Coll. Antropol. **30** (2006) 4: 867–870
Original scientific paper

Evaluation of Circle of Willis Aneurysms with Spiral Computed Tomographic Angiography

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A B S T R A C T

The aim of this retrospective study is to evaluate the specificity and sensitivity of spiral computed tomographic angiograohy (SCTA) in the detection of intracranial aneurysms. Patients were included in this study on the ground of the SCTA, digital subtraction angiography, magnetic resonance angiography, neurosurgeons operative findings and autopsy reports. Scanning protocol was slice thickness of 1mm, reconstruction interval of 0.5 mm, pitch 1. Flow rate was 3–4 ml/s, with standard scan delay time of 15–20s. In 18 patients with average age of 49.3 years SCTA results were positive for cerebral aneurysms and confirmed with other methods. On a per aneurysm basis SCTA sensitivity for detection of aneurysms was 89.47% specificity was 86.96%, positive predictive value of 85.00% and negative predictive value of 90.91%. SCTA should be used for the detection of cerebral aneurysms, especially for aneurysms with maximum diameter larger than 5mm.

Key words: *computed tomography, angiography, aneurysms*

Introduction

Spontaneous subarachnoid haemorrhage (SAH) is a neurological emergency mainly connected with ruptured intracranial aneurysm at the basis of the brain (approximately 85% of cases) with a high mortality rate, results in death in approximately 51% of patients[1,2]. The incidence is around six cases per 100 000 patients years[3]. If the patients are untreated within two weeks after initial haemorhage, rebleeding occurs in approximately 20% with mortality rate of 40%. Most of the intracranial aneurysms are located on the arterial Circle of Willis. Incidence of intracranial aneurysms in the general population varries from 1 to 7%, according to few autopsy series[1]. Conventional catheter angiography, usually performed as a selective intra-arterial digital subtraction angiography (DSA) is still the golden standard for detection of intracranial aneurysm before surgery. Complication rate of cerebral DSA in patients with SAH is 1.8% and mortality rate 0.07%[4].

Spiral (helical) computed tomographic angiography (SCTA) is non-invasive vascular imaging method based on continuous scanning during the intravascular application of contrast agent. SCTA can be also defined as a minimally invasive imaging method because the patient receives the contrast material through the cannula placed in the peripheral vein. SCTA compared with catheter angiography has advantages in direct visualisation of intraluminal, vascular wall and perivascular changes without need for intraarterial catheterisation[5,6]. Volumetric data acquisition is a basis for two and threedimensional reformations of cerebral vasculature. SCTA sensitivity for detection of intracranial aneurysms depends on aneurysm size, location and used scanning protocol. Reported results are better for aneurysms situated in the anterior part of the Circle of Willis[7–13]. Important role in precise depiction of intracranial aneurysms have twodimensional and threedimensional computer-generated reconstructions (reformattions)[5,6].

The aim of this retrospective study is to evaluate the specificity and sensitivity of SCTA in the detection of Circle of Willis aneurysms.

Received for publication November 8, 2006

Materials and Methods

The records of patients who underwent SCTA of Circle of Willis from May 2001 till May 2006 were analysed. Patients were included in this study on the ground of the SCTA results, DSA findings, MRA findings, neurosurgeons operative findings and autopsy reports. All patients were examined on single-slice spiral CT scanner with tube rotation time 0.8s (High Speed Lxi, GE Medical Systems, Milwaukee, Wisconsin, USA). Standard unenhanced axial head CT scan was performed first with slice thicknes of 3mm in the posterior fossa and 7mm above, parallel to orbitomeatal line. SCTA volume of coverage was from the uper conture of C1 arch till the top of the posterior sphenoid clinoids, to cover the region where the intracranial aneurysms are most often situated and to provide valuable anatomy landmarks for neurosurgeons. Scanning protocol parameters were slice thickness of 1mm, image reconstruction interval of 0.5mm, pitch 1 (for faster acquisition and larger volume coverage optional pitch is 1.5), 120kV, 140 to 160mAs. All patients were in supine position during the examination and scan direction was caudocranial. For all patients, non-ionic iodine contrast agents were used, in dose of 100ml and concentration from 300 to 370 mg I / ml, injected by power injector throw a needle in peripheral vein (usually cubital vein, and in few patients in central venous catheter). Intravenous line calibar was from 18 to 20 Gauges. Flow rate was 3–4 ml/s, depending on patient cardiac status, with standard scan delay time of 15–20s. Various reformatting techniques has been used for analysis of postcontrast scanns, multiplanar reformatting (MPR), maximum intensity projection (MIP), shaded surface display (SSD) and volume rendering (VR). The best reformatting modalities for depiction of intracranial aneurysms were SSD (Figure 1) and VR (Figure 2). Three-dimensional (3D) angiograms were created on accompanying workstation (Advantage Windows 4.0).

