Original Research Paper

Radiology

CT angiography in patients with acute spontaneous intracranial hemorrhage: detection and characterization of intracranial aneurysms: comparison of Volume Rendering and Maximum Intensity Projection algorithms – Part Two

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KEYWORDS :

Introduction:
Computed Tomography (CT) is the best diagnostic modality for the evaluation of intracranial hemorrhage. Rupture of a cerebral aneurysm is the most common cause of 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 bleeding and small intracranial aneurysms in patients with acute non-traumatic hemorrhage, using surgical finding or digital subtraction angiography (DSA) as the "gold standard".

Materials and methods:
Patients
Study included 150 patients with acute non-traumatic intracranial hemorrhage.

All patients diagnosed with intracranial hemorrhage by non-contrast CT, underwent CT angiography of the cerebral vessels using MIP and VR reconstruction scans.

Patients with positive findings by one and/or other method were sent directly to surgery or to DSA.

74 patients with aneurysm as the cause of bleeding, underwent surgery on the basis of the CT angiography findings. Total of 96 patients were operated. 80 patients underwent DSA, and 21 had normal DSA findings.

Methods:
All patients with non-traumatic intracranial hemorrhage were determined by age and gender.

CT angiography was performed on the multilayer and multi-detector machine (Radiology department): 4-layer Volume Zoom Siemens, Erlangen, Germany, and 64-layer Light Speed GE, USA. Conventional angiography was performed at the Department of Radiology, machine Axiom Artis, Siemens, Erlangen, Germany, by the Seldinger method.

All patients were operated at the Neurosurgical Clinic, Clinical Center Sarajevo.

MIP and VR reconstruction of CT angiography of the cerebral vessels were especially interpreted for the presence, location and aneurysm size.

Statistical analysis:
The methods of statistical analysis used:

- Methods of descriptive statistics in form of data presentation through the frequencies, percentages, mean values, proportions (especially the proportions related to the sensitivity and specificity of each method), and the average rank scores (ranks related to size).

Following methods of inferential analysis are used: The McNemar test, Wilcoxon test, Cohen kappa coefficient and ROC curve.

To test the accuracy of the tests the following statistical methods were used: sensitivity, specificity, positive predictive value and negative predictive value.

Results:
Of the 150 patients with non-traumatic intracranial hemorrhage 121 (81%) were diagnosed with aneurysm, 8 (5%) with arteriovenous malformations, in 29 (14%) bleeding cause not found.

Intracranial aneurysms:
In 121 patients, 90 females (63.4%) and 52 males (36.6%), aged 19-77, mean age 53.57, 150 aneurysms were diagnosed: 101 patients had 1 aneurysm (83%), 14 patients two (12%), 4 patients three (3%), 1 patient four (1%) and 1 patient 5 aneurysm (1%).

Sex	Number of patients	Percentage (%)
Female	95	63,4
Male	55	36,6
Total	150	100

Table 1 Structure of patients by gender

The largest number of aneurysms was found on medial cerebral artery (MCA) 62 (41%), anterior cerebral artery (ACA) 47 (31%), internal carotid artery (ICA) 33 (22%), vertebral basilar artery (VBA) 7 (5%) and on posterior cerebral artery (PCA) 1 (1%).

Artery	Number of aneurysm	Percentage (%)
MCA	62	41
ACA	47	31
ICA	33	22
VBA	7	5
PCA	1	1
Total	150	100

Table 2 Number of aneurysms on arteries

The largest number of aneurysms were medium size 90 (60%), 30 (20%) large aneurysms were found, small aneurysms 27 (18%) and giant (≥ 25 mm) 3 (2%).

Aneurysm	Number	Percentage (%)
Small (≤ 3mm)	27	18
Medium (4-10mm)	90	60
Large (11-24mm)	30	20
Giant (≥25mm)	3	2
Total	150	100

Table 3 Size of aneurysm

All aneurysms larger than 3 mm were diagnosed using MIP reconstruction of CT angiography. When the size of aneurysms were ≤ 3 mm we failed to diagnose 7 aneurysms, and we had four false-positive diagnosis of aneurysm.

