Is the outcome in acute aortic dissection type A influenced by of femoral versus central cannulation?

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Background: The purpose of this study was to evaluate the single-center experience in initial femoral versus central cannulation of the extracorporeal circulation for acute aortic dissection type A (AADA).
Methods: Between January 2003 and December 2015, 235 patients underwent repair of AADA. All patients were evaluated for the type of arterial cannulation (femoral *vs.* central) for initial bypass. Demographic data and outcome parameters were accessed.
Results: One hundred and twenty seven (54.0%) were initially cannulated in the central aortic vessels (ascending aorta or subclavian/axillary artery) and 108 (46.0%) in the femoral artery. Patients were comparable between age (62.4±14.4 *vs.* 62.9±14.4 years, P=0.805), gender (male, 62.2 *vs.* 69.4%, P=0.152) and previous sternotomy (15.7 *vs.* 16.7%, P=0.861) between both cannulation groups; while EuroSCORE I (11.5±4.0 *vs.* 12.7±4.2, P=0.031) and ASA Score (3.5±0.81 *vs.* 3.8±0.57, P=0.011) were significantly higher in the femoral artery cannulation group. Bypass (249±102 *vs.* 240±81 min, P=0.474), X-clamp (166±85 *vs.* 157±67 min, P=0.418) and circulatory arrest time (51.6±28.7 *vs.* 48.3±21.7 min, P=0.365) were similar between the groups as were lowest temperature (18.1±2.0 *vs.* 18.1±2.2, P=0.775). Postoperative neurologic deficit and 30-day mortality were comparable between both cannulation groups (11.7 *vs.* 7.2%, P=0.449 and 20.2 *vs.* 16.9%, P=0.699, central *vs.* peripheral cannulation). Multivariate analysis revealed only EuroScore I above 13 as single preoperative predictor for mortality.
Conclusions: AADA can be operated with both femoral and central cannulation with similar results. Risk for early mortality was driven by the preoperative clinical and hemodynamic status before operation rather than the cannulation technique.

Keywords: Type A dissection; cannulation; outcome

Introduction

Acute aortic dissection type A (AADA) is a life threatening medical condition with still high mortality and morbidity requiring emergent surgical therapy (1-3). While without operation outcome is inacceptable (4,5), the use of extracorporeal circulation with hypothermic circulatory arrest is the gold-standard (6).

Replacement of the ascending aorta with resection of the entry site with an open distal ascending, hemiarch or total arch replacement, depending on the intima tears, is the standard approach. For the open distal anastomosis a period of hypothermic circulatory arrest often with the use of neuroprotective strategies like selective cerebral perfusion is needed (7). Survival of AADA patients is strongly dependent on an appropriate operative strategy, but the major influencing factors on mortality still remain uncertain. Extracorporeal circulation is needed in the therapy of AADA and the cannulation techniques might influence the outcome of the patients. Central cannulation in the ascending aorta has the advantage of antegrade body perfusion, but the risk of cannulating the false lumen. This

might lead to progression of the dissection, malperfusion or aortic rupture. Therefore, cannulation of the subclavian artery—either directly or with an end-to-side prosthesis—is an alternative and adequate option in AADA patients. This is often termed as central cannulation, too, despite a short retrograde flow in this vessel. On the other hand, femoral artery cannulation is the easiest and fastest accessible site, but leads to retrograde flow in the descending and ascending aorta and might have an impact on plaque rupture and cerebral embolism. In addition, malperfusion might occur with retrograde flow (8). The primary objective of the present study is to analyze outcome parameters in a single-center series of AADA repair with different cannulation techniques for initial bypass.

Methods

Patients

All patients with diagnosed AADA operated between January 1, 2003 and December 31, 2015 were divided into two groups by the modus of initial arterial cannulation for extracorporeal circulation. Either central cannulation through the ascending aorta, right subclavian/axillary artery or right carotid artery (central cannulation group) or peripheral cannulation through the right or left femoral artery. No patient was excluded from the study. AADA was defined as diagnosed by echocardiography or computer tomography within of less than 12 hours before operation. The institutional review board approved this retrospective analysis; additional patient consent was not required.

Statistical analysis

All data were sampled retrospectively from the clinical data sheets. A χ^2-test was used to compare categorical variables; a Student t-test was used to compare continuous variables. A P value of less than 0.05 was considered statistically significant. For mortality risk factor distribution a univariate analysis was performed. All significant parameters from the univariate analysis were included in a multivariate logistic regression. IBM SPSS Statistics Version 20 (IBM Germany, Ehningen) was used for all statistical analysis.

