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Přehledový článek | Review article

Cerebral mycotic aneurysm as a consequence of infective endocarditis: A literature review

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SOUHRN

Kontext: Mykotické aneurysma mozkových tepen (cerebral mycotic aneurysm, CMA) na podkladě infekční endokarditidy (IE) se vyskytuje vzácně. Klinické projevy této patologické jednotky dosud nebyly přesně popsány.
Metody: Zdrojem údajů pro tuto studii byla komplexní rešerše literatury publikované v angličtině v letech 1990–2014 v databázích PubMed, Highwire Press a vyhledávacího stroje Google (Google search engine). Vyhledávanými termíny byly „infekční endokarditida" a „intrakraniální mykotické aneurysma/mykotické aneurysma mozkových tepen".
Výsledky: Ke vzniku CMA obvykle docházelo v průběhu 2,1 měsíce od rozvoje IE. Nejčastějším patogenem byl *Staphylococcus*; kultivací krevních vzorků byla zjištěna i přítomnost streptokoků. Nejčastějším projevem při vyšetření výpočetní tomografií bylo intraparenchymální krvácení. Spolehlivým diagnostickým nástrojem pro přesné určení místa aneurysmatu je angiogram. Nejčastěji postiženou cévou byla střední mozková tepna, následována zadní mozkovou tepnou. I když bylo u většiny pacientů nutno provést intervenční nebo chirurgickou léčbu CMA, u některých postačila konzervativní léčba. Jednorozměrová analýza prokázala, že významnými predikčními rizikovými faktory spojenými se zvýšenou mortalitou byly rozvoj herniace, postižení mateřské cévy, ruptura aneurysmatu a nechirurgická/neintervenční léčba aneurysmat.
Závěr: Vzhledem k možným důsledkům vzniku cefalokély a ruptury aneurysmatu představují CMA značné riziko. Léčba této patologické jednotky je vždy náročná, protože načasování operačních výkonů na mozku a na srdci se kvůli nutné heparizinaci při kardiochirurgických výkonech obtížně plánuje. Pacientům s IE je nutno v prevenci případných důsledků tohoto onemocnění, např. tvorby CMA, podávat antibiotika v dostatečných dávkách. Volba léčby CMA závisí na aktuální situaci. U vybraných pacientů je lze řešit konzervativně, endovaskulárně nebo chirurgicky. U pacientů s rupturou CMA se doporučuje mezi zasvorkováním nebo chirurgickou excizí aneurysmatu a kardiochirurgickým výkonem dodržet odstup nejméně dvou týdnů.

ABSTRACT

Background: Cerebral mycotic aneurysm (CMA) secondary to infectice endocarditis (IE) is rare. The clinical features of this entity have not been sufficiently clarified.
Methods: The data source of this study was based on comprehensive literature retrieval of articles published in English 1990–2014 in the PubMed, Highwire Press and Google search engine. The search terms were "infective endocarditis" and "intracranial/cerebral mycotic aneurysm".

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Results: The CMAs usually developed 2.1 months after the onset of IE. *Staphylococcus* was the most frequent pathogen and *Streptococcus* was more frequent as evidenced by blood culture. The most common presentation on computed tomography was intraparenchymal hemorrhage. Angiogram was a reliable diagnostic means for determining the location of the aneurysm. The middle cerebral artery was the most commonly affected and the posterior cerebral artery was more commonly affected. Interventional or surgical treatments of the CMAs were required in most patients, while some were recovered under conservative treatment. Univariant analysis revealed the development of herniation, parent vessel involvement, aneurysm rupture and non-surgical/interventional treatment of the aneurysms were significant predictive risk factors associated with increased mortality.

Conclusion: The CMAs are risky due to their potential consequences of cerebral hernia and aneurysmal rupture. The treatment of this entity is always challenging as it is difficult to determine the timing of the cerebral and cardiac operations concerning the necessity of heparinization in cardiac surgery. Sufficient antibiotics have to be used in IE patients in order to prevent from the potential consequence as CMAs. The choices of treatment for CMAs depend on the conditions of CMAs. They are curable to either conservative, endovascular or surgical management in selected patients. At least 2-week interval between clipping or surgical excision of the aneurysm and the cardiac procedure is recommended in patients with a ruptured CMA.

