Middle cerebral artery aneurysm identification

ASSIGN BUSTER

Middle cerebral artery is a very common site for aneurysm formation. MCA aneurysms represent 18-40 of all intracranial aneurysms. MCAAS are commonly divided into three groups: proximal (M1As), bifurcation (MbifAs), or distal (MdistAs) aneurysms. Each group presents with distinct anatomic features that have an impact on their management.

Assigning MCAAs into a particular group can sometimes be difficult since the length and caliber of the M1 segment often varies and there may be two or more major branching sites along its course. This has led to fallacies in sub-grouping of MCAAs with resultant high variability in the reported frequencies of the different subgroups: M1As (2 – 61%) and MbifAs (39 – 90%), of all MCAAs [2, 3, 5-8]. Preoperative identification of MCA aneurysm origin either at the main MCA bifurcation (Mbif) or at another branching point has a great implication on surgical planning as different groups of MCAAs pose different challenges to the neurosurgeon requiring different surgical strategies.

In this report, we present our technique for accurate identification of the MCA main bifurcation from other branching points along MCA as a key for a more accurate classification of MCA aneurysms. Furthermore we suggest an extension to the classic MCA classification. Also, we present the distribution of 1309 MCA aneurysms as a part of the largest CTA anatomic study, so far, for MCA aneurysms. Our aim is to help recognize the branching pattern of MCA with special emphasis on the exact characterization of MCA main bifurcation.

Patients and methods

Patients and radiological data:

Data were retrieved from a prospectively collected database that sequentially encompassed all patients with intracranial aneurysms admitted to the Department of Neurosurgery at Helsinki University Central Hospital (catchment area, 1. 8 million people). We identified 1124 consecutive patients with MCA aneurysms diagnosed between 2000 and 2009. We excluded 115 patients from the study due to lack of adequate CTA (98 cases) or having non-saccular MCAAs (17 cases). The remaining 1009 patients with a total of 1309 saccular MCA aneurysms had adequate cerebral CTAs. The routine use of CTA (GE Lightspeed QX/i; GE Medical Systems, Milwaukee, WI) started in the year 2000 and has been the primary imaging modality for cerebral aneurysms at our institution ever since. CTA is rapid, safe, readily available and can provide 3D reconstruction of vessels and bony structures. Each patient`s radiological images were stored in the hospital’s central digital archiving system (PACS; AGFA, IMPAX, version 4. 5), launched in 1998, from which all of the relevant diagnostic images were recalled.

Nomenclature:

For each patient, pretreatment CTA images were evaluated and measured on screen (AGFA, IMPAX DS 3000). The MCA aneurysms were identified in each patient and classified according to the location of aneurysm neck in relation to the main MCA bifurcation (fig. 6). MCA aneurysms were grouped into three groups: M1As, aneurysms on the main trunk (M1) of the MCA, between the bifurcation of internal carotid artery (ICA) and the main MCA bifurcation; MbifAs, aneurysms at the main MCA bifurcation; MdistAs, aneurysms distal to main MCA bifurcation on M2, M3 or M4 segments. Then

M1As were sub-grouped into 2 groups: M1-ECBAs, aneurysms arising at the origin of early cortical branches; M1-LSAAs, aneurysms arising at the origin of Lenticulostriate arteries. The M1-ECBAs comprised aneurysms arising at the origin of early frontal branches (M1-EFBAs) and aneurysms arising at the origin of early temporal branches (M1-ETBAs).

CTA for precise recognition of MCA main bifurcation

For localization of Mbif, we simply examine the MCA branches in sagittal views of CTA at the insular level and detect the insular trunks from direction and course then follow these trunks till their essential meeting at the Mbif. This pilot examination must be correlated with examination of axial and coronal views for accurate confirmation. In some cases with difficult branching and looping patterns, 3D reconstruction is necessary.

CTA for accurate classification of aneurysms along MCA: (figures 2-6)

We examine the direction and course of the branches originating at the neck of the aneurysm in sagittal views to know whether these branches are cortical or insular. Correlation with axial and coronal views and sometimes 3D reconstructions is necessary. Then we check the relation of this branching point to the MCA main bifurcation (the primary meeting point of insular trunks) for correct sorting of the aneurysm.

Results:

Demographics:

The mean age at diagnosis in our patient population was 54 years (range 13-89 y). The number of women 690 (68%) doubled that of men 319 (32%). Aneurysms were more common on the Rt. MCA 732 aneurysms (56%) than on the lt. MCA 577 aneurysms (44%). In 466 (46%) Patients, there were one or more additional aneurysms totaling 1761 aneurysms.