Surgical technique

A median sternotomy was performed in all patients. Aortic cannulation was performed after sternotomy. Subclavian/ axillary, carotid or femoral cannulation was performed either before sternotomy or thereafter depending on the clinical status of the patient. Direct aortic cannulation was performed after heparinization in Seldinger technique guided by transesophageal echocardiography. If the Seldinger wire was in the true lumen of the aorta a ring reinforced aortic cannula was inserted (OptiSite, Edward Lifesciences Corporation Irvine, CA, USA or EOPA, Medtronic, Minneapolis, MN, USA) and fixed with tourniquets. Subclavian/axillary or carotid cannulation was performed through an extra incision above the vessel and direct cannulation in Seldinger technique or with prior implantation of an 8 mm Dacron graft onto the vessel after heparinization. Femoral cannulation was always performed with an open approach and direct cannulation in Seldinger technique (Fem-Flex, Edward Lifesciences Corporation Irvine, CA, USA). In the femoral cannulation group the arterial cannula was switched to central for re-starting of the extracorporeal circulation after circulatory arrest.

The criteria in selection of the cannulation site was depending on the experience of the surgeon and the experience of the anesthesiologist in preforming transesophageal echocardiography in combination with the hemodynamic state of the patients and the extent of the dissection and the dissection membrane.

The body temperature was monitored with bladder or rectum measurement and esophagus temperature.

Cerebral perfusion during circulatory arrest was performed either unilateral or bilateral depending on the oxygen consumption in the brain diagnosed by Near-Infrared Spectrograph (NIRS), which was routinely performed in all patients. Retrograde cerebral perfusion was not routinely performed.

The ascending aorta was replaced with a woven Dacron graft, which was curved if the Hemi-Arch or arch was involved, too. If the aortic valve or aortic root was involved root replacement was made either with a Bentall-de Bono procedure or a valve sparing repair according to David or Yacoub. A complete arch resection with an elephant trunk was performed in the conventional technique until 2013 and with the frozen Elephant technique since 2014.

Results

Two hundred and thirty five consecutive patients were diagnosed with AADA by contrast-enhanced computer tomography or echocardiography and underwent emergent surgery.

Table 1 Patient demographics (mean ± SD)

Variables	Total N (%)	Central cannulation N (%)	Peripheral cannulation N (%)	P value
Total	235	127 (54.0%)	108 (46.0%)	
Age (years)	62.6±14.4	62.4±14.4	62.9±14.4	0.805
Gender (male)	154 (65.5%)	79 (62.2%)	75 (69.4%)	0.152
BMI (kg/m²)	27.0±4.6	26.6±4.5	27.4±4.8	0.212
EuroSCORE I	12.1±4.1	11.5±4.0	12.7±4.2	0.031
Previous sternotomy	38 (16.2%)	20 (15.7%)	18 (16.7%)	0.861
Pre-OP neurologic dysfunction	25 (10.7%)	9 (7.1%)	16 (15.1%)	0.040
Pre-OP creatinine (mmol/L)	103±74	96±41	111±100	0.150
Diabetes	18 (7.8%)	9 (7.1%)	9 (8.5%)	0.444
Shock state	53 (22.6%)	27 (21.4%)	26 (24.1%)	0.875
Previous resuscitation	9 (3.8%)	2 (1.6%)	7 (6.5%)	0.054
ASA score	3.6±0.72	3.5±0.81	3.8±0.57	0.011
EF (<50%)	37 (22.9%)	18 (21.2%)	19 (24.7%)	0.383
Pre-OP intubated	21 (9.0%)	10 (7.9%)	11 (10.2%)	0.354
Pre-OP inotropes	39 (17.2%)	18 (14.5%)	21 (20.4%)	0.161

BMI, body-mass-index; EF, ejection fraction.

The main preoperative patient demographics are seen in *Table 1*. There were no significant differences in the preoperative demographic parameters, like age, gender, body-mass-index (BMI), previous sternotomy, diabetes, shock state and creatinine. In addition, the proportion of patients with low ejection fraction, preoperative intubation and inotrope dependence before the operation was similar. Significant differences were observed between the central and femoral cannulation group in EuroSCORE I (11.5±4.0 *vs*. 12.7±4.2, P=0.031), preoperative resuscitation (1.6% *vs*. 6.5%, P=0.040), preoperative neurologic dysfunction (7.1% *vs*. 15.1%, P=0.40) and ASA (American Society of Anesthesiologist) Physical Status Classification (3.5±0.81 *vs*. 3.8±0.57, P=0.011). 42.4% of the patients in the central cannulation group were classified in ASA score 2 to 3 (patient with mild or severe systemic disease) and 57.6% in the ASA score 4 to 5 (patient with severe systemic disease that is a constant threat to life or moribund patient who is not expected to survive without the operation). In the peripheral cannulation group 25.7% were in ASA score 2 to 3 and 74.9% in ASA score 4 to 5 (P=0.009).