Keywords:
Endocarditis
Endovascular procedures
Intracranial aneurysm
Middle cerebral artery

Introduction

Neurological consequences including stroke or transient ischemic attack, cerebral hemorrhage, mycotic aneurysm, meningitis, cerebral abscess, or encephalopathy remain a significant problem of infective endocarditis (IE) [1]. Neurologic complications were significantly associated with *Staphylococcus aureus* infection and with IE affecting both the aortic and the mitral valves [2,3]. *Staphylococcus aureus* endocarditis increases the risk of neurologic morbidity and mortality [4]. Of these, cerebral mycotic aneurysm (CMA) secondary to IE is at any rate exiguous but potentially fatal. In particular, symptomatic CMAs are uncommon [5]. One to two percent of patients with native valve infective endocarditis have CMAs [5]. However, there have been no popularly accepted regimens for the management of CMAs [6]. This study aims to present the clinical features, diagnosis, treatment and prognosis of CMAs as a consequence of IE.

Methods

Comprehensive retrieval of the literature was made in the PubMed, Highwire Press and Google search engine for the year range 1990 to 2014. The search terms included "infective endocarditis" and "intracranial/cerebral mycotic aneurysm". The search ended on August 31, 2014. Only articles published in English language were retained. Duplicate publications and articles describing the patients with mycotic aneurysm of other arteries were excluded from the statistical analysis.

Data were extracted from the text, figures, or tables and included details of the study population, demographics, pathologies of IE and CMA, diagnosis, management strategies, prognosis and follow-up.

Measurement data were expressed in mean ± standard deviation with range and median values and were compared by independent sample *t*-test. Categorical variables were compared by Fisher exact test. Univariant analysis was made to assess the predictive risk factors associated with an increased mortality of this patient setting. $p < 0.05$ was considered statistically significant.

Results

A total of 68 articles [4–74] were collected with 149 patients involved. Gender was not indicated in 21 patients. Of the remaining 128 patients, 83 (64.8%) were males and 45 (35.2%) were females with a male-to-female ratio of 1.84:1. Their ages were 35.9 ± 17.0 (range, 1–87; median, 35) years (n = 117).

The duration of IE symptoms was 2.1 ± 2.3 (range, –0.75–6; median, 1.2) months (n = 8) (the minus symbol represented an onset of symptom after admission; the same below).

The major clinical symptoms of IE were described in 45 patients with fever in 42 (93.3%) and chest distress, chest pain and fatigue in 1 (2.2%) patient each. A heart murmur was audible in 33 patients with a systolic murmur in 22 (66.7%) (one of them has a S_3), a diastolic in 2 (6.1%), both systolic and diastolic in 6 (18.2%) and unknown in 3 (9.1%). Eight patients had a significant medical history including postpartum (3 days after delivery), left MCA infarct associated with Down's syndrome and endocardial cushion, aortic valvulotomy for aortic stenosis, previous IE, mitral regurgitation, mitral valve prolapse, mitral valvotomy, right intracerebral aneurysm thrombosis with residual aphasia and right hemiparesis in 1 each.

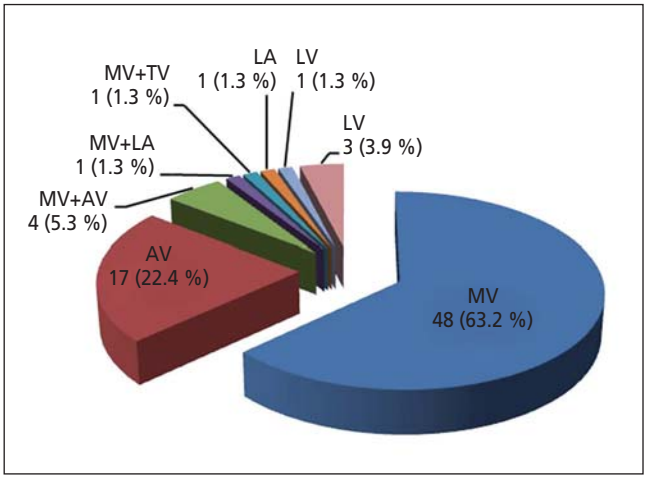

Fig. 1 – Locations of vegetations. AV – aortic valve; LA – left atrium; LV – left ventricle; MV – mitral valve; NG – not given; TV – tricuspid valve.

