ACTA MEDICA SALINIANA

ORIGINAL PAPERS

VISUALIZATION OF THE POSTERIOR COMMUNICATING ARTERY ON MAGNETIC RESONANCE ANGIOGRAPHY

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ISSN 0350-364X

DOI: 10.5457/776

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Received:
31.1.2024

Accepted:
19.6.2024.

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Funding: none

Competing interests: none

ABSTRACT

Background: The posterior communicating artery (PComA) is crucial in the formation of the circle of Willis, displaying variations such as hypoplasia and aplasia. These impact collateral blood flow, with false diagnoses, posing risks in pre-surgical planning. Discrepancies between cadaveric and radiological studies highlight the imaging modality precision concerns.

Aim: To explore the sensitivity of 3D TOF (time-of-flight) angiograms in visualizing the PComA compared to maximum intensity projection (MIP) tomograms, and to assess whether CE-MRA (contrast-enhanced MRA) improves PComA visualization compared to native MRA.

Methods: In this retrospective study there were 137 subjects who underwent MRA between July 2008 and May 2013. Subjects with cerebrovascular disease, vascular malformations and brain tumors were excluded. The study focused on 274 PComA in 137 subjects, evaluating visualization on native and CE-MRA, as well analyzing axial 3D TOF angiograms and MIP images. The analysis categories were: not visualized, poorly visualized or well visualized.

Results: Among 211 arteries visualized on CE-MRA, only 2 (0.95%) were not seen on native MRA. CE-MRA, improved visualization in 5.22% of cases, with no significant difference (p=0.99) in PComA visualization between native and CE-MRA. Out of 209 PComA visualized on native MRA, 54 (25.84%) were visible on axial 3D TOF angiograms, but not on MIP reconstructions. Basic 3D TOF tomograms significantly outperformed MIP images (p=0.038) in visualizing PComA.

Conclusion: Contrast MRA does not significantly improve the visualization of PComA compared to native MRA, but basic 3D TOF tomograms are significantly better in visualizing PComA compared to MIP reconstructions.

Key words: Posterior communicating artery aplasia, MRA, 3D TOF, MIP reconstruction

INTRODUCTION

The posterior communicating artery (PComA) plays an important role in the formation of the complex architecture of the circle of Willis. Most authors agree that PComA is the vessel most likely to display variation, in terms of reduced diameter (hypoplasia), as well as its complete absence (aplasia) [1].

Clinically, there is a significant difference between hypoplasia and aplasia, considering the role of this artery in the creation of collateral blood flow, and its variations affect the trajectory of microembolism [2] and its bilateral absence divides the circle of Willis into completely separate anterior and posterior part [3].

There is a discrepancy in the reported results of aplasia between cadaveric and radiological studies, showing that the percentage of aplasia is lower in cadaveric studies [4], which raises questions about the precision and limitations of different imaging modalities in monitoring anatomical variations. A false-positive diagnosis of aplasia could have significant implications, especially in the context of pre-surgical planning, as it can lead to unnecessary procedures and complications [5].

There are two explanations for false negative findings. The first is that the vessel has to be followed through several images, and it may be confused with another nearby vessel. The second explanation is

in the turbulent and prolonged blood flow that is almost completely transverse [6].

Earlier studies recommended contrast-enhanced MRA (CE-MRA) as the initial angiographic examination in cerebrovascular diseases, and state that this technique visualizes 30% more arterial branches that were not visible on native MRA [7]. It has also been demonstrated that three-dimensional time of flight (3D TOF) MRA compares well to digital subtraction angiography (DSA), which is considered the gold standard in evaluation of the structure of the circle of Willis [8], and that it is has greater sensitivity than maximum intensity projection (MIP) reconstructions for visualization of the cerebral arteries [6].

The aim of this study was to prove that basic 3D TOF angiograms are more sensitive for visualizing the PComA compared to MIP tomograms, and to examine whether CE-MRA improves the visualization of the PComA compared to native MRA, thereby reducing the number of false positive aplasias of the PComA.

EXAMINEES AND METHODS

Examinees: This retrospective study, performed in the period from July 2008 to May 2013 at the Department of Radiology and Nuclear Medicine of the University Clinical Centre, Tuzla, included 137 subjects (52 men and 85 women), older than 18 years, who consecutively underwent CE-MRA of the cerebral arteries. Patients with cerebrovascular disease, vascular malformations and brain tumours were excluded from the study.

