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Exploring the relationship between embolic acute stroke distribution and supra-aortic vessel patency: key findings from an in vitro model study

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ABSTRACT

Background We investigated differences in intracranial embolus distribution through communicating arteries in relation to supra-aortic vessel (SAV) patency.

Methods For this experimental analysis, we created a silicone model of the extracranial and intracranial circulations using a blood-mimicking fluid under physiological pulsatile flow. We examined the sequence of embolus lodgment on injecting 104 frangible clot analogues (406 emboli) through the right internal carotid artery (CA) as SAV patency changed: (a) all SAV patent (baseline), (b) emboli from a CA occlusion, (c) emboli contralateral to a CA occlusion and (d) occlusion of the posterior circulation. The statistical analysis included a descriptive analysis of thrombi location after occlusion (absolute and relative frequencies). Sequences of occlusions were displayed in Sankey flow charts for the four SAV conditions. Associations between SAV conditions and occlusion location were tested by Fisher's exact test. Two-sided p values were compared with a significance level of 0.05.

Results The total number of emboli was 406 (median fragments/clot: 4 (IQR: 3–5)). Embolus lodgment was dependent on SAV patency (p<0.0001). In all scenarios, embolism lodging in the anterior cerebral artery (ACA) occurred after a previous middle cerebral artery (MCA) embolism (MCA first lodge: 96%, 100/104). The rate of ipsilateral ACA embolism was 28.9% (28/97) at baseline, decreasing significantly when emboli originated from an occluded CA (16%, 14/88). There were more bihemispheric embolisations in cases of contralateral CA occlusion (37%, 45/122), with bilateral ACA embolisms preceding contralateral MCA embolism in 56% of cases (14/25 opposite MCA and ACA embolism).

Conclusions All emboli in the ACA occurred after a previous ipsilateral MCA embolism. Bihemispheric embolisms were rare, except when there was a coexisting occlusion in either CA, particularly in cases of a contralateral CA occlusion.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Multiple acute cerebral emboli can occur simultaneously through different supra-aortic vessels, but they have also been described in large artery disease. It is possible that emboli may be distributed through communicating arteries and influenced by concomitant stenosis or occlusion of supra-aortic vessels. This study aims to analyse the distribution patterns of cerebral emboli through communicating arteries based on the patency of supra-aortic vessels.

WHAT THIS STUDY ADDS

⇒ The study highlights how the distribution of emboli through the communicating arteries can be influenced by occlusion of the supra-aortic vessels. According to the findings, the middle cerebral artery was the most common site of first embolic stroke, making the possibility of isolated distal occlusion of the anterior or posterior cerebral artery very unlikely. As a rule, occlusion of one carotid artery during recurrent embolism significantly increased the rate of emboli crossing the midline, and bilateral anterior cerebral artery emboli were more frequent in cases of contralateral carotid occlusion.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study suggests that patients with severe neurological deficits and a single distal embolus in the anterior or posterior cerebral artery may still have some residual or transient neurological symptoms from a rapidly recanalised middle cerebral artery. However, in clinical practice, it is important to consider all possible differential diagnoses for isolated acute anterior and posterior cerebral artery occlusions since isolated emboli in these arteries are rare. This information can be helpful for clinicians in identifying the location and severity of the stroke, determining the source of the embolisms and stabilising the appropriate treatment plan.

