) presence of ICH, 2) 3D-CTA performed after CT scanning, 3) spontaneous ICH without trauma history, 4) cerebral angiography or magnetic resonance angiography (MRA) performed during the chronic stage. We excluded ICH patients with dominant subarachnoid hemorrhage, hemorrhagic disorders and those who have been taking anticoagulant medications. A total of 76 patients were finally included in this study. In cases in which small parenchymal hematoma ruptured into the ventricle, the parenchymal hemorrhage was defined as the anatomical site of hemorrhage. When IVH volume was larger than parenchymal ICH and the origin of the one was ambiguous, we defined the case as 'dominant IVH'.

3D-CTA was performed within 3 days after their visiting.

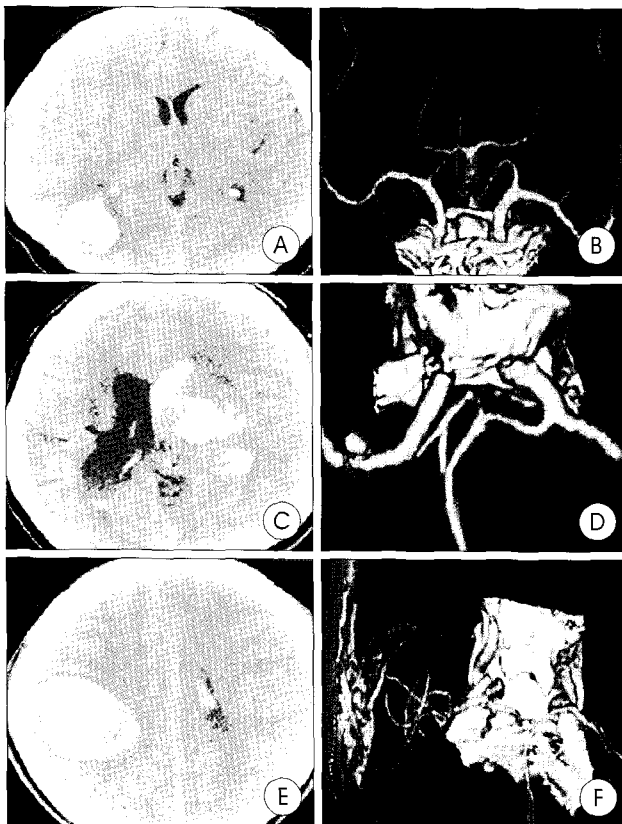


Fig. 1. Three patterns of intracerebral hemorrhage (ICH) according to the findings of three-dimensional computed tomographic angiography (3D-CTA). Type A (A, B) : Brain computed tomography shows right parietal ICH and 3D-CTA shows no lesion. Type B (C, D) : Brain computed tomography shows left basal ganglia ICH and frontal horn intraventricular hemorrhage but 3D-CTA shows contralateral side unruptured middle cerebral artery aneurysm (arrow). Type C (E, F) : Brain computed tomography shows right parietal ICH and 3D-CTA shows same side arterio-venous malformation (arrow).

If emergency operation was needed, we tried to check 3D-CTA as soon as possible. CT scan slices were planned to cover the entire field of interest from upper cervical to the vertex. An intravenous infusion of non-ionic, iodinated contrast solution Iopromide (ultravist[®]), was started at a rate of 2.5 ml/sec for about 30 seconds. After scanning is completed, reconstructions were performed in three dimensions at the console by using standard scanner software (GE-AW4.1 program). We performed conventional angiography or MRA for all patients who had screened vascular abnormalities in 3D-CTA.

ICH was classified according to the location of the hemorrhage into lobar, basal ganglia, thalamus, and posterior fossa hemorrhage (including cerebellar and brain stem) and dominant IVH. We assigned 76 ICH patients to either hypertensive or non-hypertensive groups based on their blood pressure levels during the chronic phase (systolic blood pressure greater than 160 mmHg or diastolic blood pressure greater than 95 mmHg) or a history of antihypertensive medication. The findings on 3D-CTA were classified as exhibiting one of three patterns³⁰⁾: type A (without evidence of vascular abnormality), type B (with no vascular abnormality as the source of hemorrhage, but with incidental vascular abnormality), and type C (presence of a vascular abnormality as the source of hemorrhage) (Fig. 1). For statistical comparison, we performed cross tabulation and Fisher's exact test expressed by χ^2 and significance was determined at p-value less than 0.05.

