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Cervical Debranching in the Endovascular Era: A Single Centre Experience

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WHAT THIS PAPER ADDS

With one of the largest series of cervical debranching operations with 211 cases, the results of a single centre's experience are presented. Focusing on post-operative complications and graft patency, attempts are made to identify factors that influence outcome and discuss the findings. It is concluded that cervical debranching has some relevant local complications but that long-term patency is exceptional.

Objective/Background: Debranching of the supra-aortic arteries is a common practice either as part of a hybrid treatment of aortic arch pathology or owing to arterial occlusive disease. Results of the debranching techniques have not been reported frequently.

Methods: This was a retrospective single centre study of all consecutive patients with cervical debranching procedures as part of hybrid aortic arch repair.

Results: Between 2010 and 2017, 201 patients underwent 211 cervical debranching procedures in a tertiary centre. Mean ± SD patient age was 67.7 ± 10.7 years (70.6% males; $n = 142/201$) and mean ± SD body mass index (BMI) was 26.3 ± 5. In 78.7% of the cases carotid–subclavian bypass was performed alone ($n = 166/211$) followed by transposition of the subclavian artery to the ipsilateral carotid ($n = 17/211$; 8.1%) and in 28 cases (13.3%) a combination of procedures was performed. Twenty-four cases (11.4%) were complicated with local bleeding and 21 cases required re-intervention (10.4%). Nineteen patients (9.5%) developed local peripheral neurological damage post-operatively. Eight patients (3.8%) developed a chylous fistula and five (2.4%) presented with a local wound infection. One patient (0.5%) developed a bypass graft infection. The thirty day mortality was 7.6% ($n = 16/211$): one death occurred after isolated debranching without thoracic endovascular aneurysm repair (TEVAR; 0.5%). Whether the hybrid procedures were undertaken in a single stage (simultaneous TEVAR and cervical debranching) or two stage fashion appeared to have a significant impact on 30 day mortality (single stage $n = 9/60$ [15%] vs. debranching alone or two stage hybrid procedures $n = 7/144$ [4.9%]; $p = .018$). The major stroke incidence was 4.3% ($n = 9/211$); no strokes occurred after isolated debranching. Stroke was correlated with longer operating times (odds ratio [OR] 1.006; 95% confidence interval [CI] 1.000–1.011; $p = .045$) and higher BMI (OR 1.195; 95% CI 1.009–1.415; $p = .039$). Mean ± SD follow up was 15 ± 17 months (range 0–89 months). Primary cumulative graft patency during follow up was 98.1% (n = 207/211) and secondary patency was 100%.

Conclusion: The results of cervical debranching procedures showed not only excellent patency rates, but also a significant rate of local complications. Carotid–subclavian bypass appeared to be safer with significantly fewer post-operative complications. Staged hybrid procedures also seemed to be safer.

Keywords: Aortic arch hybrid treatment, Carotid–subclavian bypass, Carotid–subclavian transposition, Cervical debranching, Stroke, TEVAR
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INTRODUCTION

Traditionally, aortic disease involving the aortic arch is repaired by an open surgical technique using cardiopulmonary bypass, which is associated with considerable morbidity and mortality, thus making the search of alternative treatments appealing.[1–6]

In the past decade, the improved expertise and development of endovascular techniques has made complex endovascular repair of the aortic arch possible. Depending on the anatomy and pathology, the aortic arch can be managed by several combinations of branched or fenestrated stent grafts and cervical debranching.[7–11]

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In the authors' institution, the number of thoracic endovascular repairs (TEVARs) has increased with the ongoing extension of indications and technical advances. The expanding indication spectrum is a result of the global shift of the Stanford Type B dissection treatment strategy in recent years from predominantly conservative to invasive because of better long-term remodelling and outcome.[12,13] Additionally, multimorbid patients with disease of the descending thoracic or thoraco-abdominal aorta may be treated by complete endovascular or hybrid treatment with a landing zone in the aortic arch.[14]

Hybrid aortic arch procedures are defined as procedures requiring a surgical revascularisation of one or more supra-aortic vessels to extend the proximal landing zone of the implanted TEVAR into the aortic arch.