INTRODUCTION

A single acute ischaemic lesion in the anterior or posterior circulation has been observed in 60%–91% of patients who have suffered ischaemic stroke.[1–4] In contrast, multiple acute ischaemic lesions affecting both the anterior and posterior circulations ranged from 5%–9% of total ischaemic

strokes,[1 4–6] increasing up to 19%–22% when multiple infarcts involved the unilateral or bilateral anterior circulation.[1 2 4] Although typically associated with cardioembolic disease, large artery disease is the second most common cause of multiple acute infarcts.[3 6 7] Thus, in 10% of cases, unilateral carotid occlusions can yield bihemispheric acute infarcts,[2 8] simultaneous anterior circulation and posterior cerebral artery (PCA) infarctions,[9] as well as contralateral infarctions.[10] In addition, coexisting causes of acute ischaemic stroke, probably much more prevalent than formerly accepted in stroke registries, have been reported in up to 7% of cases. Here, the most common association is a cardiac source of embolisms together with carotid artery (CA) stenosis 'of more than 50% on the appropriate side'.[11 12]

Clot fragmentation as a result of the physiological thrombolysis process[13] or facilitated by intravenous thrombolysis[14] can produce smaller emboli that can travel and embolise smaller vessels peripheral to the initially occluded artery.[15] Furthermore, physiological clearance of small emboli may be decreased by chronic hypoperfusion when a CA stenosis coexists.[16] In this context, it is reasonable to anticipate higher frequencies of small infarctions 'in the same vascular territory'. Nonetheless, a larger proportion (65%–80%) of multiple acute ischaemic lesions has been described as being distributed across 'different vascular territories' rather than in 'the same vascular territory'.[1 4] In this regard, an emboli shower from cardioembolic disease through different supra-aortic vessels (SAV) may well involve more than just one vascular territory,[17] but there may also be other mechanisms. One hypothesis could be that embolisms through a single extracranial artery tend to fragment into smaller pieces before lodging intracranially, for example, on their way up along the loops of the internal CA (ICA). They can then be distributed intracranially one by one through the pathways of the circle of Willis mediated by the communicating arteries, whose flow and direction could be influenced by stenosis of the SAV.

We postulated that the distribution of intracranial embolus lodgment may be variable, but distinct depending on the patency of the SAV when multiple acute thromboembolic events occur. For this experimental study, we injected fragile red blood cell (RBC)-rich thrombi into the right CA of a human-like vascular model of the intracranial and extracranial vessels modelled with a complete circle of Willis under physiological flow and pulse conditions. These thrombi fragmented upon injection, simulating recurrent acute embolism. We analysed the sequence of lodgments under four different anatomical SAV conditions: baseline, embolic source from a CA occlusion, embolic source contralateral to an occluded CA and emboli from the CA with concomitant occlusion of both vertebral arteries.

MATERIALS AND METHODS

The authors declare that the article and its supplemental online files have included all supporting data. In this in vitro experimental investigation, 104 frangible clot analogues were injected sequentially into the right CA of a silicone vascular model of the human intracranial circulation, including all communicating arteries and the extracranial region of both carotid and vertebral arteries. Clots spontaneously fragmented after clot injection under physiological flow (blood mimics) and pulse conditions (peristaltic pump), resulting in a total of 406 emboli.

This study has examined the sequence of embolisms in the different intracranial vascular territories and compared distinctive allocation features as a function of four different patency states of the SAV.

Vascular model

A vascular model from the neck arteries to the intracranial circulation was created and printed in silicone based on Digital Imaging and Communication in Medicine (DICOM) images from three-dimensional angiography from a real patient (Vascular Simulations, Stony Brook, New York, USA). The wall thickness of the intracranial vessels was 1.3 mm. The vessels extended up to the M3–M4 segments of the middle cerebral artery (MCA), the bilateral distal A2 segments of the anterior cerebral artery (ACA) including an anterior communicating artery (ACoA), and the two posterior communicating arteries (PCoA), followed by the bilateral PCAs up to the P3 segments. This model had no external carotid arteries.

