Surgical management and outcomes in patients with acute type A aortic dissection and cerebral malperfusion

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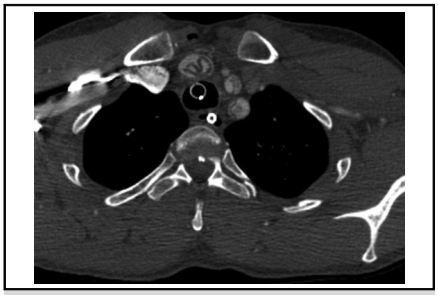
ABSTRACT

Objective: The study objective was to evaluate the surgical results in patients with acute type A aortic dissection and cerebral malperfusion.

Methods: From 2000 to 2019, 234 patients with type A aortic dissection and cerebral malperfusion were stratified into 3 groups: 50 (21%) with syncope (group 1), 152 (65%) with persistent loss of focal neurological function (group 2), and 32 (14%) with coma (group 3). Results were evaluated and compared by univariable and multivariable analyses.

Results: Median age was higher in group 1, and incidence of cardiogenic shock was higher in group 3. The femoral artery was the most common cannulation site, whereas the axillary artery was used in 18% of group 1, 30% of group 2, and 25% of group 3 patients ($P = .337$). Antegrade cerebral perfusion was performed in more than 80% of patients, and ascending aorta/arch replacement was performed in 40% of group 1, 27% of group 2, and 31% of group 3 ($P = .21$). In-hospital mortality was 18% in group 1, 27% in group 2, and 56% in group 3 ($P = .001$). Survival at 5 years is 57.0% in group 1, 57.7% in group 2, and 38.7% in group 3 ($P = .0005$). On multivariable analysis, age, cardiopulmonary bypass time, and group 3 versus group 2 were independent risk factors for mortality, whereas axillary cannulation was a protective factor.

Conclusions: Patients with aortic dissection and cerebral malperfusion without preoperative coma showed acceptable mortality, and those with coma had a high in-hospital mortality regardless of the type of brain protection. Overall axillary artery cannulation appeared to be a protective factor. (JTCVS Open 2022;10:22-33)



Dissection of all SABs in a patient with neurological impairment.

CENTRAL MESSAGE

In patients with A-AAD and CM, surgical outcomes depend on the severity of clinical presentation. Axillary artery cannulation seems to improve early results.

PERSPECTIVE

Patients with A-AAD are at high risk when presenting with CM. In this subset, surgical results depend on the severity of clinical presentation, but emergency repair, particularly using the axillary artery for CPB, appears advisable. Patients with coma show the highest mortality regardless of the surgical strategy.

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Abbreviations and Acronyms

A-AAD = type A acute aortic dissection
CI = confidence interval
CM = cerebral malperfusion
CPB = cardiopulmonary bypass
CT = computed tomography
ET = elephant trunk
OR = odds ratio
PND = permanent neurological deficit
SAB = supra-aortic branch

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Type A acute aortic dissection (A-AAD) is a life-threatening disease requiring emergency surgical repair. Although early and late outcomes have been greatly improved in the last decade,[1] in patients presenting with neurological symptoms the prognosis seems poor with a significant reduction of short-term results.[2-4] Cerebral malperfusion (CM) is known to be a risk factor for postoperative permanent neurological deficit (PND) with reported incidence rates of 10% to 30%.[3,5,6] Early reperfusion of true lumen has been advocated as an important factor to reduce PND by some authors who have proposed various procedures of revascularization of the supra-aortic branches (SABs) to reduce the duration of brain ischemia.[7,8] However, patients with A-AAD and neurological deficit often present with multiorgan malperfusion and hemodynamic instability,[9] limiting the time available for a more accurate diagnosis or for procedures before establishing cardiopulmonary bypass (CPB). Previous studies have reported different results for such patients undergoing cardiac surgery,[4,10] and the best surgical management remains controversial.

The aim of this study is to evaluate the surgical results of patients presenting with A-AAD and neurological symptoms based on the degree of clinical presentation and the intraoperative strategy.

MATERIALS AND METHODS

Study Population

From 2000 to 2019, a total of 1234 consecutive patients underwent A-AAD repair in 6 referral centers for aortic surgery. Of these, 234 (19%) presenting with neurological symptoms were considered for this analysis and stratified. Patients were divided into 3 groups according to the clinical presentation (Table 1): 50 (21%) with syncope (group 1), 152 (65%) with persistent loss of focal neurological function (group 2), and 32 (14%) with coma (group 3). In this study, syncope was defined as a loss of consciousness of fast onset, short duration, and spontaneous recovery without permanent deficits but with evidence of dissection of at least 1 supra-aortic vessel; 150 patients presented with syncope but without involvement of at least 1 supra-aortic vessel, such as that caused by transient hypotension, were excluded; coma was considered as any nonmedically induced complete mental unresponsiveness to external stimulation (Figure 1 and Video Abstract). The study protocol was approved by the local Ethics Committee (Institutional Review Board approval: n. 013/2020_IRB Tit. III cl.32 fasc.32 - June 12, 2020), and informed consent was waived.