Table 1 – Microbial spectrum by blood culture.

Microorganism	*n* (%)
Staphylococcus	36 (45)
Species undefined	18 (50)
aureus	11 (30.6) (at least 4 were methicillin-sensitive)
lugdunensis	1 (2.8)
mucilaginosus	1 (2.8)
sanguinis	1 (2.8)
uberis	1 (2.8)
Coagulase negative	1 (2.8)
epidermidis	1 (2.8)
oralis	1 (2.8)
Streptococcus	29 (36.3)
viridians	12 (41.4)
mitis	5 (17.2)
mutans	3 (10.3)
α-hemolytic	3 (10.3)
pyogenes	2 (6.9)
bovis	1 (3.4)
milleri group	1 (3.4)
salivarius	1 (3.4)
sanguinis	1 (3.4)
Enterococcus	3 (3.8)
faecalis	1 (33.3)
rhusiopathiae	1 (33.3)
Species undefined	1 (33.3)
Others	9 (11.3)
Abiotrophia defective	2 (22.2)
Cardiobacterium hominis	2 (22.2)
Gemella bergeriae	1 (11.1)
Hemophilus influenzae, nontypeable	1 (11.1)
Pasteurella multocida	1 (11.1)
Propionibacterium	1 (11.1)
Rothiadentocariosa	1 (11.1)
Unknown	3 (3.8)

Six (7.3%) patients did not have a vegetation, while 76 (92.7%) patients had, with the mitral valve being the most frequent location for a vegetation to attach (Fig. 1). Of them, 64 (84.2%) patients had a solitary vegetation while 12 (15.8%) had multiple vegetations ($\chi^2 = 71.2$, $p = 0.000$). Dimensions of 9 vegetations from 7 patients were recorded with a mean of 13.4 ± 5.2 (range, 6–20; median, 13) mm ($n = 9$). The valvular pathologies secondary to IE were mitral regurgitation in 19 (65.5%), mitral regurgitation in 5 (17.2%), and aortic regurgitation and stenosis, aortic and mitral regurgitation, mitral regurgitation and stenosis, mitral valve prolapse and mitral and tricuspid prolapse in 1 (3.4%) patient each.

Table 2 – 159 neurological symptoms in 79 patients.

Symptom	*n* (%)
Headache	43 (27.0)
Hemiparesis	28 (17.6)
Altered mental status	14 (8.8)
Vomiting	12 (7.5)
Dysarthria	7 (4.4)
Altered sensorium	6 (3.8)
Seizures	6 (3.8)
Hemiplegia	5 (3.1)
Weakness	5 (3.1)
Aphasia	4 (2.5)
Drowsiness	4 (2.5)
Dysphasia	3 (1.9)
Inability to move	3 (1.9)
Ataxia	2 (1.3)
Loss of/blurred vision	2 (1.3)
Diplopy	2 (1.3)
Disorientation	2 (1.3)
Dizziness	2 (1.3)
Nausea	2 (1.3)
Conjugate deviation	2 (1.3)
Convulsions	1 (0.6)
Lateralrectus palsy	1 (0.6)
Back pain	1 (0.6)
Paralysis	1 (0.6)
Ptosis	1 (0.6)

Blood cultures were described in 89 patients. Nine (10.1%) patients had a negative result (however culture of cerebral hematoma grew *Streptococcus viridians* in 1 patient) while 80 (89.9%) were positive. *Staphylococcus* was the most frequent pathogen followed by Streptococcus. The microbial spectrum was shown in Table 1.