The model was encased in a plexiglass container and placed in Head Gel (Vascular Simulations) to simulate the stiffness of the intracranial vascular environment. An ultrasound-compatible blood-mimicking fluid (Shelley Medical, Toronto, Canada) was used inside a closed-loop system connected to a peristaltic pump (FlowTek 125, United Biologics, Irvine, California, USA). The four neck vessels were perfused by four separate inflows. There were also four independent outflows from the model (one for each of the MCA territories, one for both ACA territories and the last draining both PCAs). There was a separate filter and reservoir for each of the four outflows to protect the pump from macroscopic debris. The pump parameters used were a pulse of 70 and a flow rate of 31%, resulting in velocities of 106 cm/s in the ICA, 118 cm/s in the MCA and 76 cm/s in the ACA, measured and controlled with a paediatric linear array transducer.

Clot production

The thrombus analogues used in this study were made from venous sheep's blood mixtures with a high RBC concentration using regular plasma without additional enrichment with fibrinogen or platelets. This method delivers very low levels of fibrin and platelet content, reducing the clot fracture toughness (friable clot analogues).[18] A detailed description is also given in online supplemental material.

Histology

To confirm the RBC-dominant nature of the clot analogues, each clot was histologically analysed using H&E. The results indicated that all thrombi consisted of more than 95% RBC, with no variations observed between readers (AJ senior neuropathologist and AVG neuroradiologist).

Clot injection and data assessment

The vascular model was tested with multiple clot injections from both carotid arteries to verify the correct permeability of printed vessels. For the experiments, each clot, approximately 1 cm in length, was carefully injected through a three-way connector system coupled to the right CA under continuous slow anterograde flow of the pump. Special care was taken to ensure that no air bubbles entered the system during this process. Once the unbroken clot analogue emerged from the connector into the common CA, manual injection was stopped and the pump parameters were slowly reset to 31% flow and a pulse rate of 70. This resulted in fragmentation of the clot as it passed from the common to the ICA, simulating the occurrence of recurrent acute embolisms through the right CA.

The experiments were video recorded and the data on the sequence of emboli lodgment analysed for each of the four vascular scenarios considered: (a) SAV without stenosis (injected clots: 29); (b) emboli through the right CA with occlusion of the left CA (injected clots: 24), (c) emboli from an occluded right CA (injected clots: 25) and (d) emboli through the right CA with concomitant occlusion of both vertebral arteries (injected clots: 26). Scenario b simulates the occurrence of multiple emboli through a completely patent CA while there is a 'silent' occlusion of the contralateral CA. On the other hand, scenario c simulates emboli from an occluded CA, where the source of the emboli is the ipsilateral CA occlusion.

External reversible clamping was used to create extracranial arterial occlusion. To simulate emboli from an occluded CA (scenario C), a clamp was placed below the entry point of the clots. The thrombi were injected gently and reached the intracranial ICA under the effect of the reversal flow of the communicating arteries. They fragmented on their own under normal pumping conditions. Each experiment ended when the last embolic fragment of each injected clot anchored. We then proceeded to release the occlusion site, if necessary, and to remove the embolic fragments by increasing pump flow and/or external manipulation.

Statistical analysis

Statistical analyses were performed by using SPSS V.26/2019 (IBM). Categorical variables were represented as absolute and relative frequencies and continuous variables with median and IQR values. Markov Chain Monte Carlo estimated p values were used to compare categorical variables and the Kruskal-Wallis test for pairwise comparisons of the continuous variables. P values ≤0.05 were deemed to indicate statistically significant differences. All reported p values were two sided. Sankey flow diagrams were prepared using R (V.4.3.1) to evaluate and compare the sequence of embolus lodges with regard to the patency status of the SAV.

RESULTS

General

The total number of embolus lodges was 406, with a minimum of one and a maximum of eight lodgments after clot injection (median number: 4, IQR 3–5). Fragment allocation by SAV condition was (a) All SAV patent: 97 emboli from 29 injected thrombi; (b) contralateral CA occluded: 122/24; (c) ipsilateral CA occluded: 88/25 and (d) both vertebral arteries occluded: 99/26. Although the different thrombus preparation methods exhibited similar fragmentation capacities (online supplemental table S1), the anatomical condition of the SAV influenced the fragmentation capacity. Specifically, ipsilateral thrombus injection with coexisting contralateral carotid vessel occlusion (condition b) was associated with more fragmentation (condition b vs a or c, p<0.0001; condition b vs d, p=0.006).