Classification of MCA aneurysms:

Table 1 shows the distribution of 1309 aneurysms along MCA. The number of aneurysms arising at the MCA main bifurcation (MbifAs) 829 (63%) doubled the total number of all aneurysms arising along M1 segment (M1As) 406 (31%). The distal MCA aneurysms (MdistAs) were the least frequent group only 74 (6%). Around three quarters (77%) of ruptured MCA aneurysms and 57% of unruptured MCA aneurysms were located at the MCA bifurcation.

Types of M1As:

Aneurysms arising along the main trunk of MCA (M1As) were grouped into 2 groups according the nature of the branches taking off at the base of the aneurysms. Among the 406 M1As, 242 (60%) aneurysms arose at the origin of early cortical branches from M1 segment (M1-ECBAs) while the remaining 164 (40%) M1As were not associated with early cortical branches but LSAs (M1-LSAAs). The aneurysms at the origin of early cortical branches (M1-ECBAs) comprised 178 aneurysms at the origin early frontal branches (M1-EFBAs) and 64 aneurysms at the origin of early temporal branches (M1-ETBAs).

Discussion:

The high variability in the reported frequencies of different groups of MCA aneurysms (M1As, 2-61%; MbifAs, 39-90%)[2, 3, 5-8] could be attributed to falsies in classification of these aneurysms and / or obtaining such incidences from small statistically unreliable series. In a trial to resolve this issue in a large statistically reliable non-selected group of MCAAs, We performed a retrospective anatomical study of CTAs for consecutive 1009 patients with 1309 saccular MCAAs aneurysms. We tried to find and follow the objective characteristics of branching points along MCA to be more precise when classifying MCA aneurysms. In our previous MCA publications [1-4, 9]we have followed the classic classification of MCA aneurysms. Recognizing the importance and the deceptive appearance of the early cortical branches, we have added an extension to the traditional classification by subdividing M1 aneurysms into M1-ECBAs and M1-LSAAs. This proofed helpful to keep attention to this previously underestimated group of aneurysms arising at the origin of early cortical branches (M1-ECBAs).

Preoperative identification of MCA aneurysm origin either at the main bifurcation or at another branching point has an implication on surgical planning especially for ruptured MCAAs as different type of MCAAs poses different challenges to the neurosurgeon requiring different surgical strategy[1-3]. Also when selecting the recipient vessel for bypass surgery if indicated to compensate for an inevitable vascular compromise during securing the aneurysm.

MCA is classically subdivided into 4 segments: the sphenoidal (M1) segment extending from ICA bifurcation to the main MCA bifurcation where insular trunks (M2) begins and course over the insula till the peri-insular sulci where the opercualar (M3) segments start and course till the lateral surface of the brain in the sylvian fissure then continue as parasylvian (M4) segments whose distal extensions are sometimes called the terminal (M5) segments [10-13]. Although Yasargil used the main MCA bifurcation as the demarcation point between M1 and M2 segments, Rhoton used the MCA genu at the limen insulae as the demarcation point between M1 and M2 segments, hence he had prebifuration M1 and post bifurcation M1[8, 14].

Aneurysms along MCA are classically divided into three groups: proximal (M1As), bifurcation (MbifAs), or distal (MdistAs) aneurysms. It is evident that the identification of the MCA main bifurcation is the key for accurate classification and grouping of these aneurysms. Although MCA anatomy has been widely described in standard anatomy, neuroradiology, and neurosurgery textbooks[8, 15-17], it is still not uncommon to mistaken the identification of the main MCA bifurcation from other branching points along the main trunk of MCA particularly those associated with a large-caliber cortical branch. This misconception led to wide range of the reported length of MCA main trunk (0 -30 mm) and large differences in the reported relative frequency of M1As (2 – 61%) and MbifAs (39 – 90%) between authers[2, 3, 5-8].

Accurate identification of the MCA main bifurcation:

Crompton named the cortical branches arising from M1 segment proximal to MCA bifurcation as early branches. Yasargil and colleagues defined the origin of the large cortical branches arising proximal to the most lateral LSAs as (false early bifurcation) and declared that aneurysms arising at this region of M1 could be mistakenly diagnosed as MCA bifurcation aneurysms. They stressed the importance of the LSAs in defining the site of the main bifurcation as the main bifurcation is usually located distal to the origin of LSAs [8, 12, 13]. These early cortical branches are found in nearly 85 to 90% of hemispheres [14].