In 39 patients, preoperative antibiotics were use including penicillin in 10 (25.6%), ampicillin in 7 (17.9%), vancomycin in 3 (7.7%), ceftriaxone in 3 (7.7%) and antibiotics unspecified in 16 (41.0%) patients. Gentamycin was jointly used with other antibiotics in 16 patients. One of the patients was also given rifampin. The antibiotic treatment lasted 4.4 ± 2.8 (range, 0.4–14; median, 5.9) weeks ($n = 50$).

Neurological onset symptoms were described in 79 patients. Headache was the most frequent symptom followed by hemiparesis (Table 2). The onset time was given for 40 patients. It was described as "sudden", "acute", or "recurrent" in 16 patients. In the remaining 24 patients, the duration of the symptoms was 0.4 ± 1.5 (range, –1.25-4; median, –0.15) months ($n = 24$) (13 patients had an onset after admission). The time interval between onsets of IE and CMA was 2.1 ± 2.5 (range, 0-12; median, 1.4) months ($n = 32$).

127 patients had 140 episodes of CMAs with 104 (81.9%) having 1 episode, 9 (7.1%) had 2 episodes, 1

Table 3 – Computed tomographic presentations of mycotic aneurysms in 140 episodes of 127 patients.

Computed tomographic presentation	*n* (%)
IPH	64 (46.7)
SAH	25 (18.2)
INF	14 (10.2)
Aneurysm	10 (7.3)
IPH, SAH	7 (5.1)
IPH, aneurysm	3 (2.2)
IPH, IVH	3 (2.2)
IPH, INF	2 (1.5)
IPH, SAH, IVH	2 (1.5)
INF, aneurysm	1 (0.7)
SAH, INF	2 (1.5)
Meningitis	1 (0.7)
SAH, meningitis	1 (0.7)
SAH, abscess	1 (0.7)
SAH, abscess, aneurysm	1 (0.7)
Normal	3 (2.2)

ICH – intraparenchymal hemorrhage; INF – infarction; IVH – intraventricular hemorrhage; SAH – subarachnoid hemorrhage.

(0.8%) had 3 episodes. Cerebral computed tomography or alternative imaging manifestations of these patients revealed intracranial hemorrhage was the most common (Table 3). Eleven (9.6%) patients present with midline shift namely herniation.

CMAs on angiogram were reported for 143 patients. The affected cerebral artery was not indicated in 33 patients. Of the remaining 110 patients, CMAs involved one vessel in 96 (87.3%), 2 vessels in 13 (11.8%) and 3 vessels in 1 (0.9%) patient. A single aneurysm developed in one or more vessels in 98 (89.9%), 2 aneurysms in one vessel in 7 (6.4%) patients and 3 or more aneurysms in one vessel in 4 (3.7%) patients, respectively. MCA was the most commonly affected artery and posterior cerebral artery was more commonly affected (Table 4). In 2 (1.4%) patients, the CMAs involving the MCA were pseudoaneurysms. The cerebral arteries affected by CMAs were reported in 73 patients. They were on the right in 35 (47.9%), left in 32 (43.8%) and bilateral in 6 (8.2%). The locations of 117 aneurysms of 102 patients were stated, and most of them were located at the distal portion of the arteries (Table 5). Totally 42 aneurysms of 32 patients ruptured (one of the aneurysms ruptured twice).

Dimensions of 49 aneurysms of 43 patients were recorded with a mean of 6.7 ± 6.6 (range, 1–40; median, 5) mm (n = 49). Three aneurysms of 2 patients progressed during hospitalization with an increment of 4 mm, 2 mm and 3.2 mm respectively. Shapes of the aneurysms were reported for 14 aneurysms in 12 patients: 5 (35.7%) were saccular, 4 (28.6%) were fusiform, 2 (14.3%) were multilobed and 1 (7.1%) each was opercular, pear-shaped and irregular, respectively.

Table 4 – Affected cerebral artery.

Affected cerebral artery	*n* (%)
Middle cerebral artery	78 (62.4)
Posterior cerebral artery	26 (20.8)
Anterior cerebral artery	9 (7.2)
Basilar artery	3 (2.3)
Posterior communicating artery	2 (1.6)
Posterior inferior cerebellar artery	1 (0.8)
Pericallosal artery	1 (0.8)
Basilar artery-superior cerebellar artery junction	1 (0.8)
Internal cerebral artery	1 (0.8)
Hippocampal artery	1 (0.8)
Callosal marginal artery	1 (0.8)
Anterial choroidal artery	1 (0.8)

Table 5 – Locations of the mycotic aneurysms.