The ipsilateral MCA was the most common first and second lodge (96.2 %, 100/104 and 37%, 38/103, respectively), with ACA emboli accounting for 35.9% (37/103) of second and 33.3% of third (30/39) lodges. Figure 1 shows the sequence of emboli lodge locations (from 1 to 8) for the four SAV conditions studied (a detailed description is also given in online supplemental table S2). Overall, ipsilateral embolisms in the ACA nearly doubled those in the ipsilateral PCA (24.4% (99/406) vs 13.8% (56/406)), but none anchored directly in the ACA as the 'first lodge' in any of the SAV conditions tested. Embolus lodges differed depending on the patency of the carotid or vertebral arteries (p<0.0001). The rate of contralateral embolism was lowest (1%, 1/97) when all four cervical vessels were patent. This contrasted with the embolus distributions observed when one of the CA was occluded. A detailed description is presented in the respective sections below and in table 1 and figure 2 (Sankey flow maps), as well as in online supplemental table S3 and figure S1.

Embolisms from an occluded CA (ipsilateral CA occlusion)

After an initial lodge in the MCA (92%, 23 of 25 first lodges), this condition (n=88) showed the highest variability in possible further embolisation sites. Overall, floating emboli in the distal ICA were observed more frequently (11.4%, 10/88) than in the other SAV conditions. While the rate of PCA embolisation remained similar to that observed in the baseline SAV condition (13.6%, 12/88 vs 11.3%, 11/97), there was an appreciable reduction in the number of ipsilateral ACA emboli (16%, 14/88 vs baseline 28.9%, 28/97).

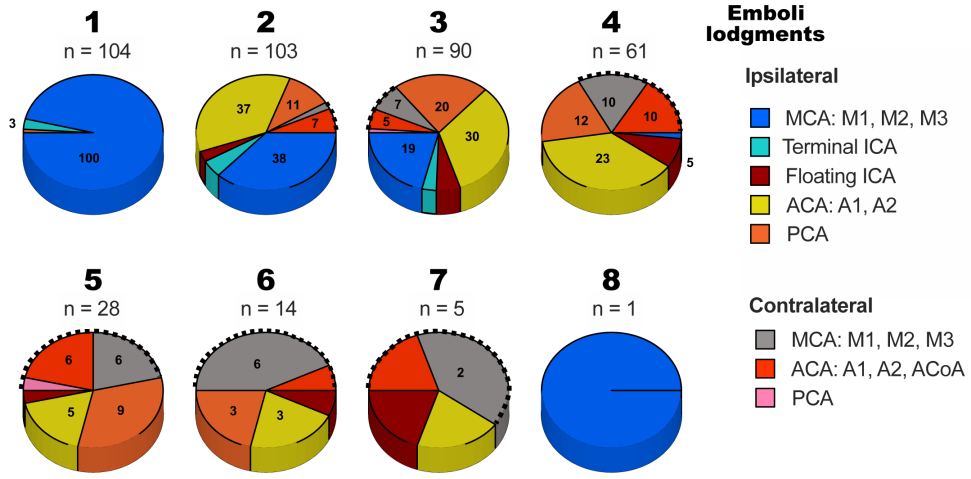

Figure 1 Sequential lodges by the 406 total emboli for the four anatomical conditions of the supra-aortic vessels tested. After fragmentation, the median number of lodgments per clot was four, with a minimum of 1 and a maximum of 8. The number indicated over each graphic (ranging from 1 to 8) is the sequential number of lodgments referred to in that chart. See the online supplemental table S1 for a more detailed description. ACA, anterior cerebral artery; ICA, internal carotid artery; MCA, middle cerebral artery; PCA, posterior cerebral artery.