The frequency of aortic arch debranching operations has increased significantly over the last few years, along with the increase in the number of TEVAR procedures. All types of aortic arch debranching are performed at the authors' institution, including left subclavian (LSA)—carotid transposition and complex procedures involving the vertebral artery and the right sided supra-aortic vessels, with the left carotid—subclavian bypass being the most common one. As the increase in the frequency of aortic arch hybrid debranching is fairly recent, knowledge of long-term outcome and complications related to this specific procedure are still developing.

The aim of the study was to analyse the results of cervical debranching procedures that were performed at the authors' centre in the last 8 years.

METHODS

This was a single centre retrospective study in a tertiary institution, with all data being acquired retrospectively. In keeping with the local and institutional regulations, neither institutional review board approval nor informed patient consent was deemed necessary for this study.

Patient selection and indication work up

The study included all consecutive patients that underwent cervical debranching procedures as part of a hybrid procedure, before or after TEVAR. Debranching procedures that were performed to treat arterial occlusive disease were excluded to preserve the cohort homogeneity.

For endovascular repair of the descending thoracic aorta a sufficient proximal and distal neck of healthy aortic wall is a standard requirement for adequate sealing, which in some cases requires coverage of the LSA. Generally, all elective cases with planned coverage of the LSA were revascularised before the TEVAR and the LSA was either occluded in the proximal end with plug embolisation in the case of a carotid—subclavian bypass, or ligated in the case of transposition, so as to minimise the risk of a type II endoleak.

The approach to aortic arch pathologies proximal to the LSA has changed significantly over the years. In the early years of the present study (2010—14) patients with arch pathologies more frequently received open surgical repair with sternotomy. With the advancements of the endovascular techniques, however, and with the introduction of new branched endografts, the treatment strategy has shifted towards endovascular repair in these cases, with branched and fenestrated endografts. These patients frequently undergo cervical debranching, depending on the target vessels of the endovascular procedure. However, quantification and statistical analysis of these aspects were deemed to be outside of the scope of this study.

Demographic data, past medical history, cardiovascular risk factors, pre-operative comorbidities, intra-operative, and peri-operative details and medical treatment with anticoagulants prior to the operations were recorded.

Definition of the endpoints

The main endpoints were the occurrence of early local complications and graft patency, in the early post-operative period (in hospital), as well as during follow up.

Local complications were defined as the presence of active bleeding or relevant haematoma, lesion of the local nerves and cervical plexus, chylous leak, wound infection, or a combination.

Post-operative primary patency was defined as the lack of graft occlusion or stenosis of any kind on ultrasound examination before discharge. During the follow up visits, primary patency was determined using the CTA scan in combination with upper extremity pulse status and the lack of clinical signs of upper extremity malperfusion. In case of doubt, an ultrasound test was performed.

The secondary endpoints of the study were early (30 day) patient mortality and the major stroke rate.

Technical remarks regarding the operative procedure

Because of the subsequent endovascular procedure, the surgical technique has been adjusted for hybrid procedures. The descent of the bypass has been altered from reasonably steep to a more horizontal course by placing the carotid anastomosis more proximally by frequently dividing the inferior omohyoid muscle, especially when the carotid artery needs to be accessed during the endovascular (second) procedure. This improves the introduction angle for guidewires and catheters via the carotid—subclavian bypass. Additionally, the common carotid artery interposition graft is resected and interposed in cases of residual type A dissection with extension of the aortic dissection into the carotid artery to achieve a better landing zone for the distal bridging stents. Dacron grafts (8 mm) were the standard material for the cervical bypasses.

The intra-operative monitoring of motor and sensory evoked potentials was not part of the treatment modality.

Data sources and statistical analysis

All patients were operated in the university hospital in Hamburg, Germany, between January 2010 and October 2017. The closing date of the study was 1 December 2017 and this date was used to calculate follow up. All cohort data, post-operative results, and patient related data were

collected retrospectively, and follow up data prospectively, by two physicians (N.K. and C.V.) from the central digital hospital administration system and from pre-operative documentation.

As a significant number of patients ($n = 10/201$; 5.0%) underwent multiple debranching operations during separate hospital stays, the statistical analysis was performed on two different databases: one where only the individual patients were documented and another where every hospital stay was considered a separate entity. As such, the "patient database" was used to determine the epidemiological data of the patient cohort and the "procedure database" was used for the subgroup analysis, treating each individual procedure as a separate case.

