Contemporary comparison of aortic arch repair by endovascular and open surgical reconstructions

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Objective: **This study analyzed total aortic arch reconstruction in a contemporary comparison of current open and endovascular repair.**

Methods: **Endovascular (group 1) and open arch procedures (group 2) performed during 2007 to 2013 were entered in a prospective database and retrospectively analyzed. Endovascular repair (proximal landing zones 0-1), with or without a hybrid adjunct, was selected for patients with a high comorbidity profile and fit anatomy. Operations involving coverage of left subclavian artery only (zone 2 proximal landing: n = 41) and open hemiarch replacement (n = 434) were excluded. Early and midterm mortality and major complications were assessed.**

Results: **Overall, 100 (78 men; mean age, 68 years) consecutive procedures were analyzed: 29 patients in group 2 and 71 in group 1. Seven group 1 patients were treated with branched or chimney stent graft, and 64 with partial or total debranching and straight stent graft. The 29 patients in group 2 were younger (mean age, 61.9 vs 70.3; $P = .005$), more frequently females (48.2% vs 11.3; $P < .001$) with less cardiac (6.9% vs 38.2%; $P = .001$), hypertensive (58.5% vs 88.4%; $P = .002$), and peripheral artery (0% vs 16.2%; $P = .031$) disease. At 30 days, there were six deaths in group 1 and four in group 2 (8.5% vs 13.8%; odds ratio, 1.7; 95% confidence interval, 0.45-6.66; $P = .47$), and four strokes in group 1 and one in group 2 (odds ratio, 0.59; 95% confidence interval, 0.06-5.59; $P = 1$). Spinal cord ischemia occurred in two group 1 patients and in no group 2 patients. Three retrograde dissections (1 fatal) were detected in group 1. During a mean follow-up of 26.2 months, two type I endoleaks and three reinterventions were recorded in group 1 (all for persistent endoleak), and one reintervention was performed in group 2. According to Kaplan Meier estimates, survival at 4 years was 79.8% in group 1 and 69.8% in group 2 ($P = .62$), and freedom from late reintervention was 94.6% and 95.5%, respectively ($P = .82$).**

Conclusions: **Despite the older age and a higher comorbidity profile in patients with challenging aortic arch disease suitable and selected for endovascular arch repair, no significant differences were detected in perioperative and 4-year outcomes compared with the younger patients undergoing open arch total repair. An endovascular approach might also be a valid alternative to open surgery in average-risk patients with aortic arch diseases requiring 0 to 1 landing zones, when morphologically feasible. However, larger concurrent comparison and longer follow-up are needed to confirm this hypothesis. (J Vasc Surg 2015;61:339-46.)**

In recent decades, open repair of the aortic arch has been advantaged by progressive improvements and adjuncts that conferred the achievement of safer outcomes and reduced mortality.[1,2] At the same time, hybrid or total endovascular repair has been increasingly used as an alternative in patients previously denied surgery because of relevant comorbidities.[3,4] Nevertheless, hybrid arch procedures, despite the reduced invasiveness and the progressive evolution in recent years, present unclear benefits in the outcome, and total endovascular repair is still in its early days.[5-7] Particularly for diseases involving total arch and requiring stent graft implantation in the ascending aorta (zone 0), perioperative mortality and stroke risks are less than satisfying.[8-15] The requirement of anatomic feasibility is an additional constraint that does not always allow the implementation of these new approaches. Still, any type of aortic arch repair requiring revascularization of supra-aortic vessels remains demanding and exposes the patient to not negligible mortality and stroke risks.

The aim of this study was to investigate the early-term and midterm outcome of aortic arch repairs in a concurrent series of patients treated with different modalities of endovascular and open surgery procedures.

METHODS

The study was based on retrospective analysis of prospectively collected data, and Institutional Review Board approval was not required according to local Ethical Committees preconditions. All patients gave informed consent before their interventional procedure.

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Data from all consecutive patients who underwent endovascular repair, with or without a hybrid adjunct, for aortic diseases involving the aortic arch from 2007 to 2013 at two vascular centers (Unit of Vascular Surgery, Hospital S. Camillo-Forlanini, Rome, and Unit of Vascular and Endovascular Surgery, Hospital S. Maria della Misericordia, University of Perugia, Perugia, Italy) were collected in a cumulative database and analyzed as group 1.

To avoid confounding factors due to major variability in surgical techniques, open arch repairs performed electively at one of the two centers were used as controls. Thereby, data for consecutive conventional total arch open surgery performed during the same period at one of the two centers (Unit of Cardiac Surgery, Hospital S. Camillo-Forlanini, Rome, Italy) were entered in the same database and examined as the control group (group 2) for this study.

