REVIEW ARTICLE

"Open" approach to aortic arch aneurysm repair☆

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Aortic arch aneurysm is a relatively rare entity in cardiac surgery. Repair of such aneurysms, either in isolation or combined with other cardiac procedures, remains a challenging task. The need to produce a relatively bloodless surgical field with circulatory arrest, while at the same time protecting the brain, is the hallmark of this challenge. However, a clear understanding of the topic allows a better and less morbid approach to such a complex surgery.

Literature has shown the advantage of selective cerebral perfusion techniques in comparison with only circulatory arrest. Ability to perfuse the brain has allowed circulatory arrest temperatures at moderate hypothermia without the need for deep hypothermia. Even though cannulation site selection appears to be a minor issue, literature has shown that the subclavian/axillary route has the best outcomes and that femoral cannulation should only be reserved for no access patients. Although different techniques for arch anastomosis have been described, we routinely perform the distal first technique as we find it to be less cumbersome and easiest to reproduce.

In this review our aim is to outline a systematic approach to aortic arch surgery. Starting with indications for intervention and proceeding with approaches on site of cannulation, approaches to brain protection with hypothermia and selective cerebral perfusion and finally surgical steps in performing the distal and arch vessels anastomosis.

Keywords: Aortic arch aneurysm, Open repair, Hypothermic circulatory arrest, Selective cerebral perfusion, Distal first anastomosis

Contents

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Introduction

Open repair of aortic arch aneurysms is a procedure that carries high risk of morbidity and mortality. The approach to open repair is complex, as it requires arresting circulation to allow for a bloodless field while at the same time ensuring the safety of the central nervous system.

In this article, we review some aspects of ''open'' repair of aortic arch aneurysms. We review guidelines on indications for intervention in arch aneurysms, assess the evidence behind different cannulation strategies, optimal circulating temperatures, adjuvant cerebral protection strategies, and surgical techniques in the ''open'' repair of arch aneurysms.

Glossary of abbreviations

TAA	thoracic aortic aneurysm
DTAA	descending thoracic aortic aneurysm
ATAA	ascending thoracic aortic aneurysm
CT-scan	computed tomographic scan
MRI	magnetic resonance imaging
HCA	hypothermic circulatory arrest
DHCA	deep hypothermic circulatory arrest
ACP	antegrade cerebral perfusion
RCP	retrograde cerebral perfusion
$CMRO_2$	cerebral metabolic rate for oxygen
PND	permanent neurological deficit
CPB	cardiopulmonary bypass

Methods

We performed electronic searches using PubMed, Cochrane Central Register of Controlled Trials (CCTR), and Google scholar. To achieve the desired sensitivity, we combined the terms aortic arch, aneurysms, open repair, hypothermic circulatory arrest, and selective cerebral perfusion as either keywords or MeSH terms. The results of retrieved articles were reviewed for potentially relevant studies.

Natural history of aortic aneurysms

In order to understand the rationale behind the size criteria for operating on aortic arch aneurysms, it is important to understand the natural behavior of the aneurysmal thoracic aorta.

Initial observations by Crawford and DeNatale demonstrated a very dismal prognosis for patients with thoracic aortic aneurysm (TAA) who were managed medically. Survival of a patient with TAA was less than five years and this was reduced to less than three years if the patient was admitted at any time [1]. These observations were confirmed by the Yale group. Patients with TAA had a significantly short life expectancy [2].

When the Yale data was further analyzed, those with descending thoracic aortic aneurysms (DTAA) had poorer outlook compared to those with ascending thoracic aortic aneurysm (ATAA). When etiology was analyzed separately, aneurysms from dissections performed worse [2].

Overall, regardless of site or etiology, prognosis depends on size. Those with larger aneurysms have poorer survival than those with smaller ones. They demonstrated faster enlargement of DTAA compared to ATAA. The DTAA grows at an average rate of 0.3 cm in diameter per year compared to 0.1 cm of the ATAA. The aorta also grows more rapidly the larger it gets [2].

The data was analyzed and the cumulative likelihood of rupture or dissection over the patient's lifetime was calculated. The authors identified discrete 'hinge points' where a sudden increase in a complication risk may be found. For ATAA, this was at a diameter of 6 cm, while for DTAA it was at 7 cm [2].

In a later analysis by the Yale group [3], attempts were made to analyze the data to predict yearly rupture, dissection, and death rate. The analysis confirms that the risk increases in a stepwise fashion as the size of the aorta increases. For instance, for a 6 cm aorta, there is a probability of 4% per year of rupture, 4% per year of dissection, and 11% per year of death