Continuous data are reported as a mean ± SD. Categorical data are expressed as absolute numbers and percentage prevalence (%) in the study cohort and continuous variables as mean ± SD. Independent two sample *t*-tests were used for normally distributed continuous variables and the Wilcoxon rank sum test was used for non-normally distributed continuous and ordinal variables. Multivariable logistic regression modelling was used to assess the risk factors for post-operative complications and graft patency, while controlling for possible confounders. Missing values were ignored when <2% of the values of each variable were missing. The follow up Index (FUI) was calculated for each patient as an indicator of follow up completeness, with a value of 1 being optimal follow up for every patient in the cohort.[15] A p value $< .05$ was considered significant. Statistical analysis was performed by SPSS 24.0 for Windows software (IBM, Armonk, NY, USA).

RESULTS

Between January 2010 and October 2017, a total of 201 patients underwent 211 cervical debranching procedures. The mean age was 67.7 ± 10.7 years (70.6% males; $n = 142/201$) and mean body mass index (BMI) was 26.3 ± 4.6. None of the variables had more than 4/201 (< 2%) values missing, so that no imputation was required. The demographics, cardiovascular risk factors, and comorbidities are shown in Table 1. Altogether, 29.9% ($n = 60/201$) of the procedures were simultaneous cervical debranching and TEVAR implantation, in the rest of the cases (70.1%; $n = 141/201$) the endovascular procedure was performed in a separate session.

In 92.4% of the cases debranching was performed prior to or simultaneously with the endovascular procedure ($n = 195/211$). Debranching was performed after the TEVAR implantation in 11 cases: in five of 211 (2.4%) as treatment for spinal cord ischaemia symptoms and in six of 211 cases to treat upper extremity ischaemia (2.8%). In five cases debranching was part of a Frozen Elephant Trunk procedure in Zone 2 (2.3%). The indications for surgery are shown in Table 2.

In total, 166 of 211 debranching procedures were carotid–subclavian bypass (78.7%) alone, 17 of 211 transpositions of the subclavian to the ipsilateral carotid artery (8.0%), and 28 cases a combination of procedures was performed (13.3%). The combined procedures included the simultaneous performance of carotid–subclavian and carotid–carotid bypass grafting ($n = 5/211$; 2.4%), carotid–subclavian bypass grafting with transposition of the vertebral artery ($n = 11/211$; 5.2%), carotid–subclavian bypass grafting with carotid interposition ($n = 5/211$; 2.4%), and bypass grafting between the right carotid artery and the LSA with re-implantation of the left carotid on the bypass graft ($n = 2/211$; 0.9%). The remaining five of the combined procedures (2.3%) were complete supra-aortic debranching as part of Frozen Elephant Trunk in Ishimaru zone 2 operations. Fig. 1 demonstrates an interposition between the left common and internal carotid artery with re-implantation of the external carotid (long arrows) and concomitant carotid–subclavian bypass (short arrows).

In 61.1% of all cases ($n = 129/211$) the procedure was performed electively. The emergencies included six symptomatic thoracic aortic aneurysms, 59 symptomatic dissections (60 symptomatic cases; 28.4%), and 22 ruptured aneurysms (10.4%).

The aortic stent graft procedures included 109 standard TEVARs (61.6%), 52 branched thoracic grafts (29.4%), and 16 fenestrated thoracic grafts (9%). All grafts used were produced by COOK Medical (Bjaeverskov, Denmark).

Table 1. Demographic characteristics of the study group ($n = 201$)

Comorbidities and cardiovascular risk factors	*n* (%)
Coronary artery disease	53 (26.4)
Congestive heart failure	21 (10.4)
Hypertension	180 (89.6)
Hyperlipidaemia	58 (28.9)
Smoking	93 (46.3)
Chronic obstructive pulmonary disorder	29 (14.4)
Diabetes mellitus	18 (9.0)
Hemodialysis	6 (3.0)
Baseline glomerular filtration rate of >60 mL/min/1.73m^2	176 (87.6)
Cerebrovascular disease	23 (11.4)
Peripheral arterial disease	25 (12.4)
Coagulopathy	8 (4.0)
Connective tissue disorder	12 (6.0)
Marfan syndrome	8 (4.0)
Loeys–Dietz syndrome	3 (1.5)
Not defined	1 (0.5)