Outcomes

Because the aim of this study was to evaluate the results of repair in patients with A-AAD and neurological symptoms at presentation, the primary end points of the study were time to in-hospital death from any cause and postoperative neurological function. The secondary end point was the impact of surgical strategy for brain protection.

Surgical Technique

Standard patient preparation was used without any cerebrospinal fluid drainage system. All operations were performed through a median sternotomy using CPB; myocardial protection was obtained with intracoronary injection of cold crystalloid or blood cardioplegia repeated every 30 minutes. Systemic perfusion was obtained through cannulation of 1 femoral artery, the right axillary artery or ascending aorta (central cannulation) depending on each center protocol. When the entrance tear was located in the ascending aorta and in the absence of dilatation of the aortic, only the ascending aorta and hemiarch were replaced. When multiple tears were present or A-AAD started in the arch, both the ascending aorta and arch were replaced. In all cases, the distal aortic suture line was carried out with the "open" technique. Initially, arch replacement was performed with reattachment of the epiaortic vessels contained in an island of arch tissue; subsequently, the aortic arch was replaced using a trifurcated or quadrifurcated graft, and adding the classic elephant trunk (ET) technique which was replaced, more recently, by the frozen ET in all centers. Deep hypothermic circulatory arrest was used whenever retrograde cerebral perfusion was selected, whereas selective antegrade cerebral perfusion was performed under moderate hypothermia through axillary artery cannulation and selective cannulation of the left carotid artery or only selective cannulation of the epiaortic vessels. The type of cerebral protection was also at the discretion of each center protocol and specific surgeon in some cases.

Postoperatively, a common protocol management included rapid awakening of the patient to evaluate and quantify any potential neurological damage as early as possible.

Patient Evaluation and Follow-up

Diagnosis of A-AAD was suspected on the basis of the clinical presentation and then confirmed by transthoracic 2-dimensional echocardiography, angio-computed tomography (CT), or their combination; CM was diagnosed by the presence of dissection involving the SAB on CT scans when available or by the intraoperative findings. When signs of preoperative neurological involvement were present, the degree of cerebral damage was assessed by neurological examination.

Patients were annually evaluated with CT scans after discharge. Whenever possible, clinical assessment was performed through direct visits, whereas phone interviews and reviews of medical records were used to obtain further information on patient status and occurrence of major postoperative complications. The causes of death were confirmed from a combination of medical records, death certificates, postmortem reports, and contact with family members and general practitioners.

Statistical Analysis

Continuous variables were expressed as mean ± standard deviation or median and range, according to the data distribution. The data were

TABLE 1. Patient demographics and preoperative clinical findings

Characteristic	Group 1 (n = 50)	Group 2 (n = 152)	Group 3 (n = 32)	*P*
Median age, y (range)	68 (50-87)	65 (28-84)	68 (48-82)	.031
Male sex, No. (%)	29 (58)	92 (60)	24 (75)	.250
Cardiac tamponade/shock, No. (%)	16 (32)	37 (24)	23 (72)	<.001
Chest pain, No. (%)	30 (60)	102 (67)	13 (40)	.019
Organ malperfusion, No. (%)	29 (62)	98 (78)	23 (85)	.040
AI moderate or more, No. (%)	14 (29)	33 (27)	7 (27)	.952
Systemic hypertension, No. (%)	37 (74)	102 (68)	19 (65)	.664
Smoking, No. (%)	23 (46)	44 (29)	6 (21)	.035
Dyslipidemia No. (%)	4 (13)	22 (16)	4 (17)	.903
DM, No. (%)	1 (2)	5 (3)	2 (7)	.554
CKD No. (%)	3 (6)	8 (5)	4 (13)	.294
AKI, No. (%)	1 (4)	13 (12)	3 (15)	.435
Chronic atrial fibrillation, No. (%)	4 (13)	11 (8)	4 (19)	.292
COA, No. (%)	2 (6)	10 (8)	2 (9)	.921
Previous stroke, No. (%)	1 (2)	9 (6)	1 (4)	.718
Marfan syndrome, No. (%)	0 (0)	1 (1)	0 (0)	1
CAD, No. (%)	1 (2)	6 (4)	5 (18)	.014
Previous cardiac surgery, No. (%)	2 (4)	8 (5)	1 (3)	1
BAV, No. (%)	0 (0)	4 (3)	2 (7)	.182