For statistical analysis only SCTA results confirmed by other methods (operative finding, DSA or autopsy report) were used. True positives were patients with positive SCTA results confirmed with DSA findings, surgically proven or described in autopsy report. False negatives were negative SCTA cases with intracranial aneurysm diagnosed with other method or found at surgery or autopsy. False positives were defined as positive SCTA results for intracranial aneurysm without confirmation in DSA, surgery or autopsy report. True negatives were patients with negative SCTA results supported by negative DSA or MRA results, or negative surgery or autopsy report. The aneurysm was used as the unit of analysis in calculation of sensitivity, specificity, positive and negative predictive value. Clinical informations were available in all cases before CT scanning procedure.

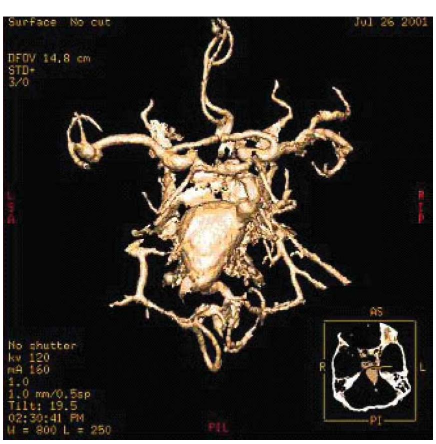

Fig. 1. Shaded Surface Display image. Basilar artery fusiform aneurysm.

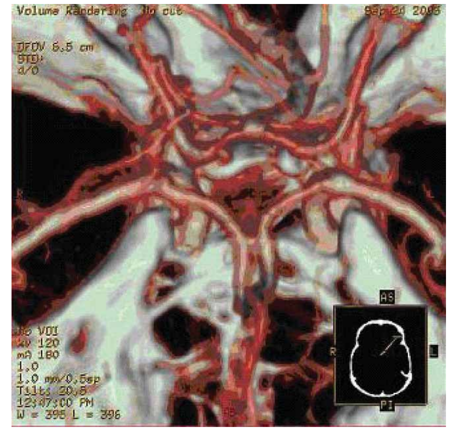

Fig. 2. Volume Rendering image of saccular aneurysm arised on anterior communicating artery.

Results

38 patients evaluated in the period from May 2001 to May 2006 were included in the statistical analysis. In 18 patients, 10 female and 8 male SCTA has depicted aneueysms and results were confirmed with DSA, during surgery or autopsy. Average age of patients was 49,3 years, in male patients 52.4 years (from 45 to 78 years) and in female patients 48.7 years (from 15 to 78 years). SAH was found in 17 patients with aneurysm. The maximum diameter of the diagnosed aneurysms has ranged from 3.5mm, measured on aneurysm of the ACoA, to 34mm measured on basilar artery aneurysm in 15 year old female patient. 13 patients were treated surgically with clipping, one patient with basilar tip aneurysm was treated with endovascular radiological intervention, with coilling. 2 patients died before tretment after further diagnostic evaluation, one with DSA and one with MRA. 2 patients died before further diagnostic evaluation. Standard scan delay time ranged from 15 to 20s. In twenty patients SCTA did not depict aneurysms on Circle of Willis and SCTA results were confirmed with MRA. Aneurysms were most often positioned on the ACoA in the anterior part of Circle of Willis, and in the posterior part they have mainly arised on basilar artery, Table 1.

