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REVIEW

Aortic Arch Reconstruction: Are Hybrid Debranching Procedures a Good Choice?

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Introduction Conventional open total arch replacement is the treatment of choice for surgical aortic arch pathologies. However, it is an invasive procedure, requiring cardiopulmonary bypass and deep hypothermic circulatory arrest leading to significant morbidity and mortality rates. Hybrid aortic arch debranching procedures without (type I) or with (type II) ascending aorta replacement seek to limit operative, bypass, and circulatory arrest times by making the arch repair procedure simpler and shorter.

Material and Methods A meta-analysis and detailed review of the literature published from January 2013 until December 2016, concerning hybrid aortic arch debranching procedures was conducted and data for morbidity and mortality rates were extracted.

Results As far as type I hybrid aortic arch reconstruction is concerned, among the 122 patients included, the pooled endoleak rate was 10.78% (95%CI = 1.94–23.40), 30-day or in-hospital mortality was 3.89% (95%CI = 0.324–9.78), stroke rate was 3.79% (95%CI = 0.25–9.77) and weighted permanent paraplegia rate was 2.4%. In terms of type II hybrid approach, among 40 patients, endoleak rate was 12.5%, 30-day or in-hospital mortality rate was 5.3%, stroke rate was 2.5%, no permanent paraplegia was noticed and late mortality rate was 12.5%.

Conclusions Hybrid aortic arch debranching procedures are a safe alternative to open repair with acceptable short- and mid-term results. They extend the envelope of intervention in aortic arch pathologies, particularly in high-risk patients who are suboptimal candidates for open surgery.

Keywords Hybrid • Endovascular • Aortic arch • Debranching • Ascending aorta replacement

Introduction

Aortic aneurysms are diagnosed more and more frequently thanks to better imaging and screening tools. Twelve per cent of thoracic and thoracoabdominal aneurysms >6 cm will rupture without treatment in a year. Moreover, up to 50% of these patients will die within 5 years, if they only receive medical treatment [1,2]. However, surgical management of patients with extensive aortic disease including the ascending aorta, the aortic arch, and the descending aorta is a technical challenge with a lot of room for innovations [3,4]. The gold standard of surgical therapy for patients with extensive thoracic aorta pathology is still the conventional elephant trunk technique, developed by Borst in 1983 [2,3,5,6]. However, conventional open surgical repair of aortic arch pathology is an invasive procedure, requiring cardiopulmonary bypass (CPB) and deep hypothermic circulatory arrest (DHCA). As a result, total arch replacement

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(TAR) is related to significant morbidity and mortality rates. Furthermore, the older the patient is, the worse are the results of open surgical repair [3,7–9]. Moreover, some patients' medical status is not fit enough to undergo such a treatment and these patients denied surgery [10]. Consequently, alternative approaches related to better morbidity and mortality outcomes are sought [11,12].

A hybrid approach is a combination of tools available only in the catheterisation laboratory with those available only in the operating room in order to gain maximum profit from both of them [12]. In 1991, Volodos and colleagues were the first who performed hybrid aortic arch repair [13]. Hybrid approaches are an attractive alternative to TAR or total endovascular techniques for any given set of cardiovascular lesions [12]. The hybrid debranching thoracic endovascular aortic repair approach combining debranching of aortic arch vessels with thoracic endovascular aortic repair (TEVAR) of the aortic arch is a way to extend the envelope of intervention in aortic arch pathologies, particularly in patients with poor physiological reserves due to comorbidities, who are suboptimal candidates for open surgery [2,14,15]. Multiple studies have demonstrated the feasibility of this approach, related to acceptable mortality and morbidity rates. The principal concept is reimplantation or bypass of aortic arch vessels to ensure a sufficiently long proximal landing zone and TEVAR implantation landing proximally in zone 0 which can be suitable for use as a landing zone either natively or artificially after ascending aorta replacement with a Dacron graft [11]. A detailed meta-analysis and review of the literature published from January 2013 until December 2016, concerning hybrid type I and type II aortic arch reconstruction procedures follows.

Material and Methods

Definitions

Type I

The debranching hybrid approach involves total arch debranching and subsequent thoracic endovascular aortic repair. An adequate proximal landing zone length is required for proper endovascular stent-graft deployment and stabilisation [16]. Debranching of head vessels creates an appropriate landing zone extending to Ishimaru Zone 0 without interrupting supra-aortic trunks perfusion [17]. As far as type I hybrid reconstruction is concerned, there is no need for ascending aorta replacement. As a result, aortic cross-clamping and CPB can be avoided [18]. However, establishing CPB with or without a short aortic cross-clamp time is also a reasonable approach [14]. When surgical revascularisation of supra-aortic trunks is complete, the second phase of antegrade or retrograde stent-graft delivery and implantation into the transverse aortic arch under fluoroscopic guidance is performed [9,19].

Type II

In case of an unsuitable proximal landing zone due to aneurysmal ascending aorta, replacement of the ascending aorta with a Dacron graft can be performed to serve as an artificially adequate landing zone for the endovascular stent-graft deployment [11,14,20]. Cardiopulmonary bypass and a short period of circulatory arrest for ascending aorta replacement under either retrograde or selective antegrade perfusion are required for the completion of type II hybrid aortic arch procedure [11,14]. After distal ascending aorta anastomosis has been completed, sequential aortic arch debranching is performed on CPB with the cross-clamp off. Finally, the stent graft is endovascularly deployed in an antegrade fashion from the ascending aorta [21].

Data Collection

An extensive electronic literature search was undertaken to identify all articles concerning debranching hybrid aortic arch repair (type I and type II) that were published from January 2013 up to December 2016. The medical literature database ''PubMed'' was systematically searched. Keywords used for the research were ''aortic arch'', ''arch debranching'', ''endovascular'', and ''hybrid''. In addition, a snowball process in the reference lists of the eligible articles was performed after retrieving the relevant articles from databases' search.

Eligibility and Exclusion Criteria

In the present review, eligible studies were categorised into two groups: group I, which included studies on total debranching of the aortic arch (type I hybrid aortic arch repair) and group II, which included studies on total debranching of the aortic arch along with ascending aorta replacement (type II hybrid aortic arch repair). Eligibility criteria were: description of intrathoracic hybrid aortic arch repair, number of patients included equal to or over two, total aortic arch debranching, and the English language. Articles in languages other than English, studies concerning frozen elephant trunk (type III hybrid aortic arch repair), case reports, and cases of partial aortic arch debranching were excluded. Studies with overlapping population were also excluded.

Data Extracted Categories

Data extracted from eligible studies included first author's name and year of publication, study period, total number of patients, mean age, percentage of males, prior medical history, prior surgical history, indications for treatment, mean length of hospital stay (days) and follow-up (months). For patients submitted to type I hybrid procedure, data on rate of off cardiopulmonary bypass procedures were extracted.

Percentages of patients with outcomes of interest were also extracted. These included 1) technical success, 2) 30-day/in-hospital mortality, 3) stroke, 4) permanent paraplegia, 5) recurrent nerve palsy, 6) transient neurologic deficit or paraplegia, 7) renal failure and renal failure requiring dialysis, 8) respiratory insufficiency or prolonged ventilation, 9) retrograde aortic dissection, 10) atrial fibrillation or other cardiac event, 11) peripheral embolisation or pulmonary embolism, 12) reoperation for bleeding, 13) endoleak, 14) late mortality, 15) cumulative survival at 1-year and 16) reoperation.