AI, Aortic insufficiency; *DM*, diabetes mellitus; *CKD*, chronic kidney disease; *AKI*, acute kidney injury; *COA*, chronic oral anticoagulation; *CAD*, coronary artery disease; *BAV*, bicuspid aortic valve.

analyzed using the Shapiro–Wilk test to verify the normal distribution. Categorical variables were presented as absolute numbers and percentages. Student *t* test or Mann–Whitney *U* test was used to compare continuous variables between groups, as appropriate. Analysis of variance or Kruskal–Wallis test was used to compare continuous variables among the 3 groups. Comparison of categorical variables was performed by chi-square analysis or Fisher exact test, as appropriate. Overall survival was described according to the Kaplan–Meier approach. Comparisons among

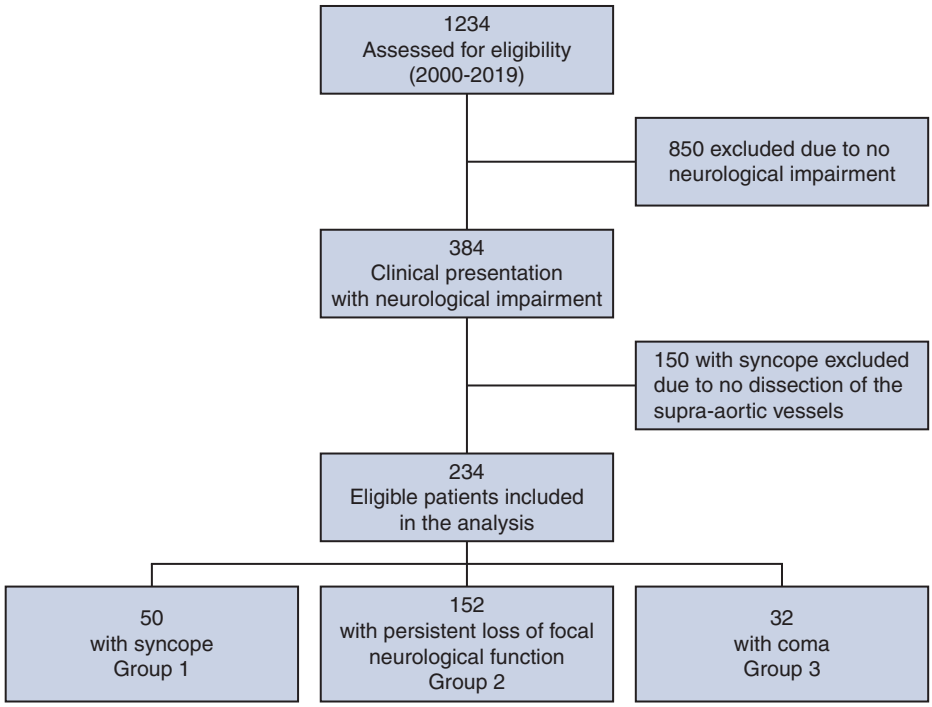


FIGURE 1. Diagram of patient selection process. After exclusion of 850 patients without neurological impairment and 150 with syncope without dissection of the supra-aortic vessels, 234 patients were eligible for analysis.

survival distributions were performed using the Tarone-Ware test. Furthermore, a long-term survival analysis for the hospital patients who survived was performed. Univariable and multivariable conditional logistic regression was performed to explore which factors were associated with in-hospital mortality, estimating odds ratios (ORs; 95% confidence intervals [CIs]), stratifying by referral centers. The multivariable analyses included all variables clinically relevant, taking into account the number of events and potential collinearities.

RESULTS

Patient Characteristics

There were 145 men and 89 women with a median age of 67 years (range, 28-87 years). Overall median follow-up was 1.38 years (range, 0 months to 19 years); it was 1.66 years (range, 0 months to 13 years) for group 1, 2 years (range, 0 months to 19 years) for group 2, and 6 months (range, 0 months to 6 years) for group 3.

Main characteristics of patients are summarized in Table 1. In group 1, 58% were men with a median age of 68 years (range, 50-87 years); 74% had arterial hypertension, 62% had systemic organ malperfusion, and 32% had cardiac tamponade at presentation. In group 2, 61% were men with a median age of 65 years (range, 28-85 years); 68% had hypertension, 78% had organ malperfusion, and 24% cardiac tamponade. In group 3, 75% were men with a median age of 68 years (range, 49-82 years); 66% had hypertension, 85% had organ malperfusion, and 72% had cardiac tamponade.