TABLE 1
NUMBER OF ANEURYSMS RELATED TO LOCALIZATION

Aneurysm localization	Total number	Male patients	Female patients
ACoA	6	2	4
ACA	1	/	1
MCA	4	1	3
ACI	1	1	/
PCoA	1	1	/
PCA	/	/	/
BA	5	4	1
Art. pericalosa	1	1	/
	19	10	9

ACoA – anterior communicating artery, ACA – anterior cerebral artery, MCA – middle cerebral artery, ICA – internal carotid artery, PCoA – posterior communicating artery, PCA – posterior cerebral artery, BA – basilar artery

In one case coexistent MCA aneurysm with maximum diameter 2,5mm was overlooked in a patient with ruptured ACoA aneurysm with maximum diameter 9mm. Ruptured ACoA aneurysm was diagnosed with SCTA and confirmed during surgery. SCTA was performed in emergency conditions caused by massive SAH. Overlooked aneurysm was found during the retrospective analysis of volume rendering 3 D angiograms after surgery, it was positioned on superior side of left MCA, cranialy oriented. It was false-positive negative SCTA result on a per aneurysm basis but true positive SCTA finding on a per patient basis because symptomatic ruptured aneurysm was diagnosed and correctly described.

There were two cases of false-positive SCTA results on a per aneurysm basis and one false- positive SCTA result on a per patient basis. In one case, which was false-positive on a per aneurysm and a per patient basis, pericalosal artery bending was wrongly described as an aneurysm. DSA indicated by neurosurgeons denied SCTA results. In one patient aneurysm of ICA infraclinoid segment was diagnosed and correctly described but tortuous basilar artery was wrongly reported as a fusiform aneurysm. ICA aneurysm was surgicaly treated because of SAH. DSA performed after recovery denied false-positive SCTA findings of basilar artery aneurysm. It was a true positive case on a per patient basis but combination of true positive and false positive cases in the same patient on a per aneurysm basis. In one case a pericalosal artery aneurysm was wrongly atributed to anterior cerebral artery, correct diagnosis was established with DSA indicated by neurosurgeons. SCTA sensitivity for detection of aneurysms on a per aneurysm basis in our study was 89.47% specificity was 86.96%, positive predictive value of 85.00% and negative predictive value of 90.91%. On a per patient basis SCTA has achieved sensitivity of 100%, specificity 95.23%, positive predictive value 94.44% and negative predictive value 100%.

Discussion

CTA provides opportunity to evaluate the etiology of SAH immediatelly after the clinical suspicion of SAH is confirmed with non-contrast brain CT scan. Short scanning time, even on single-slice spiral CT scanner, makes CTA apropriate diagnostic method for emergency patients who can not undergo long-lasting diagnostic procedures (e.g. MR) but DSA is still the golden standard for the diagnosis of cerebral aneurysms in most of the studies[13].

The role of SCTA in the diagnostic evaluation of patients with cerebral aneurysms of Circle of Willis has been describe in many studies with diferent modalities. In Alberico's prospective study published in1995. SCTA has achieved sensitivity 96% and specificity 100%, aneurysm maximum diameter medium value was 7.9mm[14]. In Ogawa's study with scan delay 45s and flow of contrast agent 1.0ml/s, sensitivity was 84%[10]. In the study published in 1998. by Velthuis et al. CTA angiography showed 95% of symptomatic aneurysms and 90% of all aneurysms[8]. Korogi et al. reported in their study published in 1999. different sensitivity of three-dimensional CTA for detection of intracranial aneurysms according to size and location of aneurysm, for aneurysms with size less than 4mm was 64–83%, but for aneurysms with size 5–12mm sensitivity was 95%[9]. In the article of Villablanca et al. published in 2002. sensitivity of CTA for very small intracranial aneurysms detection with size less than 5mm was from 98% to 100%, and specificity 100%. Sensitivity and specificity of DSA were 95% and 100%. In 10% of the cases an aneurysm was diagnosed only on the 3D reformatted images and subsequently confirmated and quantitated on 2D images[11]. Introduction of multi-slice CT scanners (MSCT) has given the new oportunities for further development of CT vascular imaging modalities because MSCT scanners are faster than single-slice CT and can scan longer distance with thinner sections. The sensitivity of MS CTA in Teksam's study from 2004. for detection of aneurysms smaller than 4mm on a per-aneurysm basis was 84%. The sensitivity and specificity of MS CTA for detection of cerebral aneurysms on a per-patient basis were 99% and 98%. Authors stated that CTA, even performed in multi-slice CT technique, is still not sensitive enough to replace DSA as a the criterion standard method in detection of cerebral aneurysms[13].