Central cannulation was performed in in 127 patients (54%); via the subclavian/axillary artery in 104 patients (81.9%), directly via the ascending aorta in 22 patients (17.3%) and via the right carotid artery in one patient (0.8%). Extracorporeal circulation was started with femoral cannulation in 108 patients (46%). Venous drainage was

performed either through the femoral vein (n=24, 10.2%) or a double-stage cannula in the right atrium (n=209, 88.9%). Bicaval venous cannulation was performed in 2 patients (0.9%).

After starting extracorporeal circulation the body temperature was cooled to around 18 ℃ (18.1±2.0 *vs*. 18.1±2.2 ℃, P=0.775). During hypothermic circulatory arrest direct cerebral perfusion was used in 55.0% with central cannulation and in 51.1% with femoral cannulation. Since 2013 the temperature management changed to higher temperatures of 24–26 ℃ with always antegrade cerebral perfusion. Concomitant cardiac procedures were coronary artery bypass grafting in 10.2% (n=24) and mitral valve reconstruction in 0.9% (n=2). An additional procedure on the aortic valve or aortic root was performed in 92 (39.3%) cases (*Table 2*).

Operation-, bypass- and X-clamp times were similar in both cannulation groups. In addition, the time of circulatory arrest and the time of cerebral perfusion were comparable.

Table 3 shows the outcome parameter. 30-day-mortality (20.2% *vs*. 16.9%, P=0.699) and stay on the intensive care unit (ICU) (9.3±9.4 *vs*. 10.3±10.5, P=0.538) were similar in the central and peripheral cannulation group as was use of the intra-aortic balloon pump (2.1% *vs*. 2.4%, P=0.538) and need of extracorporeal membrane oxygenation (3.2% *vs*. 2.4%, P=0.561) postoperatively. The mean hospital length of stay was 17.2±18.1 days in the central cannulation

Table 2 Operative parameters and additional cardiac procedures

Variables	All patients	Central cannulation	Peripheral cannulation	P value
Operation time (min)	415±138	414±142	416±133	0.903
Bypass-time (min)	245±93	249±102	240±81	0.474
Cross-clamp time (min)	162±77	166±85	157±67	0.418
Circulatory arrest time (min)	50.1±28.0	51.6±28.7	48.3±27.1	0.365
Lowest temperature (℃)	18.1±2.0	18.1±2.0	18.1±2.2	0.775
Antegrade selective cerebral perfusion	109 (53.2%)	61 (55.0%)	48 (51.1%)	0.674
Time of cerebral perfusion (min)	38.3±17.4	40.5±17.6	35.2±16.8	0.188
Additional cardiac procedures				
Aortic valve/root operation	92 (39.3%)	48 (38.1%)	44 (40.7%)	0.689
Hemiarch replacement	140 (59.6%)	77 (60.6%)	63 (58.3%)	0.790
CABG	24 (10.2%)	15 (11.8%)	9 (834%)	0.398
Mitral valve reconstruction	2 (0.9%)	2 (1.6%)	0 (0.0%)	0.502

CABG, coronary artery bypass grafting.

Table 3 Outcome parameters

Variables	All patients	Central cannulation	Peripheral cannulation	P value
30-day mortality	33 (16.8%)	19 (20.2%)	14 (16.9%)	0.699
ICU stay (days)	9.8±10.0	9.3±9.4	10.3±10.5	0.538
IABP	4 (2.3%)	2 (2.1%)	2 (2.4%)	0.561
ECMO	5 (2.8%)	3 (3.2%)	2 (2.4%)	0.561
New cerebral event	17 (7.2%)	11 (8.7%)	6 (5.6%)	0.449
Rankin scale	3.5±1.4	3.3±1.4	4.0±1.4	0.401
Psycho-syndrome	57 (24.3%)	29 (22.8%)	28 (25.9%)	0.852
Re-thoracotomy	20 (8.5%)	9 (7.1%)	11 (10.2%)	0.477
Dialysis on ICU	57 (24.3%)	25 (19.7%)	32 (29.6%)	0.073
Days on dialysis	3.0±6.7	2.7±6.4	3.3±7.1	0.576
Creatinine (mmol/L)	130±78	125±72	135±84	0.406

ICU, intensive care unit; IABP, intra-aortic balloon pump; ECMO, extracorporeal membrane oxygenation.

and 19.1±16.4 days in the peripheral cannulation group (P=0.423).