Results

The patients ranged in age from 29 to 91 years (mean 57.6) and included 50 men (64.1%) and 26 women (35.9%). All were ethnically Koreans. The most prevalent age was from 41 to 60 years (31 cases), and 10 cases (13.2%) were less than 40 years.

The most common site of ICH was the lobar (34.2%), followed by basal ganglia (30.3%) and thalamus (22.3%). The parieto-temporal (50%), fronto-temporal (23%) were common location, in the lobar type. ICH which ruptured into the ventricle were seen in 21 cases (thalamus 9, basal ganglia 6, lobar 5, posterior fossa 1) and 3 cases (2 lobar, 1 posterior fossa) of these were associated with vascular abnormalities. There was no increase in angiographic yield for ICH ruptured into the ventricle compared with those without IVH ($p=0.084$). Subarachnoid extension was found in 10 cases (lobar 4, basal ganglia 4, posterior fossa 2) and 3 cases (arteriovenous malformation 2, moyamoya disease 1) of there were associated with vascular abnormalities. There was also no increase in angiographic yield for ICH with subarachnoid extension ($p=0.092$).

Eight cases (30.8%) had vascular abnormalities in 26 lobar

ICH, 2 cases (8.7%) in 21 basal ganglia ICH, 2 cases (11.8%) in 17 thalamic ICH, 2 cases (33%) in 6 posterior fossa location, and 2 cases (50%) in 4 dominant IVH. Lobar, posterior fossa and dominant IVH had higher vascular abnormalities than thalamic and basal ganglia, although the difference was not statistically significant ($p=0.091$) (Table 2). We classified lobar, posterior fossa and dominant IVH cases as one group and thalamic and basal ganglia cases as other group. The former group showed higher possibility of vascular abnormalities than latter group with statistical significance ($p=0.041$).

Except atherosclerotic vascular stenosis, the most common vascular abnormality was cerebral aneurysm (6 cases, 7.9%). All of them were unruptured aneurysm that were demonstrated incidentally. There were five cases of moyamoya disease (6.6%), 4 cases of AVM (5.3%), and 1 case of dural sinus thrombosis (1.3%). In overall, we detected 16 cases (21.1%) of vascular abnormalities in 76 ICH patients with 3D-CT angiographic screening.

In patients with the younger age group (<40), moyamoya disease (3 cases) and AVM (2 cases) were noted. In older age group (>40), aneurysm (5 cases), moyamoya disease (2 cases), AVM (2 cases)

and dural sinus thrombosis (1 case) were observed. The vascular abnormalities were significantly more frequent in the younger age group (<40) (50.0% [5/10] versus 16.6% [11/66]) ($p=0.007$) (Table 3).

The mean age was 41.7 years (range 23 to 75) for the non-hypertensive group, and 63.0 years (range 29 to 91) for the hypertensive group. If we excluded atherosclerotic vascular stenosis, the vascular abnormality were found in 8 patients (13.5%) of hypertensive patients and 8 patients (47.0%) of non-hypertensive patients ($p<0.0001$). In 59 hypertensive group, 11 patients (18.6%) had arterial stenosis, 6 patients (10.1%) had aneurysm, and 2 patients (3.3%) had moyamoya

Table 1. Summary of 16 vascular abnormalities screened by 3D-CTA

Case	Age	Sex	ICH location	HTN	Vascular abnormality	Alternative study	Type
1	76	F	Lobar,Lt	Yes	Rt MCA aneurysm	MRA	B
2	60	M	Lobar,Lt	Yes	ACA Aneurysm	MRA	B
3	91	F	Lobar,Rt	Yes	Lt P-comA aneurysm	MRA	B
4	51	F	Thalamus,Lt	Yes	Rt MCA aneurysm	DSA	B
5	63	M	Thalamus,Lt	Yes	Rt ICA Bif aneurysm	MRA	B
6	78	F	Basal ganglia,Rt	Yes	Rt MCA aneurysm	DSA	B
7	41	M	Lobar,Lt	No	AVM	DSA	C
8	75	F	Lobar,Rt	No	Dural AVM	MRA	C
9	43	M	Lobar,Lt	Yes	Dural sinus thrombosis	MRA	C
10	25	M	Lobar,Rt	No	AVM	DSA	C
11	33	F	Lobar,Lt	No	Moyamoya disease	DSA	C
12	23	M	Posterior fossa	No	Moyamoya disease	MRA	C
13	28	F	Posterior fossa	No	AVM	DSA	C
14	46	M	Basal ganglia,Rt	Yes	Moyamoya disease	DSA	C
15	34	M	Dominant IVH	Yes	Moyamoya disease	DSA	C
16	45	M	Dominant IVH	Yes	Moyamoya disease	MRA	C