	≤ 3mm		4-10mm		11-24mm		≥25mm			
ACA	9		33		5		0		47	32%
CMA	12		36		13		1		62	42.5%
PCA	0		0		1		0		1	1%
ICA	2		15		11		2		30	20.5%
VBA	0		6		0		0		6	4%
	23	16%	90	62%	30	20%	3	2%	146	100%

Table 4 Number of aneurysms estimated by MIP reconstruction of CTA

All aneurysms larger than 3 mm were diagnosed VR reconstruction, while 3 aneurysms ≤ 3 mm were not diagnosed, and we had 3 false-positive diagnosis of aneurysm.

	≤ 3mm		4-10mm		11-24mm		≥25mm			
ACA	9		33		5		0		47	31%
MCA	15		36		13		1		65	43%
PCA	0		0		1		0		1	1%
ICA	3		15		9		2		31	21%
VBA	0		6		0		0		6	4%
	27	18%	90	60%	30	20%	3	2%	150	100%

Table 5 Aneurysms diagnosed with VR reconstruction of CTA

Common findings of MIP and VR reconstructions showed that hree aneurysms ≤ 3 mm were not diagnosed by CT angiography, whereas only one of these was bleeding. We had 5 false-positive diagnosed aneurysms also sized ≤ 3 mm.

- Sensitivity: 98.0% (95-99%).
- Specificity: 84.8% (72.5 - 91%).
- Positive predictive value: 96.7% (94 - 98%).
- Negative predictive value: 90.3% (77 - 97%).
- Positive likelihood ratio (+ LR) = Sensitivity / (1 - specificity): 6.468 (3.464 - 11.317).
- Negative likelihood ratio (-LR) = (1 - sensitivity) / specificity: 0.024 (0.007 - 0.065).
- Accuracy test = + Really positive + Really negative / Total = 147 +28 / 183 = 95.63%.
- Youden's J (Index accuracy test) = Sensitivity + Specificity - 1: 0.828 (0.678 to 0.906).
- Number Needed to Diagnose (NND) = 1 / (Sensitivity - (1 - specificity)) = 1 / (Youden's J) 1.207 (1.104 - 1.475).
- Diagnostic Odds Ratio (DOR) = 274.4 (53.23 - 1723.248).

In particular, we did statistical analysis comparing the size of aneurysms: CT angiography MIP and VR, DSA or surgery.

There were no significant differences in estimating size of aneurysms between MIP and VR methods (Wilcoxon Signed Rank Test, p = 0.317). We observed a significant difference between MIP and DSA method in estimating size of aneurysm (p = 0.025), as well as between MIP and the OP method (p = 0.005).

Aneurysms were estimated larger by DSA and OP method in comparison to the MIP method. The difference in the estimated size of aneurysms between VR and DSA methods was not significant (p = 0.057), while the difference in the estimated size of aneurysms between VR and OP methods was statistically significant (p = 0.005) and aneurysms are estimated larger by OP method.

Given the fact that all aneurysms larger than 3 mm were diagnosed by CT angiography, particularly statistical analysis is done for aneurysms ≤ 3 mm. Of the 27 aneurysms ≤ 3 mm in size, by MIP reconstruction 23 aneurysms were diagnosed, but we failed to diagnose 7 aneurysms, and we had four false-positive diagnosis of aneurysm.

- Sensitivity: 74.1% (59.4 - 83.3%).
- Specificity: 87.9% (75.8 - 95.4%).
- Positive predictive value: 83.3% (66.8 to 93.7%).
- Negative predictive value: 80.6% (69.5 to 87.5%).
- Positive likelihood ratio (+ LR) = Sensitivity / (1 - specificity): 6.11 (2.458 - 18.291).
- Negative likelihood ratio (-LR) = (1 - sensitivity) / specificity: 0.295 (0.007 - 0.058).
- Test accuracy = Really positive + Really negative / Total = 20 +29 / 60 = 81.6%.
- Youden's J (Index accuracy test) = Sensitivity + Specificity - 1: 0.620 (0.352 - 0.788). MIP method has an overall accuracy of 81.6%, or index of accuracy is 0.62.
- Number Needed to Diagnose (NND) = 1 / (Sensitivity - (1 - specificity)) = 1 / (Youden's J) 1.614 (1.270 - 2.840).
- Diagnostic Odds Ratio (DOR): 20.714 (4.588 to 104.67).

Of the 27 aneurysms ≤ 3 mm in size, 27 aneurysms were diagnosed by VR reconstruction, but we had 3 false negatives and 3 false-positive diagnosis of aneurysm.