Only hybrid/endovascular repairs involving stent graft coverage of the innominate artery or left common carotid artery (LCCA) landing in zone 0 or in zone 1 (according to Ishimaru[16]) were included. Thoracic stent grafts deployed distally, in zones 2 or 3, or endovascular completion after total arch replacement (elephant trunk) were excluded. Open repairs not requiring total arch replacement and acute type A dissections treated as an emergency were also excluded.

Determination of the type of repair was at the discretion of the surgeon. In general, endovascular or hybrid strategies were preferred for anatomically suitable and poor surgical candidates. Open surgery was offered to younger patients and for complex aortic arch diseases unfit for stent graft landing. A proximal landing zone of healthy aorta, at least 2 cm in length and <42 mm in diameter, based on multiplanar reconstructions of preoperative computed tomography angiography (CTA) scans, was required for endovascular repair.

Patients were followed up with regular postoperative appointments. The stability of the endovascular repair was monitored yearly with contrast CTA. Assessment of survival was completed by phone interview. Median follow-up was 23.4 months (mean, 27.9 months; interquartile range [IQR], 37.8 months).

The primary outcome of this study was perioperative mortality. Additional outcomes included perioperative stroke, spinal cord ischemia and complications, and all-cause survival at 4 years. Perioperative outcomes were recorded ≤30 days of surgery or in the hospital if occurring during a hospitalization that was protracted >30 days.

Aortic morphology of open surgical repairs was reviewed according to preoperative CTA scans, and the feasibility for an endovascular approach was tested in the open group as a secondary outcome measure.

All CTA images were evaluated using the dedicated Aquarius iNtuition software (TeraRecon, San Mateo, Calif).

Statistical analysis. Continuous and categoric variables were compared between groups using one-way analysis of variance and the χ^2 test. Survival and freedom from reintervention related to aortic repair was estimated using the Kaplan-Meier method. For patients who underwent staged repair, the date of the completion procedure was used to calculate survival. The probability of receiving open or endovascular treatment for arch repair based on the observed baseline covariates was tested using the propensity score from a nonparsimonious logistic regression model. Calculations were performed using SPSS software (SPSS, Chicago, Ill).

Operative technique for endovascular repair. In hybrid procedures for zone 0 landing, all supra-aortic vessels were revascularized through a median sternotomy with cervical extension of the incision cephalad to the left, allowing exposure of the supra-aortic trunks, and subsequent bypass from the ascending aorta to the individual vessels. For zone 1 landing, a carotid-to-carotid bypass using cervical incisions and retropharyngeal or antetracheal tunnel was performed in association with left subclavian artery (LSA) revascularization by transposition or bypass. The subclavian arteries were always revascularized, except in emergency cases. The LSA stump was occluded through oversewing, clipping, or endovascular plug or coils. Debranching was performed simultaneously or staged.

Branched stent grafting was associated with LCCA-to-LSA bypass with the above-described technique. The chimney technique was used in urgent cases or when a branched stent graft was not available.

Stent grafts were deployed retrograde through femoral access or by conduit for common iliac arteries in case of small access vessels. Different thoracic stent grafts available during the study period were used for thoracic endovascular aortic repair (TEVAR) and included Gore TAG and C-TAG (W. L. Gore & Associates, Flagstaff, Ariz), Talent and Valiant (Medtronic, Santa Rosa, Calif), Zenith TX2 and Alpha (Cook Inc, Bloomington, Ind), and Relay (Bolton Medical, Sunrise, Fla). Right subclavian and left carotid arteries (LSA when needed in total chimney) were accessed through a cervical cutdown to introduce a covered stent. Covered stents used for supra-aortic trunks were the Excluder iliac leg and Viabahn (W. L. Gore &Associates), Endurant iliac leg (Medtronic), or the Fluency (Bard Peripheral Vascular, Tempe, Ariz). Branched stent grafts for supra-aortic vessels revascularization included customized stent grafts by Bolton Medical.

All endovascular procedures were performed under cerebral flow monitoring using cerebral oximetry and fast cardiac pacing during deployment of the thoracic stent graft. Balloon inflation was never used in the aortic arch.

Preoperative cerebrospinal fluid drainage to prevent spinal cord ischemia was selectively used, based on length of coverage in thoracoabdominal aorta.

Surgical procedures for conventional total arch replacement. Cardiopulmonary bypass was established with cannulation of the right axillary artery and the right atrium directly or through the right femoral vein. Patients were cooled to a core temperature of 20°C to 22°C. Antegrade selective cerebral perfusion was used (flow, 10-15 mL/kg/min). In most cases, a collagen-impregnated