Rt : right, Lt : left, MCA : middle cerebral artery, ACA : anterior cerebral artery P-comA : posterior communicating artery, AVM : arterio-venous malformation, DSA : digital subtraction arteriography, IVH : intraventricular hemorrhage, MRA : magnetic resonance angiography

Table 2. Associated vascular abnormalities according to the location

Location	Vascular abnormality				Total patient's number	%	p-value
	Aneurysm	Moyamoya disease	AVM	Dural sinus thrombosis			
Lobar	3	1	3	1	26	30.76	-
Basal ganglia	1	1	0	0	23	8.69	-
Thalamus	2	0	0	0	17	11.76	-
Posterior fossa	0	1	1	0	6	33.33	-
Dominant IVH	0	2	0	0	4	50.00	-

AVM : arterio-venous malformation, IVH : intraventricular hemorrhage

Table 3. Associated vascular abnormalities according to the age

Age	Vascular abnormality				Total patient's number	%	p-value
	Aneurysm	Moyamoya disease	AVM	Dural sinus thrombosis			
<40	0	3	2	0	10	50.00	-
>40	6	2	2	1	66	16.66	-

AVM : arterio-venous malformation

disease. In 17 non-hypertensive patients group, 2 patients (11.7%) had arterial stenosis, 4 patients (23.5%) had AVM, 3 patients (17.6%) had moyamoya disease and 1 patient (5.8%) dural sinus thrombosis. Younger age (<40) and non-hypertension were shown to be significant independent factors associated with vascular abnormality.

The time required for CT scan data acquisition averaged 10 minutes per patients, and the three-dimensional images were generated in less than 20 minutes. There were no complications related to contrast material problem with 3D-CTA evaluation. The conventional angiography or MRA were performed to confirm the accuracy of 3D-CTA findings.

The 3D-CTA findings were compatible with the conventional angiography and MRA in all 16 patients with vascular abnormalities.

3D-CTA findings of 76 patients were classified as: type A (without evidence of vascular abnormality) in 60 cases (78.0%), type B (with no vascular abnormality as the source of hemorrhage, but with incidental vascular abnormality) in 6 cases (7.9%), and type C (presence of a vascular abnormality as the source of hemorrhage) in 10 cases (13.2%). The lobar, basal ganglia, thalamus were the main locations of ICH in type A patients. The basal ganglia, lobar, thalamus were the main location of ICH in type B patients. But lobar, posterior fossa and dominant IVH were main locations of ICH in type C patients. The vascular abnormality seen in type B patients was cerebral aneurysm (6 cases) and the ones in type C patients were moyamoya disease (5 cases), AVM (4 cases) and dural sinus thrombosis (1 case). The mean age of the 76 patients was 57.6, but 69.8 in type B and 39.3 in type C. In type B patients, all were diagnosed as hypertensive. In type C patients, only 4 patients were diagnosed as hypertensive (Table 1).

Discussion

Spontaneous ICH originates from the spontaneous rupture of small vessels damaged by chronic hypertension^{6,9)} accounting for 78 to 89 percent of such cases. Secondary intracerebral hemorrhage occurs in a minority of patients in association with vascular abnormalities such as AVM, aneurysm.

McCormick et al.¹⁷⁾ showed that, in his necropsy review of 144 patients who died from massive brain hemorrhage, 36% of patients with hypertension had another cause of hemorrhage. Griffiths et al.⁷⁾ reported that 25% of hypertensive patients had vascular abnormalities. Other investigators have reported the vascular abnormality ranged from 20% to 49% in non-traumatic ICH patients^{11,27)}. Griffiths et al. (49%)⁷⁾ emphasized that 'because of the referral patterns to our neuroscience centre, this result can not be considered typical for the whole population'. All of these may mean that there would be more vascular abnormalities in ICH patients than expected.

We found 16 cases (21.1%) of vascular abnormality in 76 patients. Of these, 10 cases (13.2%) were presented as the source of hemorrhage and 6 cases (7.9%) were found incidentally. This result may not represent the real incidence of vascular abnormality in ICH patients because of a small cohort study. However, author's believe that our results may represent somewhat objective data because our medical center doesn't have the referral systems. But, further study with more population will be required before it can be sufficiently.