Magnetic resonance angiography (MRA) is the non--invasive vascular imaging method based on MR imaging which is not conected with ionizing radiation exposure, and some techniques for depiction of intracranial vasculature like time-of-flight (TOF) does not require intravasculature aplication of contrast material. MR scanning usually requires longer acquisition time than CT scanning. The sensitivity of threedimensional (3D) TOF MRA for detection of aneurysms in patients with SAH was 54 to 79% and slightly better for patients without SAH 65 to 79% in Okahara's study from 2002.[15]. Metens et al reported in 2000. 3D contrast-enhanced T1-weighted MRA sensitivity 100% and specificity 94%. Very important characteristic which makes 3D contrast-enhanced T1 weighted sequence apropriate for use in uncooperative patients and emergency situations is short acquisition time[16].

The SCTA study presented in this article has been performed in a general hospital without interventional radiology division and without a neurosurgical ward. We have obtained the informations about further diagnostic procedure and therapeutic measures for only 18 of 34 patients in which SCTA has depicted aneurysms on Circle of Willis, this was the main limitation of this retrospective study. Other limitation is the fact that patients have been evaluated in different neurosurgical institutions, the protocol of MRA and DSA was not the same in all cases. Critically ill patients imaging material and clinical data were transfered to neurosurgeons in university hospitals via telemedicine programe. In all cases SCTA was performed under a general radiologist supervision. Some groups of neuroradiologists, like White et al, insists that non invasive vascular imaging methods should be performed by specialist neuroradiologist[17]. The results of The International Cooperative Study on the Timing of Aneurysm Surgery published in 1990 can be strong arguments for those who wish to carrie out non-invasive imaging of intracranial vasculature in general hospitals.[2] Authors agree with opinion exposed by White et al that non-invasive neurovascular imaging can be best performed and interpreted in specialist neuroradiology department but it is doubtfull is it always posible to organize patients urgent transfer in emergency conditions.

SCTA limitations are exposure to ionizing radiation, need for intravasculature aplication of iodine contrast material, operator-dependent two and threedimensional reconstructions and limited vascular teritory which can be evaluated.

In conclusion, authors think that spiral CT angiography should be used for the detection of cerebral aneurysms, especially for aneurysms with maximum diameter larger than 5 mm in critically ill patients.

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SPIRALNA CT ANGIOGRAFIJA WILLISOVOG KRUGA

SAŽETAK

Cilj ovog rada bio je ispitati osjetljivost i specifičnost spiralne kompjutorizirane tomografske angiografije (SCTA) u detekciji intrakranijskih aneurizmi. Bolesnici su uključeni u istraživanje na temelju nalaza SCTA, digitalne subtrakcijske angiografije, magnetske rezonancijska angiografije, operativnih nalaza neurokirurga i nalaza obdukcije. Protokol snimanja sadržavao je debljinu sloja 1mm, rekonstrukcijski interval slike 0.5mm, pitch 1. Brzina protoka kontrastnog sredstva bila je 3–4 ml/s s uobičajenim vremenom odgode snimanja od 15 do 20 s. U 18 bolesnika prosječne dobi 49.3 godine SCTA-om su dijagnosticirane aneurizme potvrđene drugim metodama. Gledano po aneurizmama osjetljivost SCTA za detekciju aneurizmi bila je 89.57%, specifičnost 86.96%, pozitivna prediktivna vrijednost 85% i negativna prediktivna vrijednost 90.91%. SCTA treba koristiti za dijagnosticiranje aneurizmi, posebice aneurizmi s najvećim promjerom većim od 5mm.