- Sensitivity: 88.9% (75-96%).
- Specificity: 90.9% (79.9 to 96.7%).
- Positive predictive value: 88.9% (75.4 - 96%).
- Negative predictive value: 90.9% (80 - 97%).
- Positive likelihood ratio (+ LR) = Sensitivity / (1 - specificity): 9.778 (3.743 - 29.227).
- Negative likelihood ratio (-LR) = (1 - sensitivity) / specificity: 0.90 (0.799 - 0.967
- Test accuracy = Really positive + Really negative / Total = 24 +30 / 60 = 88.3%.
- Youden's J (Index accuracy test) = Sensitivity + Specificity - 1: 0.798 (0.552 to 0.927).
- Number Needed to Diagnose (NND) = 1 / (Sensitivity - (1 -

specificity)) = 1 / (Youden's J) 1.253 (1.079 - 1.810).
- Diagnostic Odds Ratio (DOR): 80,00 (12, 142-704, 20).
- Kappa: 0.798 (0.552 to 0.927) Of the 27 aneurysms present, MIP and VR reconstructions 29 aneurysms were diagnosed, but there were three false-negative and 5 false-positive findings.

	Positive	Negative	Total
Positive	24	5	29
Negative	3	28	31
Total	27	33	60

Table 6 Findings of MIP + VR vs. DSA and operations for aneurysms ≤ 3 mm

- Sensitivity: 88.9% (74.8 - 96.6%).
- Specificity: 84.8% (73.3 to 91.2%).
- Positive predictive value: 82.8% (69.6 - 90%).
- Negative predictive value: 90.3% (78 - 97%).
- Positive likelihood ratio (+ LR) = Sensitivity / (1 - specificity): 5.867 (2.802 to 10.965).
- Negative likelihood ratio (-LR) = (1 - sensitivity) / specificity: 0.903 (0.780 - 0.971).
- Test accuracy = Really positive + Really negative / Total = 24 +28 / 60 = 89.66%
- Youden's J (Index accuracy test) = Sensitivity + Specificity - 1: 0.737 (0.48 - 0.878).
- Number Needed to Diagnose (NND) = 1 / (Sensitivity - (1 - specificity) = 1 / (Youden's J) 1.356 (1.139 - 2.079).
- Diagnostic Odds Ratio (DOR) = 44.8 (8.15 - 297.208).

Diagnosis of ruptured aneurysms

In 121 patients ruptured aneurysms were diagnosed with the golden standard (the operative findings or DSA). The largest number of ruptured aneurysms were of medium size 81 (67%), 24% were aneurysms larger than 10 mm, while the smallest number was aneurysms ≤ 3 mm, only 9%.

	≤ 3mm	4-10mm	11-24mm	≥25mm		
ACA	6	32	5	0	43	35.5%
MCA	0	31	13	1	45	37%
CPA	0	0	1	0	1	1%
ICA	4	13	7	2	26	21.5%
VBA	1	5	0	0	6	5%
	11 9%	81 67%	26 21.5%	3 2.5%	121 100%	

Table 7 Number of ruptured aneurysms according to operation findings or DSA findings

For MIP reconstructions we had 4 false negatives and one false positive finding and that applies to aneurysms ≤ 3 mm, while all aneurysms larger than 3 mm were diagnosed with MIP reconstruction.

- Sensitivity: 96.7% (93.7 - 97.5%).
- Specificity: 74.4% (84.6 - 99.8%).
- Positive predictive value: 99.2% (96.1 - 1.00).
- Negative predictive value: 87.9% (76.9 - 90.7%).
- Positive likelihood ratio (+ LR) = Sensitivity / (1 - specificity): 29.008 (6.094 - 551.473).
- Negative likelihood ratio (-LR) = (1 - sensitivity) / specificity: 0.034 (0.025 - 0.074).
- Test accuracy = Really positive + Really negative / Total = 117 +29 / 151 = 96.68%.
- Youden's J (Index accuracy test) = Sensitivity + Specificity - 1: 0.934 (0.783 - 0.978).
- Number Needed to Diagnose (NND) = 1 / (Sensitivity - (1 - specificity)) = 1 / (Youden's J) 1.071 (1.041 - 1.341).
- Diagnostic Odds Ratio (DOR): 848.250 (81.956 to 21817.790).

In comparison to the findings of the gold standard and the findings of VR reconstruction, we had 3 false-negative and one false-positive finding. With VR reconstructions we had 3 false negatives and one false positive finding and it applies to aneurysm ≤ 3 mm, while all aneurysms larger than 3 mm were diagnosed with VR reconstruction.