A cerebral event or cerebral infarction in the computer tomographic scan was evident in 8.7% versus 5.6% (central *vs.* peripheral cannulation, P=0.449). The Rankin Scale of the patient with cerebral infarction was comparable between the cannulation groups (3.3±1.4 *vs.* 4.0±1.4, P=0.401). In addition, the development of a postoperative psycho-syndrome was similar with almost one fourth of all patients after operation. The need for a rethoracotomy was comparable between both cannulation groups (7.1% *vs.* 10.2%, P=0.477).

The amount of blood transfusion was 5.8±6.7 units

and 7.2±11 units (P=0.246) in the central and peripheral cannulation groups. Thirty five (27.6%) of the central cannulation group and 25 (23.1%) of the peripheral cannulation group received no blood during hospital stay. The fresh frozen plasma transfusion was 3.2±5.0 units and 4.3±8.0 units (P=0.209). Seventy (55.1%) of the central cannulation group and 55 (50.9%) of the peripheral cannulation group received no fresh frozen plasma during hospital stay. Postoperative renal failure with the need for dialysis was borderline significant higher in the femoral artery group (38.6% *vs.* 26.6%, P=0.07).

Reintubation needed 17.3% (22 pts.) in the central cannulation and 19.4% (21 pts.) in the peripheral

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Table 4 Variables for 30-day mortality

Variables	Death	Survival	P value
N	33 (18.6%)	144 (81.4%)	
Age (years)	70.6±12.3	59.6±14.7	<0.001
EuroSCORE I	16.0±3.8	11.2±3.7	<0.001
Shock state	13 (39.4%)	27 (18.6%)	0.019
Resuscitation	3 (9.1%)	1 (0.7%)	0.021
Pre-OP intubated	8 (24.2%)	8 (5.6%)	0.003
Pre-OP inotropes	12 (36.4%)	17 (11.8%)	0.003
ASA score	3.9±0.62	3.4±0.75	0.003
EF (<50 %)	12 (36.4%)	24 (18.7%)	0.001
ECMO	4 (12.1%)	1 (0.7%)	0.003
EF, ejection fraction; ECMO, extracorporeal membrane oxygenation.			

Table 5 Independent preoperative risk factors for 30-day mortality

Variables	Univariate			Multivariate		
	OR	95% CI	P value	OR	95% CI	P value
Resuscitation	10.16	2.432–42.466	0.001	3.342	0.678–4.567	0.217
EuroSCORE I >13	10.39	4.109–26.274	0.000	5.037	1.161–21.85	0.031
Pre-OP intubated	4.959	1.950–12.610	0.002	4.264	0.887–20.48	0.070
Pre-OP inotropes	5.038	2.356–10.774	0.001	1.506	0.461–4.917	0.497
Age >60 y	2.357	1.099–5.058	0.028	2.365	0.581–9.625	0.229
ASA Score >4	2.739	1.203–6.235	0.016	1.094	0.340–3.519	0.880
EF (<50%)	3.190	1.377–7.387	0.007	1.990	0.671–5.904	0.215
Shock state	2.793	1.237–6.304	0.013	1.426	0.474–4.291	0.528
EF, ejection fraction.						

cannulation group (P=0.860). A tracheotomy was performed in 11.8% (15 pts.) in the central cannulation and in 12.0% (13 pts.) in the peripheral cannulation group (P=1.000).

Table 4 shows the preoperative variables with significant impact on the 30-day-mortality. Only the variables with significance are plotted. Patients with a risk of 30-day-mortality are significant older and with a higher EuroSCORE I and ASA-Classification. Additional parameters were preoperative shock state, need for resuscitation, inotrope dependency and intubation. However, in the multivariate analysis support only EuroSCORE I above 13 was a significant risk factor for 30-day-mortality in our patients (*Table 5*).