Despite the higher likelihood of contralateral embolisations in this SAV condition (16%, 14/88 vs baseline 1%, 1/65), ipsilateral ACA lodging, as a prestep for emboli to cross the midline, was very rare (1 out of 12 contralateral MCA and ACA lodges). Hence, emboli in both ACAs were very uncommon for this condition. In addition, two cases of bilateral MCA emboli without ACA involvement and the only two cases of contralateral PCA emboli in this study were observed under this SAV condition.

Embolic source contralateral to the carotid occlusion

There was greater variability in the possible embolic sites in this condition, as illustrated by the numerous flow lines on the corresponding flow map (figure 2). Compared with the previous condition (emboli from an occluded

Table 1 Frequency of intracranial lodgment of clot fragments for the four SAV conditions tested

Embolus location	Total emboli* (n=406)	Patent SAV (n=97)	Ipsilateral CA occluded (n=88)	Contralateral CA occluded (n=122)	Vertebral arteries occluded (n=99)	P value
Ipsilateral MCA	159 (39.2%)	47 (48.5%)	33 (37.5%)	39 (32%)	40 (40.4%)	<0.0001
Ipsilateral A1 and A2 segments	99 (24.4%)	28 (28.9%)	14 (15.9%)	30 (24.6%)	27 (27.3%)	
Ipsilateral PCA	56 (13.8%)	11 (11.3%)	12 (13.6%)	8 (6.6%)	25 (25.3%)	
Contralateral MCA	33 (8.1%)	0 –	7 (8%)	25 (20.5%)	1 (1%)	
Contralateral A1 and A2 segments+ACoA	30 (7.4%)	1 (1%)	5 (5.7%)	20 (16.4%)	4 (4%)	
Floating ICA thrombus	16 (3.9%)	6 (6.2%)	10 (11.4%)	0 –	0 –	
Terminal ICA	11 (2.7%)	4 (4.1%)	5 (5.7%)	0 –	2 (2%)	
Contralateral PCA	2 (0.5%)	0 –	2 (2.3%)	0 –	0 –	

Markov Chain Monte Carlo estimated p value.
*Fragments of the same clot repeating an anchor location have also been included.
ACoA, anterior communicating artery; CA, carotid artery; MCA, middle cerebral artery; PCA, posterior cerebral artery; SAV, supra-aortic vessel.