Methods: MRA was performed using one of two machines, with 1.5 Tesla strength (Siemens, model Avanto, Germany or Philips, model Achieva, The Netherlands). The MR angiography protocol consisted of non-contrast 3D TOF angiograms and CE-MRA with axial slice thickness at 0.9 mm, covering the area of the first cervical vertebra to the upper contour of the corpus callosum. On the Siemens 1.5T machine, the following imaging parameters were set: 25 ms time of repetition (TR), 7ms time of echo (TE); 20° flip angle; 256x256 matrix size; and 220 mm field of view (FOV). The imaging parameters on the Phillips machine were: TR 23 ms; TE 6.91 ms, flip angle 20°; matrix 328x208; FOV 180 mm. CE-MRA was performed after intravenous administration of 0.1 ml/kg gadolinium. In the study, the axial 3D TOF angiograms, MIP images, and 3D reconstruction of the axial angiograms were analysed by the Voxar system. All images were analysed by a single radiologist with five years' experience in MRI, and all unclear cases were further analysed by a neuro-radiologist with many years of experience. The presence of 274 PComA (137 right and the same number left) was analyzed in 137 subjects. Visualization and the quality of PComA visualization on native and CE-MRA were defined as: not visualized, poorly visualized and well visualized (Image 1), and then a combined analysis of the two methods was made.

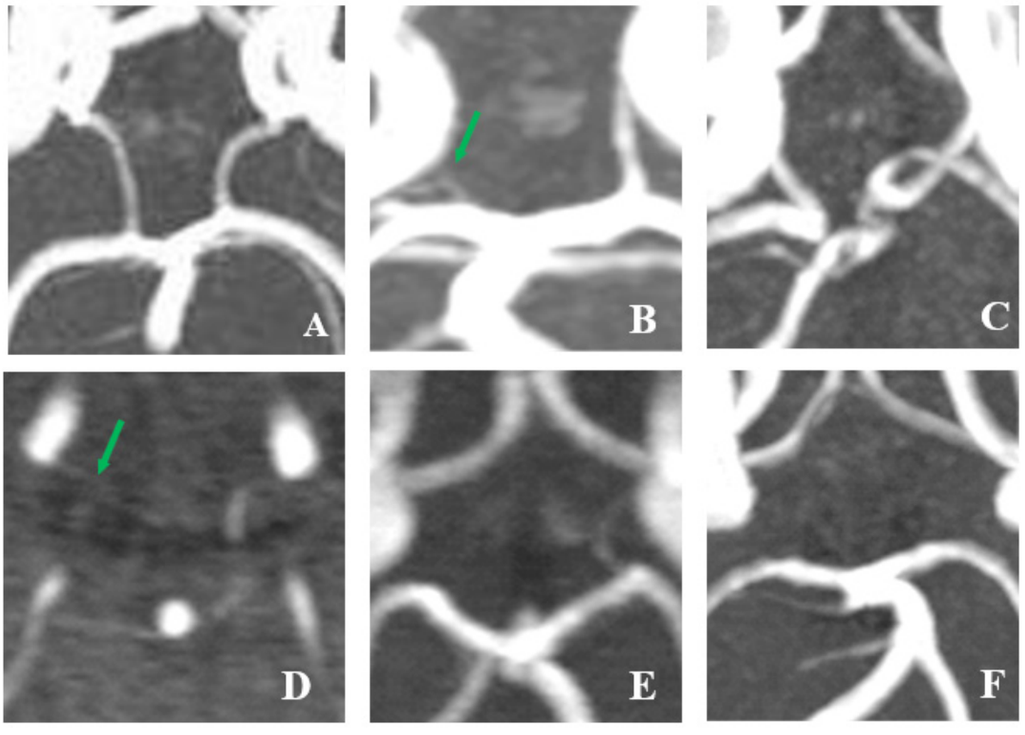

Image 1: Visualization of PComA: A-both PComA are visualized and symmetrical; B- both PComAs are visualized but are asymmetrical (the right PComA is smaller in diameter than the left); C- both PComAs are visualized-bilateral fetal type of posterior cerebral circulation; D- both PComAs are visualized but the right one is hypoplastic (axial 3D TOF angiogram); E- the right PComA is not visualized - "aplasia"; F- no PComA is visualized-"aplasia"

PcomA - arteria communicans posterior

3D TOF - three-dimensional time of flight

STATISTICAL ANALYSIS:

The collected data were stored in the Microsoft Access database while statistical analysis was performed using MedCalc statistical software. Differences between axial 3D TOF angiograms and MIP images, as well as between native MRA and CE-MRA were tested with the chi-square test. Differences on the level of $p<0.05$ were considered statistically significant.

RESULTS

Table 1 shows the visualization of PComA on native MRA and CE-MRA. In 137 subjects, 274 PComAs were analyzed (137 both right and left). Of the 274 PComAs, 63 were not visualized either on native or on CE-MRA, and were declared aplastic. Of the other 211 arteries visualized on CE-MRA, 2 (0.95%) the PComAs were not visualized on native MRA. In 9 (4.27%) cases, PComA was poorly visualized on native and well on CE-MRA, which means that CE-MRA improved the visualization of PComA compared to native MRA in 5.22% of cases. When calculating the significance of the differences in PComA visualization that were identified on MRA (n=211), the quality of visualization was not taken into account, but only the fact whether PComA was visualized or not on one of the two MRA methods. It was demonstrated that there is no significant difference (p=0.99) in PComA visualization between native and CE-MRA, meaning that CE-MRA does not significantly reduce the number of false PComA aplasias on MRA.