Surgical Data

Femoral artery cannulation was used in 68% of patients of group 1, 63% of group 2, and 63% of group 3, whereas axillary artery cannulation was used in 18% of patients of group 1, 30% of group 2, and 25% of group 3 ($P = .20$). Approximately two-thirds of the patients underwent ascending aorta and hemiarch replacement (60% in group 1, 73% in group 2, and 69% in group 3), and the remaining had ascending aorta and arch replacement (40% in group 1, 27% in group 2, and 31% in group 3; $P = .22$); ET and frozen ET were used in 15 and 3 patients, respectively. During circulatory arrest, antegrade cerebral perfusion was applied in 88% of group 1, 80% of group 2, and 90% of group 3 patients ($P = .24$). On the other hand, retrograde cerebral perfusion was used in 12% of patients of group 1, 22% of group 2, and 6% of group 3 ($P = .06$). Intraoperative times were comparable among the 3 groups, with a median CPB time of 217 minutes (range, 109-447 minutes), a median aortic crossclamp time of 120 minutes (range, 25-317 minutes), and a median circulatory arrest time of 40 minutes (range, 5-239 minutes) at a median core temperature of 24 °C (range, 16 °C-37 °C) (Table 2).

Postoperative Outcomes

There were a total of 68 in-hospital deaths in the entire cohort: Nine (18%) occurred in group 1, 41 (27%) occurred in group 2, and 18 (56%) occurred in group 3 ($P = .001$). Multiorgan failure was the cause of 12% of the deaths in group 1, 2% in group 2, and 13% in group 3 ($P = .005$). Cerebral damage was recognized as the cause of death in 4% of group 1, 9% of group 2, and 25% of group 3 patients ($P = .005$); 2% of patients from group 1, 8% from group 2, and 19% from group 3 had redissection or aortic rupture in the early postoperative hours ($P = .030$). Death due to other causes was reported in 0% of patients in group 1, 8% in group 2, and 0% in group 3.

Overall survival at 1, 5, and 7 years of the study population was 66.8% (CI, 60.2-72.5), 55.2% (CI, 47.3-62.5), and 47.6% (CI, 38.3-56.3), respectively (Figure 2, *A*). Overall survival was significantly different among groups 1, 2, and 3. At 1 year, it was 74.2% (CI, 58.9-84.5) versus 69.2% (CI, 61.1-75.9) versus 43.5% (CI, 26.2-59.7), respectively, and at 5 years, it was 57.0% (CI, 33.8-74.7) versus 57.7% (CI, 48.0-66.2) versus 38.7% (CI, 21.4-55.7), respectively (log-rank *P* test = .0005) (Figure 2, *B*). Overall survival for hospital survivors was not significantly different among the 3 groups ($P = .366$) (Figure E1).

On univariable analysis, significant risk factors for in-hospital mortality are indicated in Table 3, which also shows how axillary versus femoral artery cannulation (OR, 0.42, 95% CI, 0.19-0.95, $P = .038$) was a protective factor for in-hospital mortality. On multivariable logistic regression, only axillary versus femoral artery cannulation (OR, 0.36, CI, 0.14-0.88, $P = .026$), age (OR, 1.05, 95% CI, 1.02-1.08, $P = .003$), group 3 versus group 2 (OR, 2.90, 95% CI, 1.15-7.29, $P = .024$), and CPB time (OR, 1.01, 95% CI, 1.00-1.01, $P = .004$) were independently associated with in-hospital mortality (Table 4 and Figure 3) (Video Abstract).

Neurological Outcomes

Postoperative neurological deficit was observed in 23 patients (46%) in group 1, 71 patients (51%) from group 2, and 20 patients (63%) from group 3 ($P = .055$). Of these, 18 patients (78%) in group 1, 41 (58%) in group 2, and 16 (80%) in group 3 ($P = .08$) had a PND. The incidence of postoperative coma was significantly different among groups 1, 2, and 3: 14%, 12%, and 42%, respectively ($P < .001$).

On univariable logistic regression analysis, axillary versus femoral versus central artery cannulation was associated with permanent postoperative neurological deficit (OR, 0.47, 95% CI, 0.22-0.99, $P = .047$) in groups 1 and 2.

DISCUSSION

Despite significant progression in surgical techniques and intraoperative management, patients with A-AAD and signs of CM represent an important issue of debate particularly in terms of surgical decision-making and possible