Table 2. Indications for surgery ($n = 211$)

Indication for surgery	*n* (%)
Prior to or simultaneous with thoracic endovascular aneurysm repair	195 (92.4)
Post-operative spinal cord ischaemia	5 (2.4)
Post-operative arm ischaemia	6 (2.8)
Frozen Elephant Trunk in Ishimaru zone 2	5 (2.4)

Primary endpoints

The technical success rate was 100% and the in hospital primary graft patency was 99.1% ($n = 209/211$). The loss of

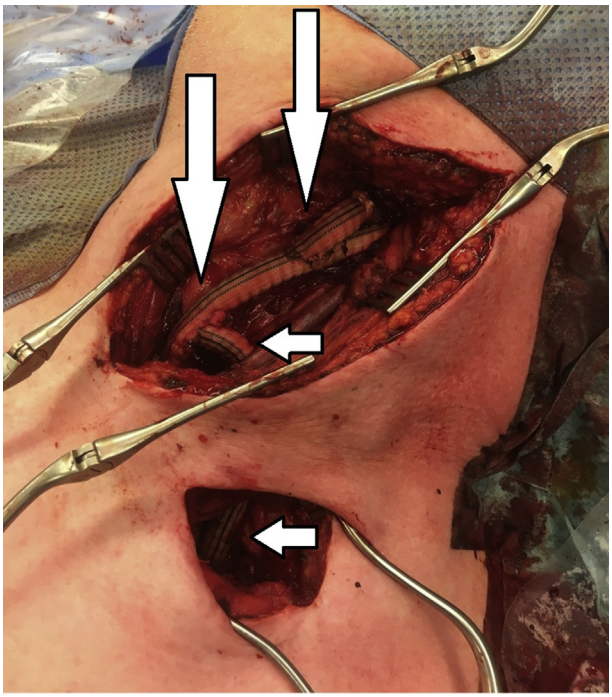


Figure 1. Left carotid–subclavian bypass (short arrows) with interposition between the left common and internal carotid artery and re-implantation of the external carotid artery (long arrows).

primary patency during the hospital stay was 0.9% ($n = 2/211$): one early stenosis of the proximal anastomosis to the carotid artery and one stent implantation due to early occlusion. The total in hospital secondary patency was 100%.

In total, 49/211 cervical revascularisations (23.2%) developed early post-operative local complications, of which 44 (20.9%) had a single complication and five (2.4%) multiple complications. Twenty-four patients (11.4%) presented with local bleeding, with 21 of them requiring a re-intervention (10%). Nineteen patients (9%) developed a complication affecting the peripheral nervous system, including paresis of the ipsilateral recurrent laryngeal nerve in 10 cases (4.7%) and Horner's syndrome in six cases (2.8%). Non-disabling upper extremity paresis on the ipsilateral side, post-operative paraesthesia of the ipsilateral arm, and a mild facial nerve paresis of unknown cause were each observed once (0.5% each). There were no phrenic nerve injuries. The incidence of peripheral nerve injury was strongly correlated with the type of debranching procedure (peripheral nerve injury after carotid-subclavian bypass grafting 12/166 [7.2%] vs. peripheral nerve injury after subclavian transposition 4/13 [30%]; $p = .04$). The combined procedures were excluded from this analysis to avoid possible confounders.

Eight patients (3.8%) developed a cutaneous chylous fistula and five (2.4%) presented a local wound infection. One patient (0.4%) developed a graft infection and the prosthesis was replaced by a "homemade" graft constructed from bovine patches with an uneventful post-operative course. The documented in hospital post-operative complications with their respective rates are shown in Table 3.