Table 1. Visualization of the posterior communicating artery on native and contrast magnetic angiography

	Contrast MRA			
Native MRA*	Good visualization	Poor visualization	Not visualized	Total
Good visualization	194	0	0	194
Poor visualization	9	6	0	15
Not visualized	2	0	63	65
Total	205	6	63	274

*MRA- magnetic resonance angiography

Table 2 shows the visualization of PComA on axial 3D TOF angiograms and MIP reconstructions. Of 274 PComAs, 65 arteries were not visualized on native MRA. Of the remaining 209 PComAs, 54 (25.84%) were visualized on axial 3D TOF angiograms without being shown on MIP reconstructions. Comparing the visualization of PComA between axial 3D TOF angiograms and MIP images, it was shown that basic 3D TOF tomograms are significantly better (p=0.038) in visualizing PComAs compared to MIPs.

Table 2. Visualization of the posterior communicating artery on native axial 3D TOF angiograms and MIP reconstructions

	Axial 3D TOF** angiograms			
MIP*	Good visualization	Poor visualization	Not visualized	Total
Good visualization	136	0	0	136
Poor visualization	18	1	0	19
Not visualized	39	15	65	119
Total	193	16	65	274

*MIP- maximum intensity projection
**3D TOF- three-dimensional time of flight

DISCUSSION

The prevalence of PComA aplasia in autopsy studies ranges from 0.6% [9] to 15.6% [10], and in MR angiographic studies from 1.4% [11] to 34.2% [12]. In the conducted research, the average prevalence of PComA aplasia among the four imaging modalities was 21.1%. From the above data, it is clear that the prevalence of PComA aplasia in MR angiographic studies is unrealistically high compared to autopsy studies, which speaks in favor of the fact that there is a significant number of false PComA aplasia on MR and other angiographic studies. Jones et al. [13] performed an analysis of the literature with the focus on PComA, which compared cadaveric and live patient imaging (LPI) studies, and concluded that there is no statistically significant difference between these two types of studies. The LPI studies included CTA, MRA and DSA studies. On antero-posterior angiograms, visualization of PComA is possible in only 30-40% of cases [14]. False-negative

findings on MRA are due to turbulence and saturation effects from slow blood flow, or long flow in one plane [6] resulting from the small diameter and almost complete transverse flow of the PComA from anterior to posterior. As a result of this, and also because of the low spatial resolution of MR, PComAs are less well visualized compared to other cerebral arteries, and a significant number are not visualized at all, which gives the finding of false hypoplasia/aplasia.

Ozsarlak et al. [7] stated that CE-MRA improves the visualization of distal branches of the ACM compared to native MRA by 69%, and that this technique visualizes 30% more arterial branches that were not visible on native MRA. One of the goals of this study was to determine whether CE-MRA can improve the visualization of PComA compared to native MRA, and thus reduce the number of false aplasias. It was demonstrated that there is no significant difference (p=0.99) in PComA visualization between native and CE-MRA. Namely, out of 211 PComAs that were visualized on CE-MRA, only in 0.95% of cases were PComAs not visualized on native MRA. In 4.27% of cases, PComA was poorly visualized on native MRA, but well on CE-MRA. CE-MRA improved the visualization of PComA in 5.22% of cases compared to native MRA, but it only slightly reduced the false number of PComA aplasia by less than 1%, which is a small percentage considering the prevalence of aplasia in autopsy studies.

The study also compared visualization of PComAs on axial 3D TOF angiograms and MIP reconstructions. In as many as 25.84% of cases, PComAs were visualized on axial 3D TOF angiograms, without being shown on MIP reconstructions. Comparing the visualization of PComA between axial 3D TOF angiograms and MIP images, it was proven that basic 3D TOF tomograms are significantly better (p=0.038) in visualizing PComA compared to MIP reconstructions. Newer studies [8] have proven that 3D-TOF-MRA compares well to DSA, which is considered the gold standard, in evaluation of the structure of the circle of Willis, which is consistent with previous studies [6] which compared visualization of cerebral arteries on axial 3D TOF angiograms and MIP images in relation to DSA. The sensitivity of axial 3D TOF angiograms in PComA visualization was 75%, and the specificity was 72%. The sensitivity of MIP images in PComA visualization was 63%, but with greater specificity compared to axial angiograms, which was 93%. The difference in sensitivity between axial 3D TOF angiograms and MIP images was 12% [7].

In the present study, since we did not have DSA as the gold standard, we could not calculate the accuracy of native MRA, CE-MRA, 3D TOF angiograms and MIP images in PComA visualization. Nevertheless, the significantly higher percentage of PComAs (25.84%) that were visualized on axial 3D TOF angiograms, but were not visible on MIP images, indirectly indicates the lower sensitivity of MIP reconstruction in the visualization of PComA compared to axial 3D TOF angiograms, and that axial 3D TOF tomograms are primary in the analysis of cerebral arteries.

CONCLUSION

Contrast MRA does not significantly improve the visualization of PComA compared to native MRA, but basic 3D TOF tomograms are significantly better in visualizing PComAs compared to MIP reconstructions.

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