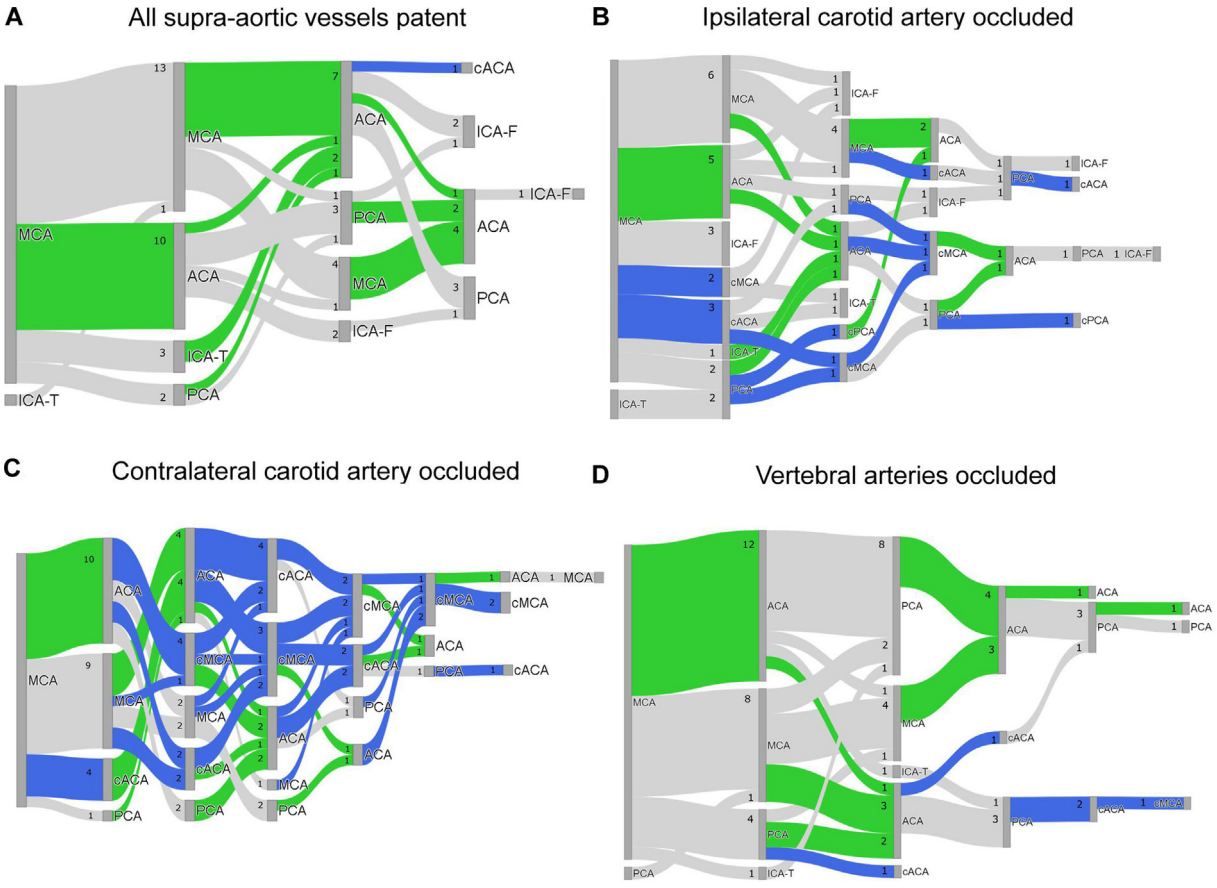

Figure 2 Sankey flow diagrams of sequential embolic lodgments by anatomical condition of the supra-aortic vessels. The diagram shows the flows and their relative quantities in proportion to each other. Vertical coloured lines represent each lodgment (first, second, third, etc). Horizontal flow lines represent the relative quantity of fragments anchored at a particular intracranial location after a specific prior clot allocation. Emboli that migrated to the opposite hemisphere are shown in blue. Emboli that travelled to the ipsilateral ACA are shown in green. (A) Baseline: supra-aortic vessels without occlusion (97 emboli from 29 injected clots); (B) Emboli from an occluded right CA (88/25); (C) Emboli through the right CA with occlusion of the left CA (122/24); (D) Emboli through the right CA with concomitant occlusion of both vertebral arteries (99/26). ACA, anterior cerebral artery; CA, carotid artery; ICA-T, terminal internal CA; MCA, middle cerebral artery; PCA, posterior cerebral artery.

CA), the rate of ipsilateral ACA emboli increased (24.6%, 30/122 vs 16%, 14/88), as did the rate of contralateral emboli (37%, 45/122 vs 16%, 14/88). Overall contralateral ACA emboli were observed in 16.4% of cases (20/122) and contralateral embolisms in the MCA in 20.5% of cases (25/122). These contralateral MCA emboli could occur without any ACA involvement, as they did in two cases (bilateral MCA occlusion in 8%, 2/25), but they were usually preceded by ipsilateral ACA embolisation (36%, 9/25) and more commonly by bilateral ACA embolisms (56%, 14/25). The overall rate of bilateral ACA embolisations observed was 21.3% (26/122).

