CT angiography in patients with acute spontaneous intracranial hemorrhage:detection and characterisation of intracranial aneurysms: comparison of Volumen Rendering and Maximum Intensity Projection algorithms

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Purpose

Intracranial hemorrhage is the most common cause of neurologic defficiency. It is considered as indication for emergency diagnostic procedure.

Non-traumatic intracranial hemorrhage is classified according to its localisation as subarachnoid hemorrhage (SAH), intracerebral hematoma (ICH), intraventricular hemorrhage (IVH), and subdural hematoma (SDH).

Cause of non-traumatic hemorrhage in 80-90% cases is aneurysm rupture, in young patient vascular malformation, and in eldery patients high blood pressure or hemorrhagic transformation of a cerebral infarct can cause intracranial hemorrhage. Less frequentlly, the cause of intracranial hemorrhage can be coagullopathy, or bleeding inside the tumor proces.

The objective of brain imaging is to identify the hemorrhage according to its different stages and to find a potential underlying cause because of the risk of recurrence and the possibilities of treatment.

The accuret identification and characterization of intracranial hemorrhage are among the most critical functions of a radiologist. Thay have important and immediate implications for further diagnostic workup, clinical management, and patient outcome.

In emergency, the diagnosis of intracranial hemorrhage is often obtained by CT scan. In some cases, according to the patient age, the medical history and the location of the hemorrhage, it may be necessary to perform an angiography in order to exclude an intracranial aneurysm or vascular malformation

Selective intra-arterial subtraction angiography (DSA) is considered to be the gold standard for demonstrating aneurysms or arteriovenous malformations in patients with acute spontaneous intracracranial hemorrhage. Complications to DSA occure in approximaly 1% of the procedures. Although the risk is small, complications such as permanent disability or even death cannot be excluded, and there is the need for non-ivasive diagnostic procedure.

During the past ten years, noninvasive imaging techniques CT angiography, MR angiography has advanced and try to replace DSA in patient with non-traumatic intracranial hemorrhage.

The aim of this study is to compare maximum intensity projection (MIP) and volume rendering (VR) CT angiography in detection and characterization of intracranial aneurysms in patients with acute non-traumatic hemorrhage, using surgical finding or digital subtraction angiography (DSA) as the "gold standard", to reduce need for invasive procedures.

Methods and Materials

In the period of one and half year, 150 patients (95 female, 55 male, range age 15-77 years, mean age 52.79 years) with acute non-traumatic intracranial hemorrhage was performed CT angiography on 4 row or 64 row CT unit. Separately were evaluated MIP and VR reconstruction for presence, location and size of aneurysm. After CT angiography was performed, patients were operated under CTA finding, or DSA was performed.

Results

In 121 patients 150 aneurysms were detected. In 101 patients was detected one aneurysm (83%), in 14 two aneurysms (12%), in 4 patients three aneurysms (3%), in 1 patient four and in 1 five aneurysms (1%).

Most of aneurysms were diagnose on MCA (41%), and were medium size (60%) (Table 1.)

Table 1. Aneurysms diagnosed on surgery and DSA ("gold standard")

	# 3mm	**4-10mm**	**11-24mm**	**#25mm**	
ACA	9	33	5	0	47 31%
MCA	12	36	13	1	62 41%
PCA	0	0	1	0	1 1%
ICA	5	15	11	2	33 22%
VBA	1	6	0	0	7 5%
	27 18%	90 60%	30 20%	3 2%	150 100%

On MIP CT angiography were diagnosed 7 fals negativ and 4 fals positive aneurysms and sensitivity/ specificity/PPV/NPV/ accuracy was 95.3/87.9/97.3/80.6/93.9%.

On VR CTangiography were diagnosed 3 fals negative and 3 fals positive aneurysms, and sensitivity/ specificity/PPV/NPV/ accuracy was 98.0/90.9/98.0/90.9/96.7%.

For MIP+VR algorithm sensitivity/ specificity/PPV/NPV/ accuracy was 98.0/84.8/96.7/90.3/95.6%, respectively. (Table 2)

Table 2.