Our result showed the similar pattern of high incidence of

vascular abnormalities with younger, lobar and non-hypertensive ICH patients like other considered as objective and meaningful reports^{6,8,11,25)}. Mean age of type C (vascular abnormality associated with ICH) patients was 39.3 years. Six (60%) patients were diagnosed as normotensive. The lobar (50%) location was predominantly associated with vascular abnormalities. Eight patients (47.0%) had vascular abnormalities in non-hypertensive patients, and 8 (13.5%) patients in hypertensive patients. Gilbert et al.⁶⁾ reported that cerebral angiography was positive in 6 (12.8%) hypertensive patients, and in 22 (44%) non-hypertensive patients.

Regarding to ICH location, several studies^{12,26)} have shown that spontaneous ICHs were located most commonly in basal ganglia, thalamus, lobar, and posterior fossa. Others^{6,20)} have reported that lobar was the main location of ICH. Common locations of ICH in our study were lobar, basal ganglia, thalamus, posterior fossa in descending order and showed high incidence of vascular abnormalities in lobar and posterior fossa ICH ($p=0.091$). There is no clear explanation especially there was a small patient population in this study.

Ryo et al.²⁵⁾ reported that subarachnoid extension was expected to have more vascular abnormalities, but we didn't find any corresponding increment in vascular abnormalities. There are no ICH from aneurysm rupture in our study as opposed to other studies^{14,27)}. We assumed that there was no cases of ICH due to aneurysm, because those patients whose CT scans predominantly showed subarachnoid hemorrhages were excluded.

In this study, 3D-CTA studies were added by other alternative studies such as conventional angiography or MRA to increase the accuracy of its findings. We confirmed 16 patients of vascular abnormalities with additional studies and the findings were compatible. Therefore, 3D-CTA manifested as a highly sensitive modality in our study as reported elsewhere^{3,8,23)}.

In this regard, 3D-CTA may be useful in planning operation and other medical treatments. Type B patients (incidental aneurysm) were treated with no difference with type A patients according to ICH amount, location, and patient's clinical status. It is recommended in these patients, to take cautious steps to prevent unexpected aneurysmal rupture and cerebral infarction by careful blood pressure and intake/output control. Particularly, in type C patients, even more careful decisions were made for proper management. If patient's clinical status was stable, we didn't plan a urgent operation (craniectomy or craniotomy) without confirmatory study. Instead of urgent major operation, we evacuated hemorrhage carefully with stereotactic method or controlled increased intracranial pressure with extraventricular drainage, followed by planning of the proper operation for vascular abnormality.

Severe idiosyncratic reactions to iodinated contrast agents

have been reported¹³), but this was not witnessed in our study. Rather, several advantages of 3D-CTA were noted in our study such as detecting early hemorrhagic change in acute stage of spontaneous ICH. One case showed contrast extravasation during 3D-CTA which helped us to find the hematoma enlargement. Also, it provided us a clue to decide the proper operation time. Owing to the tremendous cut-down in examination time, it is even possible in critically ill or uncooperative patients without sedation or intubation.

Conclusion

3D-CTA is considered a useful screening method in ICH patients as a non-invasive alternative study for vascular abnormality assessment. Our data suggest that it is more valuable in non-hypertensive, lobar location and in the younger patients with spontaneous ICH.

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Commentary

The usefulness of CT angiography (CTA) is increasing rapidly with improved performance of the CT machine. Its non-invasiveness, short scanning time and wider availability have made this imaging technique to replace conventional angiography for many purposes, including pre-operative study for cerebral aneurysm surgery. In relatively low performance CT machine, however, the low resolution and coexistence of arterial and venous structures limited its extent of applicability, but the recent CT machines, especially that with 256 detectors, are expected to provide an image comparable to that of the conventional digital angiography.

In such context, this paper is appropriate in timing, showing the usefulness of CTA as the first choice screening or diagnostic procedure for cerebrovascular disease. This paper is well documenting the usefulness of routine screening with CTA,

especially in patients with lobar and posterior fossa hemorrhage, and non-hypertensive young patients.

The total number of patients analyzed in this study, however, is somewhat small, and the proportion of hemorrhage in lobar area is larger than that of the usual cases. Further study with more number of cases seems to be necessary to define further

refined sensitivity and specificity of CTA for screening vascular abnormalities.

Chang Wan Oh, M.D.
Department of Neurosurgery, Seoul National University