In the anatomical study for the early branches of MCA, Rhoton and colleagues found that the early branches arising on the proximal half of the main trunk of MCA resembled postbifurcation trunks of M1 in some aspects with possibility of being misinterpreted as postbifurcation trunks of the M1 leading to false localization of the main bifurcation. They could identify LSAs on M1 segment distal to the origin of these early branches. MCA main bifurcation was identified proximal to the genu in 82%, at the level of genu in 8%, and distal to the genu in 10% of hemispheres [14].

It is obvious that the exact identification of MCA main bifurcation is the key for correct sorting of aneurysms along the MCA. It is popular to subjectively accept a branching point close to MCA genu giving rise to the largest branches as the MCA main bifurcation. It is also not uncommon to feel more internal confidence when such a branching point holds an aneurysm to consider it as MCA main bifurcation. This might be correct in the majority of cases but unfortunately it would be misleading in some cases.

The idea for identification of the main MCA bifurcation (Mbif) accurately is to find a constant criterion for Mbif which can be used as a hallmark for identification of Mbif from other branching points along the MCA with high certainity. Keeping into mind that Mbif might share some characteristics (like size of out-coming branches, location in relation to MCA genu and relation to LSAs) with other branching points along MCA preclude accepting any of these characteristics as a hallmark for Mbif.

The fact that all insular trunks (M2s) authentically originate from one point that is the MCA main bifurcation, means that the primary meeting point of all insular trunks (M2s) can be considered as a hallmark for Mbif. So, simply by identifying the insular trunks and following them proximally till their original meeting into one point, the Mbif can be localized accurately and with certainty. Insular (M2) trunks cannot be identified by being the largest branches as early cortical branches are sometimes of the same caliber or even larger than the actual M2 trunks. M2 trunks run along the insula from the limen insula for a variable distance taking the superior and posterior directions. So by observing the direction and course of each of the branches originating from the MCA trunk in sagittal, coronal and axial CTA views, it will be easy to identify the insular trunks and to follow them proximally till their authentic meeting at the Mbif.

In fewer words, considering that the main MCA bifurcation is not always distal to the origin of LSAs or always proximal or at the genu, but it always gives insular trunks (M2s) means that identification of the primary starting point of these insular trunks will guide to the main MCA bifurcation. These insular trunks should be recognized by their course over the insula for variable distance not by their size as some early cortical branches might be of similar or even larger size.

Among all the aneurysms arising along MCA, those aneurysms arising from M1 segment at the origin of early cortical branches (ECB) are more likely to be misdiagnosed as a bifurcation aneurysm especially when the cortical branch is large and arises close to the MCA genu. The fact that early temporal branch becomes smaller as it arises closer to genu[14]means that it would not be common to misinterpret an aneurysm arising at the origin of an early temporal branch as a bifurcation aneurysm even if it is close to genu. There is no relation between the size of EFB and its distance from the genu. In angiograms, such large frontal branches look very similar to post bifurcation M2 trunks. This shows clearly how some aneurysms arising at the origin of large early frontal branches (EFB) could be, if enough attention was not paid, misclassified as MCA bifurcation aneurysm especially when close to the MCA genu.

Ulm et al.[7] unexpectedly found, in their anatomical retrospective study of MCAAs with special emphasis on those aneurysms arising from M1 at the origin of early cortical branches, that M1As arising at the neck of EFB were more common than MbifAs and they claimed that many of EFB aneurysms were misclassified as early MbifAs reasoning why MbifAs were reported in previous pubilcations to be the most common location for MCAAs. This was contrary to our and general experience of Mbif being the most common location for MCAAs [1-5, 13, 18].

During this study, it was easy to sort some aneurysms along MCA, such as a small aneurysm at the origin of LSAs close to ICA bifurcation or a small aneurysm along M4 segment, precisely from the first look. Unfortunately, the biggest percentage of MCA aneurysms arose close to the MCA genu at some branching points which included early cortical branches, MCA main bifurcation and early furcation of M2 branches. This necessitated a lot of work to discriminate between these branches for precise sorting of MCA aneurysms. Moreover, some morphological characteristics of the aneurysms, such as large aneurysm size and complex projections, added to the difficulty for proper distinguishing of these branches. The task was more difficult for ruptured MCA aneurysms especially when associated with large ICH distorting the anatomy. On the other hand the availability of the 3D reconstructions, which made it possible to examine the aneurysms and MCA branches from different angles, together with the classic CTA views paved the way to accomplish our goal for sorting MCA aneurysms accurately with high degree of certainty.

