Insufficient unilateral cerebral perfusion during emergent aortic arch surgery

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A 71-year old female was referred because of acute aortic dissection. The preoperative CT-angiography of the aorta revealed an aortic dissection limited to the arch only (Fig. 1). According to own classification [3], which took into consideration the distal extent of dissection (D) and the location of the intimal tear (E) in three main segments of the aorta (a, ascending aorta; b, aortic arch; c, descending aorta), it was the Type D-b, E-b. The CT-angiography revealed additionally an abnormal origin of the right subclavian artery (arteria lusoria) from distal aortic arch (Fig. 1).

The patient was operated on an emergent basis. The intraoperative neurovascular monitoring consisted of arterial pressure lines in both radial arteries, electroencephalography and near-infrared spectroscopy (NIRO 200, Hamamatsu Phototonics, Hamamatsu, Japan). For arterial return, the right common carotid artery was cannulated on the neck as described previously [4]. During cooling at the full flow of 4.0 l/min, the mean arterial pressure in the right and left radial artery was 40 and 38 mmHg, respectively, and the regional cerebral tissue oxygenation (TOI, tissue oxygen index) remained normal (67% on the right and 61% on the left). The surgery included aortic arch replacement for which mild hypothermic (31.3°C) circulatory arrest and UCP were used according to our protocol reported elsewhere [4]. For this purpose, the right carotid artery was cross-clamped and the perfusion was limited to UCP with a flow of 0.8 l/min. Immediately after initiation of UCP, a continuous drop of oxygenation on the left side was observed that reached a level of 15% after 6 min. Therefore, the second branch of the arterial line (a Y-shaped arterial line is routinely prepared for completion of bilateral perfusion, if necessary [4, 5]) was used for perfusion of the left hemisphere via the left common carotid artery. Hence, the bilateral cerebral perfusion was completed after 10 min of UCP resulting in an instant improvement of the oxygenation (60% on the right and 70% on the left), and the arch replacement was continued. Because the patient did not suffer any symptoms of compression, the arteria lusoria was not repaired; however, we are convinced that a repair of arteria lusoria can be omitted under emergent circumstances. The overall time of lower body ischaemia needed for the distal aortic anastomosis, which was performed with the aortic arch above the origin of the arteria lusoria, because there was no more dissection at this level, was 40 min and the overall time of cerebral perfusion was 90 min. The patient awoke without adverse neurological symptoms and was extubated 21 h after surgery.
subclavian artery for cannulation. This normally ensures sufficient UCP by a retrograde flow to the right carotid artery. To rely on that in the case presented would lead to catastrophic neurological consequences after clamping the presumed innominate artery which, in reality, was a right common carotid artery that originated separately.

Secondly, it emphasizes the importance of intraoperative neuromonitoring during UCP because the pathways of sufficient cross-perfusion and the role of anatomical completeness of the circle of Willis remain unclear, even if neurological results after use of UCP for brain protection are very good and insufficiency of UCP seems to be exceptional [1, 2, 4, 5]. Among 600 arch surgeries using UCP that were performed at our institution from 2002 up to date, this case was the only one in which insufficient perfusion of contralateral hemisphere could be documented. Therefore, we performed a cranial CT-angiography after surgery, which revealed incompleteness of the circle of Willis with abnormal anterior and posterior components on the right side (Fig. 2). In cases of normally originating right subclavian arteries perfusion of the right vertebral artery (which is normally ensured when right-sided brain perfusion is performed) would have led to sufficient perfusion. Nevertheless, we observed in similar cases with two or even three interruptions within the circle of Willis, which could be found in ~20% of patients, sufficient cross-perfusion [5]. Possibly, the thin-caliber vessels of the circle, which appear to be aplastic or hypoplastic in angiographic examination, often widen when the flow is impaired and this ensures sufficient cross-perfusion. A similar role can be considered for extracranial collaterals, especially in cases with incomplete circle of Willis, although, the flow in extracranial collaterals can be impaired in patients with rare arterial pathologies, especially, as in the case presented, with pathologies within the aortic arch branches.

This case additionally highlights the necessity of intraoperative monitoring, even if convincing standards revealing insufficient brain protection still do not exist. Near-infrared spectroscopy can be considered as an effective tool for detection of significant impairment of cerebral perfusion, although the reliable oxygenation threshold could not be determined up to present [6]. Therefore, further investigations are necessary to find out the values that indicate critical perfusion and the appropriate strategy to ensure complementation of bilateral cerebral perfusion when UCP is used during arch surgery.

ACKNOWLEDGEMENTS

Sadly, during the preparation of this paper, Steffen Fröhner died unexpectedly. His fellow co-authors would like to dedicate this paper to his memory. Additionally, the authors would like to thank Melissa Lindner, Alexandra Metz, and Bianca Müller for preparing this article.

Conflict of interest: none declared.

REFERENCES

eComment. The origin of the right vertebral artery?

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doi: 10.1093/icvts/ivr042A
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We have read with interest the article from Urbanski and colleagues [1]. With the advent of precise non-invasive imaging techniques, such as computed tomography scan and magnetic resonance angiography, arch anomalies are easily recognized.

In the arteria lusoria configuration, four vessels arise sequentially from the aortic arch: the right common carotid artery, the left common carotid artery, the left subclavian artery, and the aberrant right subclavian artery. The latter arises on the left side of the thorax as the last branch of the aortic arch, and has to cross upwards and to the right behind the oesophagus in the majority of cases. The right vertebral artery arises from the lusoria artery but it can also originate from the proximal segment of the right common carotid artery [2].

It is well established that the safety and adequacy of unilateral cerebral perfusion through the right axillary artery in patients with normal arch vessel origin depend on an intact circle of Willis [3]. In the arteria lusoria configuration, we agree with Urbanski and colleagues that performing right subclavian perfusion for cerebral protection is valueless [1]. A direct cannulation of the right carotid artery is, in our opinion, insufficient in patients with arteria lusoria, unless the right vertebral artery originates from the right carotid artery.

In the absence of aortic arch vessel anomalies, right subclavian cannulation ensures sufficient perfusion for both cerebral hemispheres, independent of the integrity of the circle of Willis, because two cerebral arteries (carotid and vertebral) are perfused through the right axillary or right subclavian artery. The vertebrobasilar system, which supplies blood to the posterior part of the circle of Willis, also contributes to the perfusion of the medulla via the anterior spinal artery, thus ensuring sufficient blood for spinal protection during circulatory arrest.

Recognizing the aberrant course of the right vertebral artery, especially in the setting of aortic arch anomalies, may be helpful in planning the best cerebral protection when performing arch surgery.

Conflict of interest: none declared.

References