Locations	*n* (%)
Distal	61 (46.2)
Branches	30 (22.7)
Central	13 (9.8)
Proximal	6 (4.5)
Bifurcations	4 (3.0)
Tip (of the basilar artery)	3 (2.3)
Arterial junctions	2 (1.5)
Trifurcation	1 (0.8)
Peripheral (exact location not given)	12 (9.1)

Of the conservative treatment group, 16 patients received antibiotics and 1 patient received aminocaproic acid and phenytoin sodium treatment instead of antibiotics and the aneurysm decreased in size. The time interval for the antibiotics to take effect was 6.3 ± 2.5 (range, 3–12; median, 6) weeks (n = 9). Nine patients only had decompressive craniotomy with the CMAs without being intervened. In the interventional and surgical groups, effects of antibiotics prior to intervention were described in 13 patients for their 15 aneurysms as resolution in 1 (6.7%), decrease in size in 2 (13.3%), no change in 3 (20%), increase in size in 3 (20%) and unspecified in 6 (40%) aneurysms (Table 6). In a patient with 3 CMAs, one CMA showed complete resolution and one CMA decreased in size following antibiotic treatment but the third aneurysm necessitated an interventional therapy. In another patient, antibiotic treatment dwindled one of his 2 CMAs and the other enlarged aneurysm was coiled successfully. Another 2 patients had 3 and 2 CMAs respectively, and all of which were successfully interventionally treated. Of them, 3 (5.4%) patients had twice interventions due to recurrent aneurysms. Totally 62 aneurysms of 56 patients were interventionally treated (Table 7). In the interventionally treated patients, the parent vessel was sacrificed in 5 (8.9%) patients. Two (3.6%) patients had hematoma

Table 6 – Results of mycotic aneurysm treatment, *n* (%).

Treatment	Complete resolution	Decrease in size	No change	Increase in size	Not stated
Conservative	8 (47.1)	1 (5.9)			8 (47.1)
Craniotomy	3 (33.3)	1 (11.1)			5 (55.6)
Interventional	15 (30.6)				34 (69.4)
Surgical	13 (36.1)				23 (63.9)
Untreated	2 (66.7)				1 (33.3)
Not stated	6 (33.3)	3 (16.7)	6 (33.3)	3 (16.7)	

Table 7 – Interventional material.

Interventional material	*n* (%)
Coil	32 (51.6)
Guglielmi detachable coil	7 (21.9)
n-Butyle-2-cyanoacrylate	2 (6.3)
Onyx	2 (6.3)
Platinum	2 (6.3)
Polyvinyl alcohol	2 (6.3)
Unspecified	17 (53.1)
Glue	25 (40.3)
Cyanoacrylate	14 (56)
Unspecified	11 (44)
Coil + glue	3 (4.8)
Stent	2 (3.2)

evacuation, 1 (1.8%) patient had duraplasty and 1 (1.8%) patient had ventriculostomy. In the surgical patients, surgical techniques for the aneurysms included 17 (47.2%) clippings, 16 (44.4%) aneurysmal excisions, 1 (2.8%) excision with clipping, 1 (2.8%) excision with superficial temporal artery-MCA bypass and 1 (2.8%) clipping with ligation. Of the surgical patients, hematoma evacuation was performed in 8 patients, and external ventricular drainage was performed 4times for 3 patients (one of them had twice external ventricular drainages and once hematoma evacuation). Two (11.8%, 2/17) patients had hematoma culture, one was negative and the other was positive for Streptococcus viridans.