	MIP	**VR**	**MIP + VR**
Sensitivity (%)	95.3 (92 - 97)	98 (95 - 99.3)	98 (95 - 99)
Specificity (%)	87.9 (74.6 - 95.5)	90.9 (79 - 96.7)	84.8 (72.5 - 91)

Pozitive predictive value PPV(%)	97.3 % (94.4 - 99 %)	98 % (95.4 - 99.3 %)	96.7 % (94 - 98 %)
Negative predictive value NPV(%)	80.6 % (68.4 - 87.6 %)	90.9 % (79 - 96.7 %)	90.3 % (77 - 97 %)
Accuracy (%)	93.9	96.7	95.63

Intervals with 95% confidence

Area under Roc curve for MIP algorithm is 0.916, for VR is 0.945 in relation to gold standard and show high accuracy for both tests (MIP and VR) , but there is no significant different between thise two methods and gold standard (OP, DSA) p=0.18.

All aneurysms larger than 3mm were diagnosed on CT angiography on both MIP and VR reconstruction.

Using Wilcoxon Signed Rank Test, p=0.057, there was no significant different between VR vs. DSA finding in size of aneurysms, but there was significant different between VR vs. surgical finding in size of aneurysms (p=0.005). On surgery, anurysms were found significantly large then on VR CT angiography.

Disscusion

Table 3. Localization of aneurysms

	ACA (%)	MCA (%)	ICA (%)	PCA (%)	VBA (%)
Merhemic	31	41	22	1	5
Osborn	30-35	20	30-35		10
Numminen	22	39	31	3	5
Zhang	29	16	48	1	6
Hwang	36.5	28.5	28	0.5	6.5
Donmez	30	32	30		8
Merhemic	26.5	34.5	28	3	8

In our study most aneurysms were found on MCA, like in Numminen et al. study.

There was significant different between VR vs. surgical finding in size of aneurysms (p=0.005). On surgery, anurysms were found significantly large then on VR CT angiography. Despide the fact that surgical finding is gold standard, we can not rely on that when size of aneurysm is questioned. Surgent does not measure aneurysms with any instrument and their finding is approximative, rely on expirience.(Fig.1.)

All aneurysms larger than 3mm were diagnosed on CT angiography on both MIP and VR reconstruction. Three aneurysms smaller then 4mm (one on PICA, and two on ICA) were not diagnosed on VR algorithm CT angiography (Fig.2), and three aneurysms on MCA were fals positive diagnosed.

Table 4. Intracranial aneurysms: CTA findings in different studies

	Sensitivity	Specificity	PPV	NPV	Accuracy
Merhemic MIP	95.3	87.9	97.3	80.6	83.2
VR	98.0	90.92	98.0	90.9	96.7
MIP+VR	98.0	84.8	96.7	90.3	95.63
McKinney	97.4	90.0	97.4	90.0	95.63
Donmez	95.1	94.1			95.0
Yoon	92.5	93.3			92.6
Zhang	91.5	95.0	97.7	82.6	92.5
	95.7	95.0	97.8	90.5	95.5
Ramasudara	94.0	80.0	94.0	80.0	
Li	98.1	100	100	85.7	
	99.0	100	100	92.3	
Hiratsuka	87	79.0			85.0

Most of studies were performed on 64-row spiral CT unit. In our study, only 30 patient underwent CTA on 64-row unit, and all others on 4-row CT unit.In our study all patients were evaluated by two radiologist with more than 10 years of experience, and this is the reason that our results were very good.

In all studies only small aneurysms were not diagnosed on CTA, like in our study. Volume rendering (VR) reconstruction has much higher sensitivity, specificity, PPV, NPV and accuracy than MIP. (Fig.3.)