TABLE 2. Summary of main surgical and postoperative data

Characteristic	Group 1 n = 50	Group 2 n = 152	Group 3 n = 32	*P*
Arterial cannulation				.337
Femoral, No. (%)	34 (68)	95 (62.5)	20 (62.5)	
Axillary, No. (%)	9 (18)	46 (30.3)	8 (25)	
Aortic, No. (%)	7 (14)	11 (7.2)	4 (12.5)	
Type of surgery				.219
AA + hemiarch replacement, No. (%)	30 (60)	111 (73.0)	22 (68.7)	
AA + arch replacement, n (%)	20 (40)	41 (27.0)	10 (31.2)	
RCP, n (%)	6 (12)	33 (22.1)	2 (6.2)	.055
ACP, n (%)	44 (88)	118 (79.7)	28 (87.5)	.204
No perfusion, No. (%)	8 (16)	46 (31.1)	2 (6.2)	.054
Median CPB time, min (range)	210 (117-386)	223 (109-447)	221 (120-373)	.809
Median clamp time, min (range)	122 (25-245)	120 (45-317)	114 (60-241)	.890
Median arrest time, min (range)	40 (7-120)	40 (5-329)	35 (7-134)	.330
Median lowest temperature, °C (range)	24 (7-31)	24 (16-37)	25 (18-31)	.203
Median HCT, % (range)	18 (15-24)	23 (12-32)	23 (19-27)	.005
In-hospital death, No. (%)	9 (18)	41 (27)	18 (56)	.001
Mechanical ventilation ≥96 h, No. (%)	23 (47.9)	57 (43)	18 (66)	.090
Median ICU stay, d (range)	6 (1-98)	5 (1-62)	7 (1-129)	.497
Median hospital stay, d (range)	14 (2-193)	16 (1-109)	15 (2-129)	.803
Surgical reexploration, No. (%)	7 (14)	29 (21)	4 (15)	.510
Postoperative neurological deficit, No. (%):	23 (46)	71 (52)	20 (74)	.055
Permanent deficit, No. (%)	18 (78)	41 (58)	16 (80)	
Transient deficit, No. (%)	5 (22)	29 (41.4)	4 (20)	
Paraplegia, No. (%)	3 (6)	12 (9)	2 (8)	.982
Coma, No. (%)	7 (14)	16 (12)	11 (42)	<.001
Perioperative AMI, No. (%)	0 (0)	5 (4)	1 (4)	.440
Atrial fibrillation, No. (%)	18 (36)	55 (40)	7 (27)	.428
AKI, n (%)	19 (38)	64 (45)	17 (60)	.154
CVVH/dialysis, n (%)	10 (20)	26 (19)	7 (27)	.641

AA, Ascending aorta; *RCP*, retrograde cerebral perfusion; *ACP*, antegrade cerebral perfusion; *CPB*, cardiopulmonary bypass; *HCT*, hematocrit; *ICU*, intensive care unit; *AMI*, acute myocardial infarction; *AKI*, acute kidney injury; *CVVH*, continuous venovenous hemofiltration.

futility in performing a complex repair in patients with potentially irreversible cerebral damage.

Various studies have shown that CM represents a major risk factor for the worsening of early results observed in patients after surgical repair of A-AAD.[5,9,10] Data from the International Registry of Aortic Dissection and the German Registry for Acute Aortic Dissection Type A reported 15% and 11% of patients, respectively, with A-AAD with clinical signs and symptoms of CM at presentation[5,9]; in our study, we found a 19% of incidence of this complication, slightly superior to that previously reported. Such differences found in data from multicenter registries may reflect the difficulty of a correct diagnosis of neurological involvement when shock and altered consciousness are present; indeed, some of these patients initially admitted to peripheral hospitals may be referred already intubated and on mechanical ventilation, so their neurological status may be difficult to be ascertained.

In the present multicenter study, we aimed to assess the outcomes of a series of patients undergoing repair of A-AAD and CM according to the type of clinical presentation. For this reason, we divided patients into 3 groups, those with syncope, those with persistent loss of focal neurological function, and those with coma, analyzing them separately and comparing the outcomes observed.

In our study, hospital mortality in the entire series was 29% and significantly greater for patients with coma compared with those with syncope or persistent loss of focal neurological function (56% vs 18% vs 27%; $P = .001$).