Table 3. In hospital post-operative complications ($n = 211$)

Complication	*n* (%)
In hospital death	16 (7.6)
Myocardial infarction	6 (2.9)
Heart failure	2 (0.9)
Post-operative arrhythmia	14 (6.6)
Respiratory complications	29 (13.7)
Pneumonia	9 (4.3)
Respiratory failure with tracheotomy	1 (0.5)
Respiratory failure with no tracheotomy	2 (0.9)
Prolonged intubation	17 (8.1)
Pneumothorax	0 (0)
Bleeding	24 (11.4)
Bleeding requiring re-intervention	21 (10.0)
Bleeding with no re-intervention required	3 (1.4)
Cerebrovascular complications	15 (7.1)
Major stroke	9 (4.3)
Minor stroke	1 (0.5)
Transient ischaemic attack	4 (1.9)
Intracranial bleeding	1 (0.5)
Peripheral neurological disorder	19 (9.0)
Chylous leak	8 (3.8)
Wound infection	5 (2.4)

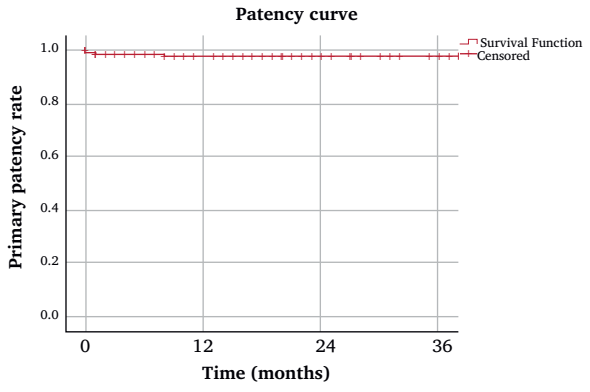
None of the demographic parameters, including BMI, was associated with a higher incidence of local post-operative complications. Likewise, the pre-operative status of the supra-aortic vessels (previous cervical vessel intervention, dissection of the carotid or the subclavian artery) did not statistically correlate with the presence of post-operative complications.

The incidence of local complications also did not correlate with whether the procedure was a debranching operation alone or a hybrid one, or if the hybrid procedure was undertaken in a one or two step fashion. Moreover, emergency operations also did not correlate with a higher incidence of local complications.

The mean operating time was 245 ± 126 minutes for all procedures, 206 ± 93 minutes for debranching alone, and 363 ± 143 minutes for simultaneous TEVAR and debranching operations and did not correlate with the incidence of local post-operative complications (250 ± 126 minutes in patients with no complications vs. 223 ± 123 minutes in patients with post-operative complications; $p = .2$).

On multiple logistic regression analysis, the incidence of local post-operative complications was associated with the type of debranching operation (local complication incidence higher after transposition of the subclavian artery: odds ratio [OR] 3.352, 95% confidence interval [CI] 1.175–9.563; $p = .02$).

The mean follow up was 15 ± 17 months (range 0–89 months) and mean FUI was 0.61 ± 0.36 (range 0–1). The primary cumulative graft patency during follow up was 98.1% ($n = 207/211$), as two additional graft stenoses were observed, but neither was treated owing to lack of symptoms. Secondary patency during follow up remained 100%. The cumulative primary patency during follow-up is demonstrated in Fig. 2.



	1-month	6-month	8-month	12-month	24-month
Primary patency	98.5%	98.5%	97.6%	97.6%	97.6%
Patients at risk	173	120	110	79	44

Figure 2. Kaplan–Meier curve for primary patency.

Secondary endpoints

Thirty day mortality was 7.6% (n = 16/211): one death occurred after an isolated debranching procedure with the patient suffering a ST elevation myocardial infarction (0.5%), six deaths occurred after TEVAR as a staged procedure (2.8%), and the remaining nine deaths after a combined TEVAR and debranching procedure (4.3%). The leading cause of death was haemorrhagic shock due to acute bleeding as a result of an intra-operative vessel injury or the endovascular procedure ($n = 5/16$) access vessels, followed by multiple organ failure of unknown cause ($n = 4/16$), myocardial infarction ($n = 4/16$), and septic shock after a respiratory infection ($n = 3/16$).

The factors associated with early mortality were pre-operative creatinine levels (1.7 ± 1.2 mg/dL in patients dying within 30 days vs. 1.2 ± 0.8 mg/dL in surviving patients; $p = .016$), mean procedure duration (409 ± 230 minutes in patients dying within 30 days vs. 230 ± 103 minutes in surviving patients; $p < 0.001$), whether the debranching and endovascular operations were done simultaneously (30 day mortality in patients that underwent simultaneous TEVAR and debranching 9/60 [15%] vs. 30 day mortality after sole debranching or two stage hybrid procedures 7/144 [4.9%]; $p = .018$) and whether it was an emergency procedure (30 day mortality in emergency procedures 13/82 [15.9%] vs. 30 day mortality in elective procedures 3/129 [2.3%]; $p = .001$).