Findings of VR vs DSA, OP for bleeding aneurysms

	Positive	Negative	
Positive	118	1	119
Negative	3	29	32
	121	30	151

Table 8 Findings of VR vs DSA, OP for bleeding aneurysms

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- Sensitivity: 97.5% (94.6 to 98.3%).
- Specificity: 96.7% (85 - 99.8%).
- Positive predictive value: 99.2% (95.2 - 100%).
- Negative predictive value: 90.62% (79.6 - 93.6%).
- Positive likelihood ratio (+ LR) = Sensitivity / (1 - specificity): 29,256 (6289 - 552,372).
- Negative likelihood ratio (-LR) = (1 – Sensitivity) / specificity: 0.026 (0.017 - 0.063).
- Test accuracy = Really positive + Really negative / total = 118 + 29/151 = 97.35%.
- Youden's J (Index accuracy test) = Sensitivity + Specificity - 1: 0.942 (0.796 - 0.981).
- Number Needed to Diagnose (NND) = 1 / (Sensitivity - (1 - specificity)) = 1 / (Youden's J) 1.062 (1.019 - 1.257).
- Diagnostic Odds Ratio (DOR): 1140.667 (99.26-32491.678).
- Kappa = 0.919 (0.776 to 0.957). Repeatability of methods was 0.919.

In comparison of the findings of the golden standard and the findings of MIP and VR reconstructions, we had 3 false-negative and one false-positive finding.

- Sensitivity: 97.5% (94.6 to 98.3%).
- Specificity: 96.7% (85 - 99.8%).
- Positive predictive value: 99.2% (95.2 - 100%).
- Negative predictive value: 90.62% (79.6 - 93.6%).
- Positive likelihood ratio (+ LR) = Sensitivity / (1 - specificity): 29,256 (6289 - 552,372).
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- Diagnostic Odds Ratio (DOR): 1140.667 (99.26-32491.678).
- Kappa = 0.919 (0.776 to 0.957).

Statistical comparison of the results for bleeding aneurysms using McNemar's $\chi 2$ test:

a) Statistical comparison of results MIP vs. VR using McNemar's $\chi 2$ test p = 0,1. Since p> 0.05, there are no significant differences between the findings of MIP vs. VR method.

b) Statistical comparison of the results: MIP vs. the "gold standard" using McNemar's $\chi 2$test. p = 0.125. Since p> 0.05, there were no statistically significant differences in the detection of aneurysms

between the MIP and the golden standard method.

c) The statistical comparison of the results: VR vs. golden standard using McNemar's $\chi 2$test. $p = 0.25$. Since $p > 0.05$, there were no statistically significant differences in the detection of aneurysms between the MIP and the golden standard method.

There is a significant difference in mean size between ruptured and non-ruptured aneurysms using all four methods ($p < 0.001$). The average size of bleeding (ruptured) aneurysm is 7 mm (MIP / VR / DSA / OP = 7.62 / 7.64 / 8.26 / 8.16), while the average size of non-ruptured aneurysms is 3mm (MIP / VR / DSA / OP = 3.02 / 3.13 / 3.13 / 3.62). It should be noted that there was 121 bleeding (ruptured), but only 29 non-ruptured aneurysms.

The area under the ROC curve for non-ruptured aneurysms is a good for MIP method (0.86), but significantly lower than the VR method (0.94), which is very good. MIP method diagnosed 26 of 29 aneurysms, 89.6%, (sensitivity), and specificity of 84%, PPV 80% and NPV of 87.5%. VR method diagnosed 29 of the 29 aneurysms that have not ruptured, the NPV is 100%, whereas PPV is lower, in those in which the aneurysm was diagnosed, 90.6% actually had an aneurysm.

Discussion:

According to the gold standard (operative findings or DSA), most aneurysms in our study are that of medium size (4-10 mm), 90 (60%), corresponding to study from Donmez et al. where out of 164 aneurysms, medium were found in 53% (132), in a study by Merhemic et al. 56 were found, 4% of 100 aneurysms, and Ramasundara et al. found 68% out of 36 aneurysms.

Small aneurysms (≤ 3 mm) were diagnosed in 27 cases (18%), while their percentage significantly varies at different authors (Donmez et al.[1] 24% , Ramasundara et al.[3] 24%, Li et al. 31%, Yoon et al29%, Zhang et al. 13%, Hiratsuka et al. 8.5%).