Discussion

Mortality with acute aortic dissection type A remains high with an average 30-day-mortality of around 17%, which progressively increase to 25% in octogenarians (2). Despite modern surgical techniques mortality remained constantly high over the last decade (1). In our single-center study we report a 30-day-mortality of 16.8% in 235 patients, which confirms multi-center registry studies with 30-day mortalities between 16.9% and 22% (1,9). Our cannulation strategy for initial bypass had no impact on mortality. While some studies show a positive effect with central cannulation (10) other studies could not demonstrate any benefit (1,11-13). In a meta-analysis from Patris *et al.* femoral cannulation had a negative outcome, but was used mainly in critically ill patients in hemodynamic collapse when institution of cardiopulmonary bypass was required rapidly (14). Our data show, that femoral cannulation was performed more often in a sicker patient group measured by the ASA classification. However, the ASA classification

is still a subjective classification dependent from the judgment of the anesthesiologist. Nevertheless, higher EuroSCORE I, previous resuscitation and preoperative neurologic dysfunction were significant more often in femoral cannulation group. The reason might be a faster access to the cannulation site, compared to the subclavian artery, in the need for a fast sternotomy due the pericardial effusion/tamponade and hemodynamic instability. Despite this sicker and hemodynamic instable patient group outcome parameter were not adversely affected by femoral cannulation. In the study from Etz *et al.* the group with femoral artery cannulation showed significant shorter operation and circulatory arrest times. However, outcome parameters, especially postoperative stroke (18% *vs.* 15%) and early death (21 *vs.* 20%, peripheral *vs.* central cannulation) were comparable (11). In the meta-analysis from Tiwari *et al.* just axillary artery cannulation was superior regarding outcome but not central cannulation in total (15). In addition, the study from Kamiya *et al.* could only show a borderline significance with aortic in contrast to femoral cannulation regarding 30-day-mortality, despite higher ASA classification in the femoral cannulation group (13). The large German Registry for acute aortic dissection (GERAADA) with 2,137 patients could not show any significant impact of the cannulation site on any outcome parameter (1).

Preoperative neurologic symptoms were presented in around 7% and postoperative neurologic symptoms in up to 20% of the patients (1). In our study, we could not find any differences in neurologic symptoms regarding the perfusion strategy. In a meta-analysis of nine acute type A dissection studies Ren *et al.* could show a significant benefit in short-term and postoperative neurology in patients with axillary cannulation in contrast to femoral artery cannulation (12). As a limitation of this study, it is not known if selective cerebral perfusion was performed during circulatory arrest and which was the lowest body temperature. In our study, we used deep circulatory arrest with an average temperature of 18.1 ℃ and additional selective antegrade cerebral perfusion in 53% of all patients. The time of cerebral perfusion was in average 76.8% of the time of circulatory arrest with no differences between both perfusion groups. However, the use of additional selective cerebral perfusion had no impact in postoperative mortality or neurology in our study at an average temperature of 18 ℃. With adequate cerebral perfusion and cerebral monitoring a moderate hypothermic arrest with temperatures between 24 and 28 ℃ are acceptable. In the setting of antegrade cerebral perfusion, deep hypothermia does not provide any additional benefit (16). Conzelmann *et al.* could similar show that neurological complications does not seem to be affected by choice of the arterial cannulation site (17).

Similar to the multi-center study from Rylski *et al.* age was not a predictor for worse neurologic outcome but for mortality (2). Our 30-day-mortality was 7% in the age group below 50 years, 15.3% in the group between 50 and 70 and 28% above 70 years of age (P=0.023).

Univariate and multivariate logistic regression analysis was performed to characterize risk factors for 30-day-mortality. Age was a significant factor for worse 30-day-mortality as was worse clinical appearance before the operation (EuroSCORE I, shock, reanimation, intubation, inotropic support). In addition, only one patient with postoperative ECMO support after operation of acute type A aortic dissection survived. However, in the multivariate analysis the only preoperative significant independent risk factor for 30-day-mortality was EuroSCORE I above 13.

Limitations

This study has some limitations, which needed to be addressed. First, this is a retrospective data analysis in a very heterogeneous patient population. In addition, the choice of cannulating a central or peripheral vessel was mainly driven by the experience of the surgeon rather than objective parameters.

Conclusions

Our single-center study with 235 patients operated on AADA revealed that the cannulation technique (femoral or central vessels) did not have any impact on postoperative neurology or 30-day-mortaliy or any other postoperative outcome parameter. This might be triggered by the constantly use of circulatory arrest at a profound hypothermic state with a body temperature around 18 ℃. This low temperature did not affect the average operation time or the need for re-thoracotomy for bleeding compared to the literature. Mortality in the early 30 days after the operation was depending on the hemodynamic state and the overall clinical status measured by the EuroScore I and ASA classification at the time of presenting in the operation room. Higher age was a risk factor for mortality but not postoperative neurology.

We conclude, that femoral artery cannulation is a

safe and easy accessible technique with similar outcome in AADA patients, which is still useful especially in hemodynamic instable patients.

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