RADIOLOGICAL DIAGNOSIS AND THERAPY OF THE EXTRACRANIAL CAROTID ARTERY STENOSIS (SUMMARY)

1. Introduction

1.3 million people die in Europe each year because of stroke. Until the early nineties, the non-medical method of stroke prevention was the endarterectomy based on the diagnosis provided by catheter-based angiography. It is an old diagnostic thrive to substitute invasive diagnostic methods by less invasive ones. Nowadays, numerous vessel diseases can also be cured by interventional radiological procedures. We sought to assess the value of the minimal invasive, conventional CT-angiography to determine patient eligibility for carotid endarterectomy. We were also keen on proving that carotid artery stenting is effective in the treatment of primary atherosclerotic lesions, and it carries a low risk of complications.

2. Purpose

2.1. To determine, how accurate is the single slice spiral CT-angiography in grading of carotid stenosis.

2.2. To determine how reliable is CT-angiography in the plaque evaluation?

2.3. To determine, if single slice spiral CT-angiography is able to detect every abnormality that could alter the decision-making before carotid endarterectomy.

2.6. To determine if the endovascular therapy (stent placement) could be carried out with similar or lower perioperative complication rate as carotid endarterectomy.

2.7. To determine the impact of our own periprocedural distal embolisation rate by means of MR FLAIR imaging.

2.8. To determine the long-term efficacy of endovascular therapy in stroke prevention and brain perfusion.

3. Physics of CT-angiography

CT-angiography can be carried out on spiral-CT scanners, which are capable of depicting a complete anatomic region without any gap. Volume scanning was enabled by the simultaneous application of the slip-ring technology that replaced the power supply cables of the X-ray tube, and the continuous patient transportation. The X-ray tube and the detectors can be rotated in the same direction numerous times and a whole body volume can be depicted. Large

volume of intravenous contrast material, administered with relatively high flow, after passing the pulmonary circulation, moves in bolus n the arteries. Timing the thin-slice scanning accurately to the arrival of the bolus, pictures of high quality can be obtained, which can be postprocessed by the computer, creating angiogramm-like pictures. Such postprocessing types are: multiplanar reconstruction (MPR), surface shaded display (SSD), volume rendering technique (VRT) and the maximum intensity projection (MIP).

4. About self-expanding stents

The stent-protected endovascular therapy of carotid artery stenosis gained more popularity in the late nineties, when the development of catheters and other equipment enabled the procedure to be carried out with far less complications. The self-expanding stents are much more suitable in treating carotid stenosis than the balloon mounted stents used before. Loss of stents is not any more a fear. Self-expanding stents have a lower profile (5F, app. 1.66 mm), a smoother outer surface, are much more flexible, and resist external compression better than balloon mounted stents. Further technical development is expected to improve these qualities.

5. CT- angiography in the evaluation of carotid bifurcation stenosis

Materials and Methods

62 consecutive patients (19 women, 43 men) who were 42-87 years old (mean 65 years) were studied with CT angiography and DSA. CT angiography was performed on a Siemens Somatom Plus 4 Scanner (Siemens, Erlangen, Germany), or a GE CTi scanner (General Electric, Milwaukee, USA). The following scanning parameters were used: beam collimation 3 mm (210 mA, 120 kV), pitch 1.5, and reconstruction thickness 1 mm. A total of 120 ml of nonionic contrast material (Omnipaque, 300 mg I/ml, Nycomed) was injected. Axial images and the MIP and SSD images created at increments of 30 degrees were evaluated. Stenosis measurements were done on the axial CT, the CT angiography MIP, and the DSA images. The degree of stenosis was measured according to the NASCET method. The results of the two scanners were compared with One Way Analysis of Variance (ANOVA) on ranks test. Linear regression was used to determine correlation between the stenosis measurements on DSA & MIP images, and on DSA & axial CT images. Sensitivity, specificity, accuracy, positive and negative predictive values, and likelihood ratios were calculated to compare each test to DSA. Calcification and the detectability of the soft components of the plaques were noted. Digital subtraction angiogramms and CT angiogramms were also

evaluated for ulcerations. Abnormalities detected on DSA images that fell outside the range of CT-angiography were collected.