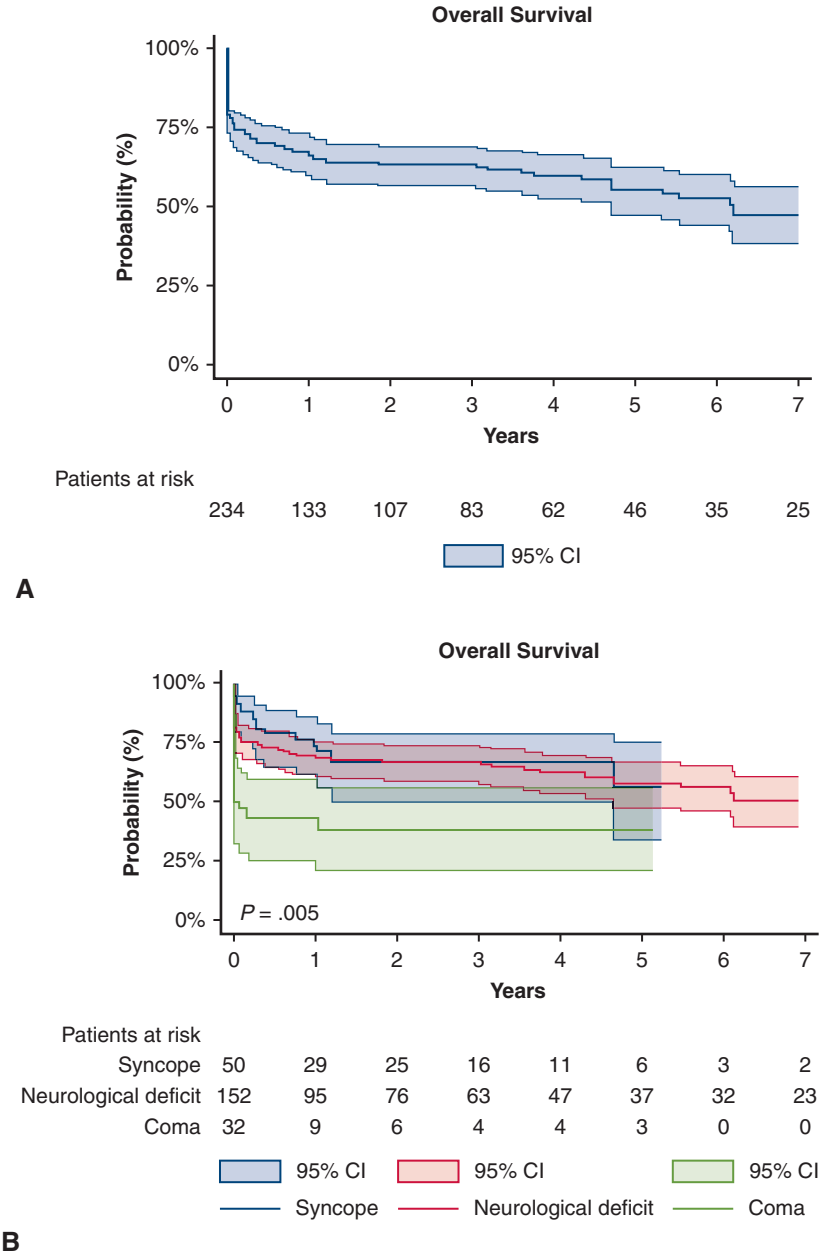


FIGURE 2. A, Overall actuarial survival in the study population is 66.8%, 55.2%, and 47.6%, at 1, 5, and 7 years, respectively. B, Actuarial survival based on clinical presentation was 74.2%, 69.2%, and 43.5% at 1 year and 57.0%, 57.7%, and 38.7% at 5 years. Patients presenting with coma (green line) have the worst survival compared with those with syncope (blue line) or neurological deficit (red line). *CI*, Confidence interval.

Coma (OR, 45, $P < .001$) was found to be a strong predictor of reduced hospital survival at multivariable analysis. Sultan and colleagues[9] reported an in-hospital mortality of 25.7% from the International Registry of Aortic Dissection registry, substantially unchanged in the last 2 decades despite the improvement of brain protection techniques. Similar results are reported by Czerny and colleagues[5] from the German Registry for Acute Aortic Dissection Type A registry with a mortality ranging from 21.3% to 43.4% according to the number of organ systems affected by malperfusion. Concerning operative mortality, better results have been observed in single-center series. Tsukube and colleagues[6] reported a mortality of 14% after early surgery in patients presenting with coma with full recovery of consciousness achieved in 86% of cases, whereas Estrera and colleagues[11] reported hospital mortality of 7% with complete recovery or improvement of the neurologic status in 14% and 43% of patients, respectively.

TABLE 3. Results of univariable logistic regression analysis for predictors of in-hospital mortality