Embolisms originating from the right CA while both vertebral arteries were closed

In comparison, this condition (n=99) displayed the highest rate of embolisms in the ipsilateral PCA (25.3 %, 25/99), with a percentage of ipsilateral ACA embolisms similar to in the baseline situation (27%, 27/99 vs baseline 29%, 28/97) and a relatively low rate of contralateral embolisms (5%, 5/99 vs baseline 1%, 1/97). An embolus entered the PCA as the first lodgment in only one case. Among other combinations, most of the remaining PCA emboli occurred after ipsilateral occlusion of the MCA and ACA vessels (60%, 15/25) or after previous ipsilateral MCA occlusion (24%, 6/25). No contralateral PCA emboli were observed in this condition.

DISCUSSION

Our study has demonstrated how changes in the patency of the SAV influence the spread of emboli in intracranial vessels through the communicating arteries. When all the SAVs were open, the overall rate of occurrence of emboli in the ipsilateral ACA territory was more than twice that in the PCA territory (29% vs 11%), and the occurrence of emboli crossing from one hemisphere to the other was a very uncommon event (1%). As a rule, occlusion of one CA during recurrent embolism significantly increased the rate of emboli crossing the midline. When the embolic source was a carotid occlusion with normal contralateral CA, the overall rate of ipsilateral ACA emboli decreased to

the level of the PCA emboli and the likelihood of floating ICA thrombi increased (11%). In general, contralateral events required at least one previous anchorage in the ipsilateral MCA and were very unlikely unless one of the carotid arteries was occluded. In fact, they were most frequent when the contralateral CA was occluded and embolisms occurred through the normal lumen ipsilateral CA (37%, including contralateral ACA and MCA embolisms). In addition, an important observation in our study was that none of the emboli in the ACA occurred as a first lodge in any of the SAV conditions tested. This was also true for the PCA in the vast majority of cases.

The overall percentage values for emboli that we have found may appear high. However, studies of cerebral infarctions in animals using transcranial ultrasound have not detected lower occurrences of intracranial emboli.[19] Moreover, the clot analogues used in this study were rich in RBC, which have a lower fracture toughness than fibrin-rich thrombi.[18] This allowed us to produce multiple emboli from fractures of a single clot.

Consistent with the reduced rate of ipsilateral ACA involvement of emboli from an occluded carotid recorded in our study, Bogousslavsky observed sparse ACA territory infarction in patients with ipsilateral carotid occlusions (>90%) and multiple infarcts.[20] One potential explanation may be the direction of flow in the A1 segment at the time embolism occurs. Reverse flow in the A1 segment to offset high-grade CA stenosis could potentially reduce ipsilateral ACA embolisms by making navigation against the flow more difficult for emboli.[21] On the other hand, augmented anterograde flow in the ipsilateral A1 segment through the ACoA might facilitate ACA embolisations. This could explain why previous analyses of stroke distribution in patients have reported a higher incidence of ACA embolisms in the presence of contralateral CA stenosis or, functionally similar, contralateral A1 segment hypoplasia of the ACA.[2 22 23] Our findings also support this hypothesis, with higher rates of ACA emboli being recorded when the acute multiple embolisms occurred contralateral to an occluded CA.

There have been a few reports of isolated embolisms in the ACA or PCA.[15] Both distal occlusions can exhibit typical symptoms of MCA occlusion. Therefore, it may be difficult to attribute neurological symptoms to one artery or the other.[24 25] Our results suggest that embolisms from the anterior circulation to ACA or PCA territories should not occur without at least one prior embolism in the ipsilateral MCA territory. Regardless of how they arrive, whether from the opposite hemisphere via the ACoA or from downstream, emboli are less likely to spontaneously dissolve in cases of restricted anterograde flow, that is, proximal arterial stenosis.[16 26] This implies that in the case of bihemispheric emboli, those lodged in a hemisphere devoid of stenosis are more susceptible to lysis. Additionally, the speed of neurological recovery in patients after arterial recanalisation varies.[27 28] These factors may also mask the underlying stroke aetiology in patients with multiple acute strokes and CA stenosis. In this respect, patients with a high initial National Institute of Health Stroke Scale (NIHSS) score and a single distal embolus in the ACA or PCA on imaging may still have some residual or transitory neurological symptoms from a rapidly recanalised concomitant MCA occlusion. It is unclear whether overlapping symptoms, missed infarcts on imaging or difficulties in identifying or allocating transient symptoms could contribute to possible underestimation of concomitant infarction in the MCA territory.