Images for this section:

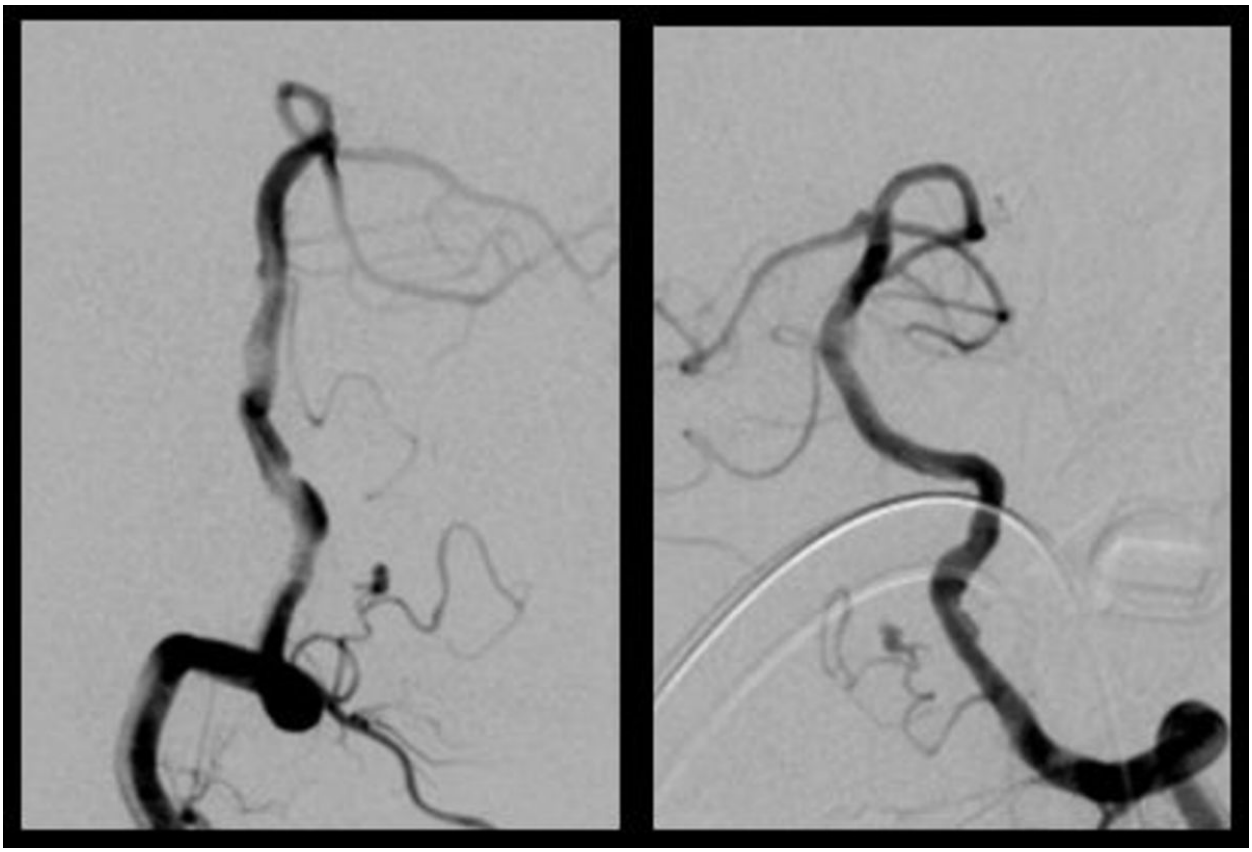

Fig. 1: DSA. PICA periferal small aneurysm, not diagnosed on CTA (MIP or VR)