The largest number of ruptured aneurysms is aneurysm of medium size 67% (11/121). Aneurysms bigger than 10 mm participated with 24% (29/121), and only 9% (11/121) were small aneurysms (≤ 3 mm). Out of the total 27 diagnosed small aneurysms, 11 (43%) had ruptured being less than half of diagnosed small aneurysms. According to the study by Hiratsuka et al.[7] 4 of 47 aneurysms were smaller than 3 mm.

In study of Li et al of the 145 aneurysms, 43 (29.6%) were <3mm.
Medium size of ruptured aneurysms was 8.16 to 8.27 mm found by golden standard (DSA and operation findings), while the size of non-ruptured intracranial aneurysms according to the golden standard is between 3.13 to 3.62 mm. There was a significant difference in medium size between ruptured and non-ruptured intracranial aneurysms using all four methods ($p < 0.001$).
According to Yue W. size of non-ruptured intracranial aneurysms in his study was 12.5 ± 8.0 mm showing that our results are not in correlation with those of the Yue W.

According to Numminen et al. the average size of non-ruptured aneurysms was 4.5 mm, where 47 aneurysms were diagnosed at 60 patients using CT angiography, which correlates with our findings showing that the medium size of non-ruptured aneurysms is small.

At MIP reconstruction, four aneurysms where diagnosed as false positive results, and all four were on the bifurcation of the middle cerebral artery, 2 mm in size, which turned out to be a cranked fold of branches of middle cerebral artery.

With VR reconstructions we did not diagnose 3 aneurysms ≤ 3 mm and two on ICA size of 1 mm and 2 mm, and on the periphery of posterior inferior cerebellar artery, size 3 mm. We had 3 false-positive diagnosis of aneurysm, all three at the bifurcation of the MCA and the size was 1 and 2 mm.

Of the total of 27 diagnosed small aneurysms (≤ 3 mm), only 11 ruptured, which is less than 50%. Four aneurysms were not diagnosed using MIP reconstruction, while only one aneurysm was falsely diagnosed with MIP reconstruction.

Better results are obtained by findings of VR reconstruction than of MIP reconstruction, but the difference was not statistically significant. In common findings of MIP and VR, three aneurysms were not diagnosed, two on intern carotid artery size 1 and 2 mm, and a large 3 mm aneurysm in the posterior inferior cerebellar artery, while we had five false-positive findings, which significantly reduced specificity for 5%, and only 1% of accuracy.

Common findings of MIP and VR reconstructions have 97.5% of sensitivity, 96.7% of specificity, PPV of 99.2%, NPP of 90.6%, accuracy of 97.35%. Positive and negative likelihood ratio is 29.256 and 0.026. In order to diagnose one patient with an aneurysm by VR method 1.06 patients should be examined. Overall discriminatory power of this test, the ability to separate the positive and the negative findings, is 1140, which is slightly better than the MIP findings, but significantly lower than the VR findings. The precision of this test was kappa = 0.919.

There was no statistically significant difference (McNemar's test) in the detection of ruptured aneurysms between MIP and VR findings of CT angiography, nor between the findings of the MIP and the golden standard (DSA, OP), nor between the VR and the golden standard ($p > 0.05$).

Sensitivity to all aneurysms was 95.3% for the MIP, VR and MIP + VR 98%, for aneurysms ≤ 3 mm MIP falls to 74.1%, MIP + VR 88.9%, for ruptured aneurysms MIP 96.5%, VR and for MIP + VR 97.5%, indicating that the majority of aneurysms is diagnosed by VR method, although the sensitivity decreases by 10% in the case of aneurysms ≤ 3 mm.

Aulbach et al for aneurysms smaller then 3mm, had sensitivity of 94%, specificity 98%, and PPV and NPV 94 and 98%.

Menke et al in a large meta-analysis summarized the findings from 45 studies (3.643 patients) comparing the CT angiography with DSA findings in the diagnosis of cerebral aneurysms by 1,4,16, and 64-layer CT machine during the period from 1995 to 2010 year. By the year 2002, only MIP reconstruction was evaluated in the studies, and only after 2002, the VR has become commonplace for the evaluation of aneurysms. Sensitivity was 95.0% and specificity 96%.