Five (3.9%) patients had a subacute IE. In 46 patients, pathologies secondary to IE were reported including valvular insufficiency/stenosis in 39 (84.8%) (mitral insufficiency in 20 [51.3%], mitral prolapse in 7 [17.9%], aortic and mitral insufficiency in 5 [12.8%], aortic insufficiency in 4 [10.3%], and aortic stenosis and insufficiency, mitral and tricuspid insufficiency, and mitral stenosis and insufficiency in 1 [2.6%] patient each), vavular perforation in 8 (17.4%), chord rupture 4 (8.6%), abscess formation 2 (4.3%), and fistula, posterior column (papillary muscle?) damage and valve destruction in 1 (2.2%) each. At least three patients had prosthetic valve disorders. Treatment of IE was described in 65 patients: 27 (41.5%) were conservatively and 38 (58.5%) were surgically managed. The surgical treatment included mitral valve replacement in 14 (36.8%), mitral valve repair in 5 (13.2%), aortic valve replacement in 4 (10.5%), aortic and mitral valve replacements in 3 (7.9%), aortic valve replacement with mitral valve repair in 2 (5.3%) and unstated operation in 10 (26.3%). The time interval between neurological and cardiac operations was 1.2 ± 1.9 (range, –0.5–8; median, 0.69) months (n = 24) (in 3 [12.5%] patients with a cardiac operation ahead of neurological operation, the time interval was recorded as minus). Four patients had vegetation culture and 1 patient had resected valve culture, with 3 negative and 2 positive (for *Enterococcus faecalis* and coagulase-negative *Staphylococcus*, respectively). Patients were at a follow-up of 9.9 ± 9.5 (range, 1.5–48; median, 6) months (n = 36). Prognosis was described for 112 patients with 48 (42.9%) full recoveries, 44 (39.3%) improvements, 2 (1.8%) complicated, 2 (1.8%) vegetative and 16 (14.3%) deaths.

Univariant analysis revealed the development of herniation (p = 0.049), parent vessel involvement (p = 0.020), aneurysm rupture (p = 0.002) and non-surgical/interventional treatment of the aneurysms (p = 0.007) were associated with increased mortality.

Discussion

Mycotic aneurysms are rare inflammatory neurovascular lesions, comprising 0.7–5.4% of all intracranial aneurysms. Sixty five percent of CMA patients have an underlying IE etiology. Other common sources of infection are intravenous drug abuse (6.3%), bacterial meningitis (5.2%), poor dental hygiene (4.2%) and cavernous sinus thrombosis (2.8%) [75].

CMAs occur more frequently in the course of acute IE rather than in the subacute course [76]. *Streptococcus viridans* and *Staphylococcus aureus* are the most common organisms that cause infective endocarditis. As a result they also are the two pathogens most frequently associated with CMA, a complication of IE [6]. CMAs develop secondary to IE when cardiac vegetations are friable prone to septic emboli lodging into the intracranial vessels usually the branches [42]. Pathological studies of the cerebral aneurysm revealed a large number of neutrophils invading arterial walls. The diagnosis of mycotic aneurysm and bacterial vasculitis was supported by the presence of IE [56]. Histopathology of the biopsy specimen showed acute or chronic inflammatory lesion with granulation tissue formation, blood clot and organizing thrombus [77]. The acute inflammation leads to neutrophils infiltration followed by degradation of the media and adventitia, fragmentation of the internal elastic lamina and proliferation of the intima. The weakened vessel wall in combination with the pulsatile pressure in the vasculature leads to an

aneurysm formation and consequential growth [75]. Cytokines and the formation abnormality of collagen fibers are liable to aneurysmal formation [51].

As silent CMAs are pending to rupture and thus potentially lethal, cerebral angiographic studies are recommended in patients with IE [78]. Typically CMAs are multiple, distal, and fusiform aneurysms, but the angiographic and clinical presentations can vary significantly. The most common presentation of CMA is intracranial hemorrhages [6]. Computed tomography scan, magnetic resonance imaging and digital subtraction angiography are the commonly used imaging procedures in CMA. The important imaging findings are subarachnoid hemorrhage or intracerebral hemorrhage in a patient with ruptured CMA [79]. Other findings may include infarct, edema, hydrocephalus, or rarely subdural hematomas [6]. Digital subtraction angiography confirmed the diagnosis, delineated anatomical details and later detected the complete resolution of the aneurysm following conservative management with intravenous antimicrobial agents [6]. Septic infarct is more common than intraparenchymal hemorrhage where the bleeding can be subarachnoid, intraparenchymal, or intraventricular [75].