Results

Two cases had to be excluded because of severe motion artefact. In the remaining 120 arteries studied, no significant difference was found between the results of DSA, MIP or axial images in the two centres with ANOVA on ranks test. Linear regression showed high degree of correlation between DSA and axial images (R=0.937), the DSA and MIP images (R=0.946), and the MIP and axial CT images (R=0.955) in determination of stenosis at the carotid bifurcation. The specificity of CT angiography MIP images in detecting disease that would require surgery was 93.9%, the sensitivity 100%, negative predictive value 100%, positive predictive value 88.3%, accuracy 95.8%. The specificity of CT angiography axial CT images in detecting disease that would require surgery was 93.9%, the sensitivity 94.7%, negative predictive value 97.4%, positive predictive value 87.8%, accuracy 94.1%. CT-angiography had a tendency to overestimate stenoses as compared to DSA. Overestimation on both the MIP and the axial CT images was the result of atheromatous, calcified plaques oriented oblique to the standard antero-posterior, 45 degree oblique, and lateral imaging planes of DSA. Because of geometric reasons, I found MIP images to be closest to reality. MIP images largely underestimated the stenosis in one case. Calcification and the detectability of the soft components of the plaques were excellent. Following pathology fell outside the examination range of CT-angiography: One 95% stenosis at the origin of the left common carotid artery, two intracranial occlusions.

6. **Endovascular therapy of the carotid artery bifurcation stenosis**

Patients and methods

149 patients (86 men, 63 women, 33 - 82 years old, mean age 57,5) were evaluated angiographically. 146 primary atherosclerotic lesions, and 8 post-endarterectomy restenoses were considered for CAS. All patients had significant, over 60 % stenosis according to NASCET criteria. Exclusion criteria were the following: Intracranial tumor, disabling stroke, stroke within 6 weeks, occlusion of the interla carotid artery. Relative contraindication were severe kinking, and special haemodynamic situations caused by multiplex stenoses and/or occlusions. Both symptomatic and asymptomatic patients with primary atherosclerotic plaques or post-endarterectomy restenoses were candidates if they didn’t meet our exclusion criteria. Atherosclerotic plaques were classified as smooth, irregular and ulcerated. Stenting was carried out in 86% with Monorail Carotid Wallstent. Predilation or use of protecting device was avoided in 96%. Procedural success-

and periprocedural complication rates were noted. In 5 patients MR examination was carried out before and after the procedure. The only selection criteria was that they had to live in-town. Fast spin echo T_2 weighted axial, FLAIR sequential axial, and T_1 weighted coronal images were obtained. Follow-up consisted of color coded duplex sonography at 1, 6 and 12 months.

Results

26,2% of the patients suffered from diabetes mellitus, 54,4% from hypertonia, and 74,7% of the patients had a history of ipsilateral stroke or TIA. 18,1% of our patients was older than 79 years old, had organ failure likely to cause death within 5 years, had contralateral occlusion, or a more severe lesion cranial to the surgical lesion. All these patients would have been excluded from the NASCET study. 146 primary atherosclerotic lesions and 8 post-endarterectomy restenoses were considered for stent implantation. The procedure was not carried out in three patients because of morphological or haemodynamic reasons. In the remaining 146 patients stent implantation was attempted into 151 arteries, in 150 cases successfully. 142 primary atherosclerotic lesions and 8 post-endarterectomy restenoses were treated. Subtotal occlusions (stenoses over 95%) were detected in 27,3% of the lesions. Plaques were smooth in 23%, irregular in 51% and ulcerated in 26%. Predilation was donr in 5 cases, postdilation was avoided in 12 cases. Residual stenosis was always less than 30%. Complications were following: major stroke/death (nonvascular): 2,0%, minor stroke or TIA 1,4%. In 3 patients were false aneurysms found at the puncture site, none of them required surgery. None of the patients undergoing MR examination developod any neurological events. Two patients had new ischemic lesions. 50 patients have a follow-up longer than one year, while 97 patients have a follow-up longer than 6 months. No new ipsilateral stroke was found so far. Significant restenosis occurred in two patients. The first patient underwent surgical graft insertion, and developed restestenosis at the two ends of the graft. In the other case restenosis was successfully dilated with a high-pressure balloon.

7. Conclusions

1. Single slice spiral CT-angiography is more accurate in determination of the degree of stenosis at the carotid bifurcation than DSA based on images obtained in two or three planes.

2. Plaque calcification is depicted by CT in all cases, and soft components of the plaque can be well differentiated from the calcification. Ulceration cannot be reliably detected in all cases.

3. Single slice spiral CT-angiography is unable to detect intracranial, or intrathoracic lesions. The examination provides accurate information about lesions in the cervical area.

4. Working in team based on strict protocol, with the best available equipment, stent supported endovascular treatment of the carotid bifurcation stenosis can be carried out even in NASCET high-risk patients with clinical complication rates as low as published in the ACAS.

5. Our periprocedural distal embolisation rate does not exceed the embolisation rate of big western-European centers, nor the embolisation rate related to endarterectomy.

6. Durability of the results of endovascular therapy seems to be adequate for long lasting stroke prevention and improved brain circulation.