On logistic regression analysis, early mortality was strongly associated with the type of emergency (30 day mortality rate higher in patients with a ruptured vessel: OR 8.48, 95% CI 1.28–56.13; $p = .027$), with the pre-operative renal function (30 day mortality rate higher for patients with a higher pre-operative creatinine: OR 2.13, 95% CI 1.23–3.67; $p = .007$), and with operation duration (30 day mortality rate higher for patients whose procedures lasted longer: OR 1.007, 95% CI 1.003–1.011; $p = .001$). Fig. 3 demonstrates the estimated patient survival according to the Kaplan–Meier plot.

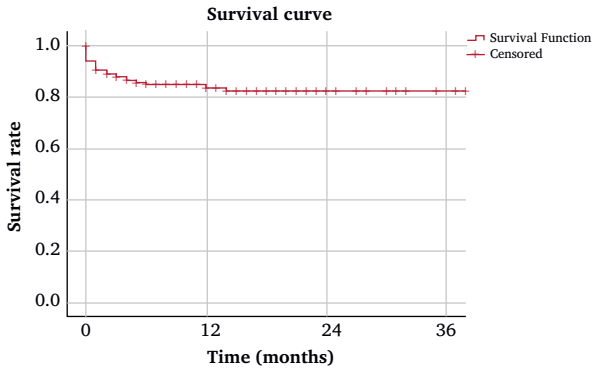
The total major stroke incidence was 4.3% (9/211), in eight cases after a combined TEVAR and debranching procedure (3.8%) and in one case after the TEVAR implantation in a staged procedure (0.5%). No major strokes were observed after an isolated debranching operation. The factors associated with a higher incidence of major stroke post-operatively were simultaneous procedures (major stroke in patients after debranching alone or two stage hybrid procedure 1/151 [0.7%] vs. major stroke in patients with simultaneous TEVAR and debranching $n = 8/60$ [13.3%]; $p < 0.001$), operation duration (mean procedure duration in patients without stroke 237 ± 118 minutes vs. mean operating time in patients with post-operative stroke 405 ± 189 minutes; $p < 0.001$) and BMI (mean BMI in patients with no major post-operative stroke 26 ± 5 vs. mean BMI in patients that suffered from major post-operative stroke 32 ± 7, $p = .001$).

On logistic regression analysis, a significant correlation between the procedure duration and post-operative stroke was observed (major stroke more frequent in longer operations: OR 1.006, 95% CI 1.000–1.011; $p = .045$), as well as between BMI and post-operative stroke (major stroke more frequent post-operatively in obese patients: OR 1.195, 95% CI 1.009–1.415; $p = .039$).

DISCUSSION

Whereas cervical debranching is not a new technique, it was traditionally performed to treat arterial vascular diseases of the supra-aortic vessels. The increase in the number of TEVAR procedures in the last decade has had an immediate effect on clinical routines, as seen in the ever increasing number of cervical debranching procedures. However, the outcomes of these procedures have not been adequately studied yet.

According to Madenci et al.,[16] who published the largest series on cervical debranching procedures focusing on the



	1-month	6-month	12-month	24-month
Alive	90.8%	85%	84%	82.6%
Patients at risk	155	107	70	38

Figure 3. Kaplan–Meier patient survival curve.

operative complications, the incidence of major stroke was 3.5% and mortality at 3.3%. However, emergency cases were excluded from their study, making the result comparison, particularly for mortality, difficult.[16]

In the present authors' practice carotid-subclavian bypass grafting is the most common form of aortic arch debranching. When covering the subclavian artery in combination with stenting of a considerable part of the thoracic aorta, an important part of the spinal cord circulation is lost, along with collateral circulation via the vertebral artery. The most important reason to perform a carotid—subclavian bypass is to reduce the risk for spinal cord ischaemia and posterior stroke.[17,18] Another advantage is the prevention of upper extremity ischaemia. However, as almost all patients that were treated at the authors' centre with a hybrid procedure for aortic arch pathologies underwent revascularisation of the supra-aortic vessels, a conclusion on these points could not be drawn.