Unruptured CMA may have a spontaneous obliteration in most cases [8]. The management of a CMA depends on the presence or absence of hemorrhage, anatomic location and clinical course [80]. As antimicrobial therapy may take effect for CMAs, conservative regimens are therefore preferred in some institutes [60]. Endovascular techniques are popularly recognized for the management of all types of CMAs. The advantages of endovascular therapy over surgery are a decreased risk of anesthesia, rapid anticoagulation therapy and avoidance of delay for aneurysmal treatment and cardiac surgery. A major indication for endovascular therapy would be a patient with high surgical risk, a patient candidate for cardiac surgery [75], and a surgically inaccessible or multiple CMAs [15]. The choice between open surgery and endovascular management and between preservation and sacrifice of the parent vessel depends primarily on a multiple factors including the morphology and location of the aneurysm [75]. In patients with intracranial hemorrhage, surgery should be postponed for 2–3 weeks [1]. Some author recommended postponing it for 4–6 weeks [81]. CMAs with a well-defined neck can be subjected to direct clipping [49]. Endovascular treatment is recommended for CMAs, if there is no severe mass effect [1]. Endovascular coiling has been successfully performed as early as 1 day before valve replacement [82].

The timing of cardiac surgery is sometimes difficult to determine as heparinization and hypotension during cardiopulmonary bypass or postoperative anticoagulant therapy are liable to amplify the cerebral damage [7]. Cardiac surgery within 3 days is indicated for the patients with severe heart failure, uncontrolled infection, abscess, or persisting high emboli risk; otherwise a 4-week delay is warranted [83]. If bacteremia and cardiac failure can be controlled, antibiotic regimens and the direct attachment of clips may be effective therapies [24]. An interval of 2–3 weeks between clipping or surgical excision of the aneurysm and the cardiac procedure is recommended in patients with ruptured CMAs [66]. It was hypothesized that introducing the foreign material into the CMA may increase the opportunity of infection and rupture [84]. However, no postprocedural infections or abscesses were found in the interventionally treated patients [75]. Comparisons between surgical clipping and endovascular treatment showed that coiling was associated with a better outcome [85]. Ruptured CMAs are generally managed by surgery. The commonly used procedures are clipping, trapping, anastomosis and proximal ligation [6]. Patients with ruptured aneurysm with hematoma and mass effect would require urgent surgery [6].

The prognosis of these patients depends on the prompt recognition and early aggressive treatment. Both endovascular and surgical techniques are safe and effective options that have been shown to increase survival when compared to conservative management alone [82]. Follow-up angiographic results were better with clipping, as total aneurysm occlusion was 81.4% of the patients in comparison to 57.5% in the patients with coiling [86]. Technical success (aneurysm occlusion without rupture or recanalization) and clinical success (no neurologic complication attributable to the intervention) were obtained equally endovascularly and neurosurgically [82]. Anticoagulation needed reversal before craniotomy for clipping after valve replacement [82].

Conclusions

The CMA is infrequent, and it is rare as a consequence of IE. The CMAs are risky due to their potential consequences of cerebral hernia and aneurysmal rupture. The treatment of this entity is always challenging as it is difficult to determine the timing of the cerebral and cardiac operations concerning the necessity of heparinization in cardiac surgery. Management of multiple or recurrent CMAs is even more complex considering the diverse choices of treatment in relation to the locations, sizes and time of occurrence of the CMAs. The CMAs are curable to either conservative, interventional, or surgical treatment in selected patients. Cardiac operation should be postponed unless there is severe heart failure. At least a 2-week interval between clipping or surgical excision of the aneurysm and the cardiac procedure is recommended in patients with a ruptured CMA. Sufficient antibiotics have to be used in IE patients in order to prevent from the potential consequence as CMAs.

Conflict of interest
None declared.

Ethical statement
Authors state that the research was conducted according to ethical standards.

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