In our study, out of 150 diagnosed aneurysms, 27 aneurysms were ≤ 3 mm. Given the fact that all aneurysms larger than 3 mm were diagnosed by CT angiography, sensitivity, specificity, PPV, NPP, and accuracy is 100% for aneurysms larger than 3 mm. For aneurysm ≤ 3 mm MIP reconstruction failed to diagnose 7 aneurysms. There were 4 false-positive, and all four were diagnosed at the MCA and were sized between 1 and 2 mm. Sensitivity, specificity, PPV, NPV, and accuracy was 79.4%, 87.8%, 87%, 80.5% and 83%.

By VR reconstructions, we diagnosed 3 aneurysms ≤ 3 mm. We had 3 false-positive diagnosis of aneurysm. Sensitivity, specificity, PPV, NPV, and accuracy were 90%, 90.6%, 90%, 90.6% and 90.3%. In common findings of MIP and VR reconstructions sensitivity, specificity, PPV, NPV and accuracy was 90%, 85.3%, 84.4%, 90.6% and 87.5%, which is weaker result than those from VR reconstruction.

Authors	Sensitivity (%)	Specificity (%)	PPD (%)	NPD (%)	Test accuracy (%)
Merhemic Z MIP	*79.4*	*87.9*	*87.1*	*80.5*	*83.6*
VR	*90*	*90.6*	*90*	*90.6*	*90.3*
MIP+VR	*90*	*85.3*	*84.4*	*90.6*	*87.5*
McKinney et al	92.3	100	100	99.9	95.2
Donmez et al [1]	86.1	94.1		88.7	

Table 9 Results of studies by different authors for the presence of aneurysms ≤ 3 by CTA

We had high 90% sensitivity for small aneurysms, and it is from evaluation of VR reconstruction, because MIP reconstruction gives only 79% of sensitivity. Results of the MIP reconstruction findings reduce the sensitivity, specificity, PPV, and NPV as well as accuracy at common findings of MIP + VR compared to results of VR reconstruction.

In most papers results are somewhat weaker than ours, while Li et al [4] show the sensitivity of 93.7% and 96.8%, but it must be noted that all examinations were made on a 64-layer CT machine. McKinney et al [13] did not diagnose only one small aneurysm in the ophthalmic area of the internal carotid artery.

According to Zhang et al.[14] view on the dual-energy CT machine does not provide significantly better results compared to standard CT angiography. Aneurysm size 1.7 mm was not diagnosed on three-furcation of cerebral artery, and a small ophthalmic aneurysm and by conventional CTA two more aneurysm in infraclinoid area of the intern carotid artery.

The paper by Zhang et al.[14] found a remarkable correspondence between the findings of dual CTA and 3D DSA in detection of small aneurysms, so that for aneurysms ≤ 3 mm sensitivity, specificity, PPV and NPV are 80%, 100%, 100% and 99.9%. Only one aneurysm, out of 5 small aneurysms found with 3D DSA, was not diagnosed with DE CTA.

Li et al [4] in the analysis by the 64-layer machine, out of 32 aneurysms ≤ 3 mm, two radiologists in the evaluation failed to diagnose a small aneurysm at the ICA, and one radiologist did not diagnose an aneurysm on the anterior communicate artery also less than 3 mm. That showed sensitivity, specificity, PPV and NPV for the first radiologist of 93.7%, 100%, 100%, 85.7%, and for the second radiologist 96.8%, 100%, 100% and 92.3%. Li et al. believes that improved diagnostic accuracy is mostly produced by scanning speed of 64-layer CT machine, so the blood vessels are optimally visible by contrast with excellent spatial resolution. They believe that the findings of CT angiography are sufficient to determine further treatment.

Donmez et al [1] in the study using 16-layer CT machine in which 164 aneurysms diagnosed by DSA examination, 156 were diagnosed on CTA. From 8 aneurysms that are not diagnosed by CTA, 6 was on the back communicating artery, 1 on supraclinoidal part of ICA, and 1 on trifurcation of medial artery. Five aneurysm were <3 mm, and 3 were the sizes of 3-5 mm.

High sensitivity of small aneurysms is due to the progress of the CT techniques, and also the great experience of radiologists who evaluated the review. In our study, we only had 3 false-negative and one false-positive results and these were all aneurysms smaller then ≤ 3 mm. Two were on the internal carotid artery, and one on the periphery of posterior inferior cerebellar artery (PICA). It often happens that the aneurysm is not observed when it is located in an unusual place. False-positive findings can occur when arteries make the loop, as it was the case with the middle cerebral artery in our study.