Our results suggest that a causal association between isolated ACA occlusion and ipsilateral extracranial CA occlusion should be approached cautiously and all other differential diagnoses considered. Furthermore, additional supporting evidence such as simultaneous ischaemia in the ipsilateral MCA territory would be helpful since in our experimental study there was no ACA involvement without prior MCA embolism. Although uncommon, it has implications for the medical therapy for acute stroke as well as for the indications and performance of mechanical thrombectomies. It is crucial to evaluate all possible routes for intracranial embolism. Endovascular procedures can be challenging in cases where chronic extracranial occlusions of the CA are asymptomatic and do not directly cause embolisms. In some cases, anterograde access through the occlusion might not be possible. Alternatively, a complex vascular access route from the opposite cerebral circulation through the small communicating arteries might be required, thereby increasing the risk of severe complications.[29]

Limitations

This experimental study has several limitations. The study did not explore the variations of the circle of Willis, which would undoubtedly affect the distribution of intracranial emboli. Although there was similar clot frangibility depending on the production method, there were more clot fragments when the embolic source was contralateral to carotid occlusion. While several factors could contribute to this variation (the force applied in clot injection, unnoticed variations in pump flow), the anatomical condition tested and the associated flow distribution provide a reasonable explanation. In a closed vascular model like ours, the spared flow from the contralateral carotid occlusion would be distributed to the other patent SAV, which might result in higher anterograde flow and contribute to mechanical clot fragmentation. Clot fragmentation in our study occurred as the clot passed from the common to the ICA, especially at the carotid siphon level. Differences in the tortuosity of the terminal ICA or the outflow angles of the ACA and the MCA could also affect outcomes.[30] Moreover, fluctuations in the standard pump velocities used in this study could potentially influence the total count of fragments generated or, to a lesser extent, the intracranial distribution of the emboli.

We reported all macroscopic clot fragments that were anchored in the model, including recurrent emboli in the same vascular territory. Thus, the overall percentages of embolus lodges should be interpreted with caution.

Microemboli were not monitored or assessed. Moreover, working with highly frangible RBC-rich clots might underestimate the rate of terminal ICA occlusion, which could in turn influence the incidence of PCA emboli in our study. Furthermore, no assessment of cerebellar emboli from the anterior circulation was feasible, in that only the vertebral arteries and both PCoA and PCA were modelled.

The histology of thrombi from carotid plaques may differ from the red thrombi used in this study, which could affect their tendency to fragment. The study focuses on assessing the haemodynamics and successive anchoring of thrombi, which may vary depending on various factors, including histology. Therefore, replication of this experimental study with other clot types or other pump hemodynamics could change the results.[17]

CONCLUSIONS

Bihemispheric stroke occurred preferentially in cases of CA occlusion. Embolic showers contralateral to a CA occlusion resulted in the highest embolism rates in the opposite hemisphere, with a higher rate of bilateral ACA involvement. Furthermore, emboli could cross the midline without involving the ipsilateral ACA more frequently when the embolic shower came from an occluded CA. Finally, neither ipsilateral emboli in the ACA nor contralateral events occurred without at least one previous ipsilateral MCA embolism.

Distribution of cranial emboli may vary, but the hemisphere with the largest clot burden likely indicates the primary pathway of emboli to the intracranial vessels. Nevertheless, in the acute setting, cases of multiple acute ischaemias could be underestimated and the 'causal weight' of CA stenosis overestimated since physiologically partial recanalisation will be easier in the hemisphere with normal anterograde flow.

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