The question of routine revascularization of the LSA in hybrid arch procedures is a controversial one, with no definitive answer. Many proponents[16,19—23] and sceptics[24] can be found in the literature. After studying 508 cases of thoracic endovascular treatment with LSA coverage, Teixeira et al. found that revascularisation of the LSA significantly reduced the risk of spinal cord ischaemia. Moreover, Zamor et al. showed that coverage of the LSA without revascularisation increases the risk of stroke and arm ischaemia significantly.[19] However, despite overwhelming evidence in the literature that LSA revascularisation should be performed routinely, the rate of local surgical complications should be considered when deciding on LSA revascularisation.

In general, the complications of isolated cervical debranching in the present cohort did not significantly impact early outcome, as they were mostly wound related and the major complication rates, 30 day mortality and major stroke, were 0.5% and 0%, respectively. The leading complication was post-operative bleeding, with re-operation required in most cases, followed by peripheral nerve injury, the most frequent being injury of the ipsilateral recurrent laryngeal nerve and Horner syndrome. However, these complications are considered to be minor in comparison with the possible adverse effects of LSA coverage without revascularisation, strongly supporting the routine revascularisation of the supra-aortic vessels in hybrid procedures with planned coverage.

Regarding peripheral nerve complications, a significantly higher number of nerve injury was observed after subclavian transposition procedures in comparison with the carotid—subclavian bypass grafting. The transposition of the subclavian artery was initially the authors' preferred method of subclavian revascularisation, but was replaced by carotid—subclavian bypass grafting due to the clinical observation of a significantly higher number of post-operative complications. This analysis supports this change in strategy, showing that carotid—subclavian bypass grafting is superior regarding patient post-operative course. Unfortunately, the exact status of the Horner syndrome post-operatively could not be identified reliably on follow up in this retrospective study, although a significant number of patients had improved symptoms during follow up.

In regard to whether the debranching procedure should be synchronous or subsequent to the endovascular repair, there are not sufficient bibliographic data. From the present results there seems to be a significantly higher incidence of early mortality and stroke after combined TEVAR and debranching procedures, as shown in the univariable analysis. However, this is surely associated with the fact that single stage procedures were more frequent in emergencies that are generally associated with higher complication rates. The strategy has shifted in this field, as all elective cases are planned in two stages and synchronous hybrid repairs are performed only in emergencies, trying to avoid long operating times.

The theory of the concurrent flow, which presumes that leaving both the bypass graft and the native vessel patent and implanting the stent graft that occludes the target vessel in a different session can lead to an early occlusion of the bypass graft could not be validated from the results, in which no occlusions occurred during the time between cervical debranching and the endovascular procedure, although we try to keep the interval between operations no longer than one month when possible.

Limitations

The results reflect a retrospective analysis of clinical data, so an underestimation of the complications can be expected. In an attempt to minimise complication rate underestimation, data on outcome assessment for each patient were entered prospectively into the database by trained personnel.

Moreover, follow up is inherently suboptimal in retrospective studies, which is also reflected in this study by the significant SD from the mean follow up time. This is better demonstrated with the FUI, which in this study had a mean value of 0.61 ± 0.36, with the optimum being 1. This means that a significant number of patients were lost to follow up, increasing the risk of attrition bias and underestimation of the occurrence of graft occlusion and/or death during the course of the follow up. This does not, however, affect the validity of the reported early adverse events.

Data from only one centre were analysed, which may limit the generalisability of the results. Although a multicentre analysis of a multinational database may provide greater external validity, the results confirm trends reported in other studies.

CONCLUSION

Cervical debranching procedures have become an essential part of complex thoracic endovascular procedures. These procedures vary in complexity and technique and affect overall post-operative outcome. Experience with excellent short and mid-term patency rates has been presented. The local complication rates during the early post-operative period have a limited impact on the mid-term course. Complete endovascular techniques with fenestrations or branches for all supra-aortic branches may reduce the local complication rates but must achieve similar long-term

patency outcomes to compete with open supra-aortic vessel revascularisation. Based on the results and relevant bibliographical data, routine revascularisation of the supra-aortic vessels is supported in every case that stent graft coverage is required, and when possible in a staged fashion. Moreover, it is recommended, preferably, to perform a carotid–subclavian bypass instead of transposition of the subclavian artery, owing to the lower rate of peripheral nerve lesions.

CONFLICT OF INTEREST

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