The present work shows, in harmony with our previous publications (table 3), that MCA bifurcation is the most common location for aneurysms along the MCA. The number of MbifAs 829 (63%) doubled the total number of all M1As 406 (31%) including those aneurysms arising at the origin of LSAs and those at the origin of ECBs. MCA bifurcation aneurysms comprised 77% of ruptured MCA aneurysms and 57% of unruptured MCA aneurysms. Among the 406 M1As, 178 (44%) aneurysms arose at the origin of early frontal branches (M1-EFBAs). The diameter of the associated early frontal branch was â‰¥ half the diameter of M1 in 106 (60%) cases. We assume that such aneurysms, without careful examination, might be misclassified as MbifAs especially when the associated large EFB is close to the genu of MCA. Early temporal branches were associated with 64 (16%) aneurysms (M1-ETBAs). The remaining 164 (40%) M1As were not associated with early cortical branches but with LSAs (M1-LSAAs). (Table 2)

At the end of this study we realized that many M1 aneurysms arising at the origin of large early cortical branches especially EFB could be sometimes misclassified as MbifAs, but Mbif is still the most common location for aneurysms along MCA. We agree with Ulm et al [7] for the possibility to mistaken EFB aneurysms as bifurcation aneurysms if much care was not paid, but we assume that their surprising results of EFB being the most common location for MCAAs came from the small number of the cases included in their study. (Table 4)

Conclusion:

Careful objective analysis of MCA branching pattern from preoperative CTA is very important to understand patient-specific vascular anatomy which aids the surgeon to successfully exclude MCAAs from the circulation while preserving the surrounding vasculature. Although many M1 aneurysms arising at the origin of large early cortical branches especially EFB could have been misclassified as MbifAs in previous reports, Mbif is still the most common location for aneurysms along MCA.

Figures legends:

Fig. 1: Identification of MCA main bifurcation

CTA images (A: sagittal, B: coronal & C: axial & D: 3D reconstruction) demonstrating an early cortical branch aneurysm (white arrow) arising at the origin of an early frontal branch (green arrow) proximal to the main MCA bifurcation (yellow arrow) which gives frontal (red arrow) and temporal (blue arrow) M2 trunks. The MCA main bifurcation (yellow arrow) is located at the genu. The accompanying diagrams (E, F & G) display how to accurately identify the main MCA bifurcation from other branching points along MCA just by following the insular branches back towards their primary meeting at one point that is the MCA main bifurcation. We are used to start the check in sagittal views then to confirm by rechecking the axial and coronal CTA views. 3D reconstructions are sometimes needed.

Fig. 2

CTA images (A: axial, B: coronal, C: sagittal & the corresponding 3D reconstruction views (D, E & F respectively) demonstrating an early cortical branch aneurysm (white arrows) arising at the origin of a large early frontal cortical branch (green arrow) just proximal to the right MCA genu. Such an aneurysm can be subjectively misclassified as an MCA bifurcation aneurysm especially in coronal views, but in sagittal and axial views, the frontal branch (green arrow) is seen running anteriorly and superiorly away from the insula. Also, the right MCA bifurcation (yellow arrow) is clearly seen distal to the genu giving frontal (red arrow) and temporal (blue arrow) insular trunks.

Fig. 3

CTA images (A: axial, B: coronal, C: sagittal & D: 3D reconstruction) demonstrating an aneurysm (white arrow) arising at the main MCA bifurcation (yellow arrow) which gives frontal (red arrow) and temporal (blue arrow) M2 trunks. Notice the frontal cortical branch (green arrow) arising from the frontal M2 trunk (red arrow). The MCA main bifurcation (yellow arrow) is located proximal to genu.

Fig. 4

CTA images (A: axial, B: coronal & C: sagittal) demonstrating an early cortical branch aneurysm (white arrow) arising at the origin of an early frontal branch (green arrow) proximal to the main MCA bifurcation (yellow arrow) which gives frontal (red arrow) and temporal (blue arrow) M2 trunks. The MCA main bifurcation (yellow arrow) is located proximal to genu.

Fig. 5

CTA images (A: axial, B: coronal, C: sagittal & D: 3D reconstruction) demonstrating an early cortical branch aneurysm (white arrow) arising at the origin of an early temporal branch (green arrow) proximal to the main MCA bifurcation (yellow arrow) which gives frontal (red arrow) and temporal (blue arrow) M2 trunks. The MCA main bifurcation (yellow arrow) is located at genu.

Fig. 6

CTA images (A: axial, B: coronal & C: sagittal) demonstrating a distal MCA aneurysm (white arrow) arising at the takeoff of a frontal cortical branch (green arrow) from the left frontal M2 trunk (red arrow) distal to the main MCA bifurcation (yellow arrow) which gives frontal (red arrow) and temporal (blue arrow) M2 trunks. The MCA main bifurcation (yellow arrow) is located proximal to genu.