According to current literature, the golden standard for the diagnosis of intracranial aneurysms is not anymore standard DSA, but 3D DSA, which allows evaluation of each vessel in several directions, and the diagnosis, is much safer. One aneurysm on the internal carotid artery size 1 mm was diagnosed with 3D DSA, while this was a false negative finding on CTA.

In new days, we are more focused how from CT angiography, and could morphology and growth predict evaluation and rupture of an aneurysm. In study that was performed by Mehan et al 152 patients with total of 180 UIA hat at least two CTA studies. Six aneurysms in six different patients ruptured during the CTA follow-up period for an overall rupture rate of 3.3% and an annual rupture rate of 0.97%. All ruptured aneurysms were bigger than 9 mm. In this analysis, the statistically significant predictors of aneurysm rupture were aneurysm size and growth.

Conclusion:

CTA examination is essential for diagnosing the cause of intracranial bleeding. In comparison CTA vs. DSA, there was significant difference in findings MIP vs. DSA, but there was no significant difference in findings VR vs. DSA. It is enough to evaluate only volume rendering (VR) reconstruction for detection and characterization of intracranial bleeding aneurysms and for aneurysms ≤ 3 mm. There is a significant difference in mean size between ruptured and non-ruptured aneurysms using all four methods. Ruptured aneurysms are much larger than non-ruptured, and in surgery, size of aneurysms was significantly larger then on CTA. The average size of bleeding (ruptured) aneurysm is 7 mm, while the average size of non-ruptured aneurysms is 3mm.

Refrenses:

1. Donmez H, Serifov E, Kahriman G, et al. A. Comparison of 16-row multislice CT angiography with conventional angiography for detection and evaluation of intracranial aneurysms. Eur J Radiol. 2011; 80(2):455-61.
2. Merhemić Z, Pandža H, Thurnher MM. Magnetic resonance angiography in diagnosis of intracranial aneurysms. AIM. 2009; 17(2): 94-99.
3. Ramasundara S, Mitchell PJ, Dowling RJ. Bone subtraction CT angiography for the detection of intracranial aneurysms.J Med Imaging Radiat Oncol. 2010;54(6):526-33.
4. Li Q, Lv F, Li Y, Luo T, Li K, Xie P. Evaluation of 64-section CT angiography for detection and treatment planning of intracranial aneurysms by using DSA and surgical findings. Radiology. 2009; 252(3):808-815.
5. Yoon DY, Chang CS, Choi S, Kim WK, Lee JH. Multidetector row CT angiography in spontaneous lobar intracerebral hemorrhage: A prospective comparison with conventional angiograph. AJNR 2009; 30:962-967.
6. Zhang LJ, Wu SY,Poon CS, Zhao YE, Chai X, Zhou CS, Lu GM. Automatic bone removal Dual –energy CT angiography for the evaluation of intracranial aneurysms. J Comput Assist Tomogr 2010; 34:816-24.
7. Hiratsuka Y, Miki H, Kiriyama I, Kikuchi K, Takahashi S, Matsubara I, Sadamoto K, Mochizuki T. Diagnosis of unruptured intracranial aneurysms: 3T MR angiography versus 64-channel multi-detector row CT angiography. Magn Reson Med Sci. 2008;7(4):169-78.
8. Qi Li, Fajin Lv, Xie Peng at al. 64-section multidetector CT angiography for evaluation of intracranial aneurysms: comparison with 3D rotational angiography. Acta Radiol. 2014; Vol 55(7): 840-846.
9. Yue W. Endovascular treatment of unruptured intracranial aneurysms. Interv Neuroradiol. 2011;17(4):420-4.
10. Numminen J, Tarkiainen A, Niemela M, Porras M, Hernesniemi J, Kangasniemi M. Detection of unruptured cerebral artery aneurysms MRA at 3.0 tesla: comparison with multislice helical computed tomographic angiography.Acta Radiol. 2011; 52(6):670-4.
11. Aulbach P1, Mucha D2, Engellandt K1, Hädrich K1, Kuhn M3, von Kummer R4. Diagnostic Impact of Bone-Subtraction CT Angiography for Patients with Acute Subarachnoid Hemorrhage. AJNR Am J Neuroradiol. 2016 Feb;37(2):236-43.
12. Menke J, Larsen J, Kallenberg K. Diagnosing cerebral aneurysms by computed tomographic angiography: meta-analysis. Ann Neurol. 2011; 69(4): 646-654.