Univariable analysis	OR (95% CI)	*P*
Age	1.03 (1.00-1.06)	.028
Male sex	1.29 (0.72-2.33)	.396
Group		
Syncope vs neurological deficit	0.59 (0.25-1.38)	.224
Coma vs neurological deficit	3.64 (1.66-8.00)	.001
Coma vs syncope	6.16 (2.20-17.27)	.001
Cardiac tamponade/shock	2.88 (1.55-5.35)	.001
Chest pain	0.76 (0.43-1.37)	.366
Organ malperfusion	1.43 (0.63-3.23)	.393
AI moderate or more	1.00 (0.47-2.10)	.996
Systemic hypertension	0.80 (0.43-1.49)	.491
Smoking	0.70 (0.36-1.35)	.289
Dyslipidemia	0.74 (0.30-1.86)	.529
DM	1.70 (0.39-7.36)	.475
CKD	1.87 (0.63-5.57)	.257
AKI	3.28 (1.13-9.48)	.028
Chronic atrial fibrillation	2.02 (0.75-5.44)	.162
COA	4.24 (1.37-13.08)	.012
History of stroke	3.54 (1.05-11.98)	.042
CAD	2.81 (0.87-9.11)	.085
Previous cardiac surgery	3.11 (0.92-10.52)	.068
BAV	1.32 (0.24-7.37)	.750
Axillary vs femoral arterial cannulation	0.42 (0.19-0.95)	.038
Aortic vs femoral arterial cannulation	1.06 (0.40-2.80)	.907
Aortic vs axillary	2.50 (0.78-8.05)	.123
AA + arch replacement vs AA + hemiarch replacement	0.61 (0.31-1.19)	.146
RCP	1.11 (0.45-2.74)	.820
ACP	1.21 (0.46-3.14)	.696
No cerebral perfusion	2.40 (0.48-11.91)	.282
CPB time	1.01 (1.00-1.01)	.023
Clamp time	1.00 (1.00-1.01)	.398
Arrest time	1.00 (1.00-1.01)	.363
Temperature	0.93 (0.82-1.05)	.236
Nadir HCT	0.91 (0.80-1.03)	.130
Mechanical ventilation ≥96 h	2.44 (1.24-4.78)	.009
ICU stay	1.01 (0.99-1.03)	.432
Surgical reexploration	2.70 (1.29-5.67)	.008
Postoperative neurological deficit	1.63 (1.08-2.47)	.020
Paraplegia	1.95 (0.87-4.35)	.103
Coma	44.31 (14.66-133.92)	<.001
AMI	6.89 (1.23-38.62)	.028
AF	0.58 (0.29-1.17)	.131
AKI	2.20 (1.16-4.18)	.015
CVVH/dialysis	2.66 (1.27-5.57)	.010

(Continued)

TABLE 3. Continued

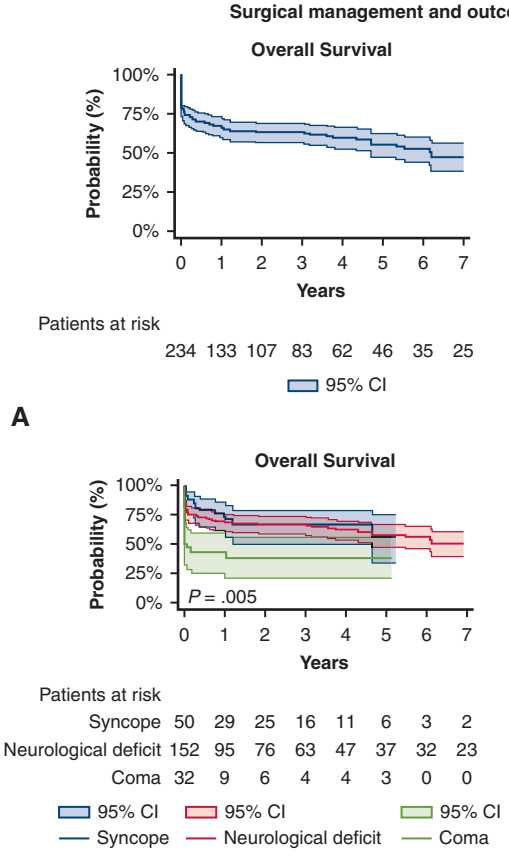
OR, Odds ratio; *CI*, confidence interval; *AI*, aortic insufficiency; *DM*, diabetes mellitus; *CKD*, chronic kidney disease; *AKI*, acute kidney injury; *COA*, chronic oral anticoagulation; *CAD*, coronary artery disease; *BAV*, bicuspid aortic valve; *AA*, ascending aorta; *RCP*, retrograde cerebral perfusion; *ACP*, antegrade cerebral perfusion; *CPB*, cardiopulmonary bypass; *HCT*, hematocrit; *ICU*, intensive care unit; *AMI*, acute myocardial infarction; *AF*, atrial fibrillation; *CVVH*, continuous venovenous hemofiltration.

In patients with A-AAD and CM, some authors have adopted an aggressive revascularization of the carotid arteries, even with percutaneous endovascular stenting, followed by surgery to limit the cerebral ischemic time.[12-15] Gomibuchi and colleagues[8] reported hospital mortality of 4.8% in 42 patients presenting with imaging CM with an incidence of greater than 50% of PND. The same authors subsequently applied in such patients a policy of early reperfusion with extra-anatomic revascularization, observing a marked decrease in this complication. Based on these results, preoperative imaging of SABs and early reperfusion have been proposed to reduce the risk of PND in patients with CM, with or without neurological symptoms. In some centers, CT scans were performed routinely as preoperative imaging studies[4,7,8] to confirm rapidly both the diagnosis and the involvement of the epiaortic vessels to avoid any delay in performing surgery. In these patients, preoperative neurological clinical assessment is also crucial; however, cranial CT scans, when performed to define the degree of cerebral damage, may underestimate the preoperative consequences of any CM, including stroke in those patients with a short interval time from onset of