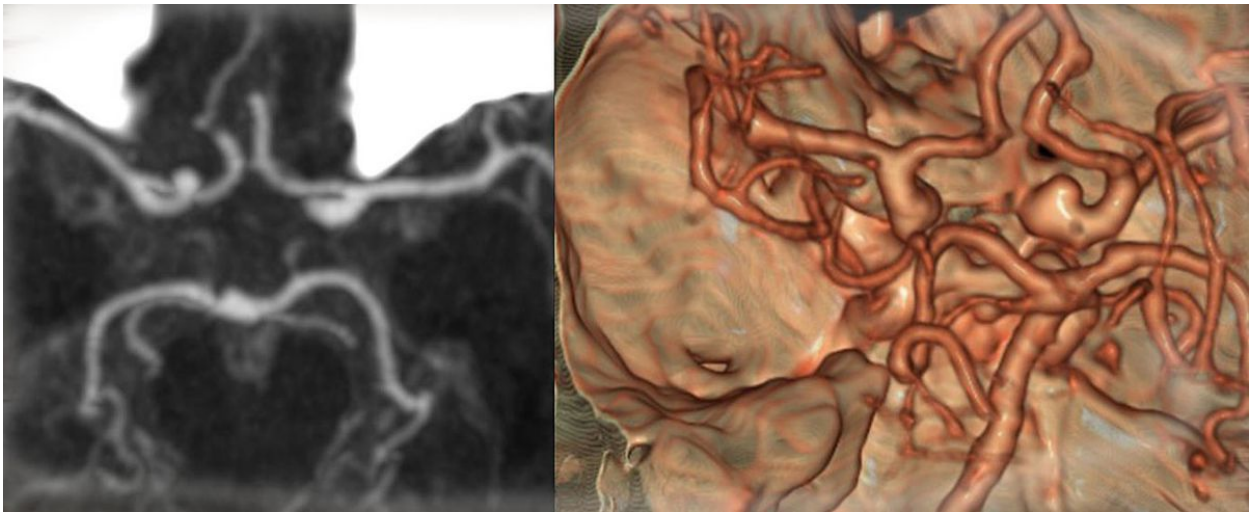

Fig. 2: ICA small aneurysm diagnosed on VR, not diagnosed on MIP reconstruction CTA.

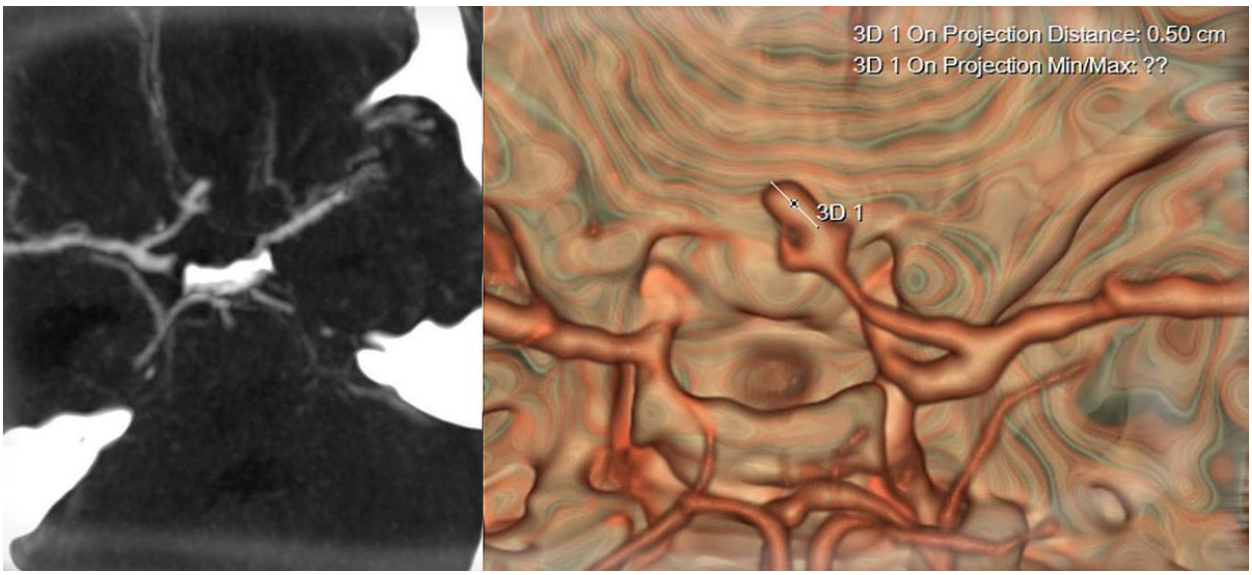

Fig. 3: CTA. ACoA aneurysm 5mm large (MIP and VR), on surgery 12mm large.

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Conclusion

All aneurysms larger than 3mm were diagnosed on MIP and VR reconstruction CTangiography. Based on our results, the evaluation of volume rendering(VR) reconstruction only should be sufficient for detection and characterization of intracranial aneurysms. There was significant difference between the size of aneurysms found during surgery and estimated based on MIP or VR reconstructions. Aneurysms were found larger on surgery than measured on CT angiography.

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