TABLE 4. Results of multivariable logistic regression analysis for predictors of in-hospital mortality

Multivariable analysis	OR (95% CI)	*P*
Age	1.05 (1.02-1.08)	.003
Cardiac tamponade/shock	1.99 (0.97-4.07)	.060
Axillary artery cannulation vs femoral	0.36 (0.14-0.88)	.026
Central artery cannulation vs femoral	1.33 (0.43-4.10)	.619
Central artery cannulation vs axillary	3.73 (0.96-14.45)	.057
CPB time	1.01 (1.00-1.01)	.004
Group		
Syncope vs neurological deficit	0.44 (0.18-1.10)	.080
Coma vs neurological deficit	2.90 (1.15-7.29)	.024
Coma vs syncope	6.58 (2.11-20.50)	.001

OR, Odds ratio; *CI*, confidence interval; *CPB*, cardiopulmonary bypass.



From 2000 to 2019, 234 patients with type A aortic dissection and cerebral malperfusion were stratified into 3 Groups: 50 (21%) with syncope (Group 1), 152 (65%) with persistent loss of focal neurological function (Group 2) and 32 (14%) with coma (Group 3)

In hospital mortality was 29%; Group 1 vs 2 vs 3 = 18% vs 27% vs 56% ($P = .001$)

Multivariable logistic regression analysis for predictors of in-hospital mortality

	OR (95% CI)	*P*
Age	1.05 (1.02-1.08)	.003
Cardiac tamponade/shock	1.73 (0.88-3.39)	.111
Axillary artery cannulation vs Femoral Central artery cannulation vs Femoral	0.44 (0.20-0.96) 1.15 (0.39-3.36)	.039 .802
CPB time	1.01 (0.99-1.01)	.011
Group Syncope vs neurological deficit Coma vs neurological deficit	 0.43 (0.18-1.03) 2.75 (1.12-6.74)	 .058 .027

In patients with type A acute aortic dissection and cerebral malperfusion surgical results depend on the severity of clinical presentation, those with coma showing the highest mortality. Emergency repair, particularly using the axillary artery for cardiopulmonary bypass, appears advisable.

FIGURE 3. We have studied 234 patients with A-AAD and CM: 50 (21%) with syncope (group 1), 152 (65%) with persistent loss of focal neurological function (group 2), and 32 (14%) with coma (group 3). Overall hospital mortality was 29%, and it was significantly greater for patients with coma (group 3). At multivariable analysis, risk factors for mortality were age, coma (group 3) versus persistent loss of focal neurological function (group 2), and duration of CPB, whereas axillary artery cannulation provided a protective effect. Overall survival in the entire series at 1, 5, and 7 years was 66.8%, 55.2%, and 47.6%, respectively (A). Survival, based on clinical presentation, was significantly different among groups 1, 2, and 3: 74.2%, 69.2%, and 43.5% at 1 year and 57.0%, 57.7%, and 38.7% at 5 years, respectively ($P = .0005$). B, In the present experience, patients with CM presenting with coma show the highest mortality regardless of the surgical strategy. *CI*, Confidence interval; *CPB*, cardiopulmonary bypass; *OR*, odds ratio.

symptoms to diagnosis, and it may justify the different preoperative stroke rates (from 1.1% to 16%) reported in the literature.[2,4,11,16,17]

Although techniques aimed to an early cerebral revascularization may appear advisable in some settings, it must also be recognized that patients with A-AAD and neurological deficit often present severe hemodynamic instability, limiting the time available for possible extra-anatomic reperfusion procedures before establishing CPB, particularly when surgeons without much experience are involved in surgical decision-making and treatment.[9] Additionally, in a recent experience with the use of a new hybrid prosthesis, a single-stage strategy to treat CM in a series of 47 has proved effective and may represent another available option.[18]

An interesting result of our study was the significant impact of axillary artery cannulation observed on early outcomes. Our data showed that axillary artery compared with femoral artery cannulation for CPB has a protective effect at multivariable analysis with regard to in-hospital mortality (OR, 0.12, $P = .006$) and at univariable logistic regression analysis in relation to postoperative PND in patients presenting with syncope and persistent loss of focal neurological function (OR, 0.47, $P = .047$) (Figure 4). Antegrade or retrograde cerebral perfusion did not influence postoperative mortality or the incidence of neurological deficits. These results seem to indicate that an early antegrade arterial reperfusion of the true lumen may have a substantial role in reducing the duration of brain ischemia and in limiting the extension of neurological deficit as previously observed.[7,11,19]

Group 1 patients, presenting with syncope, showed a lower, although still significant, in-hospital mortality

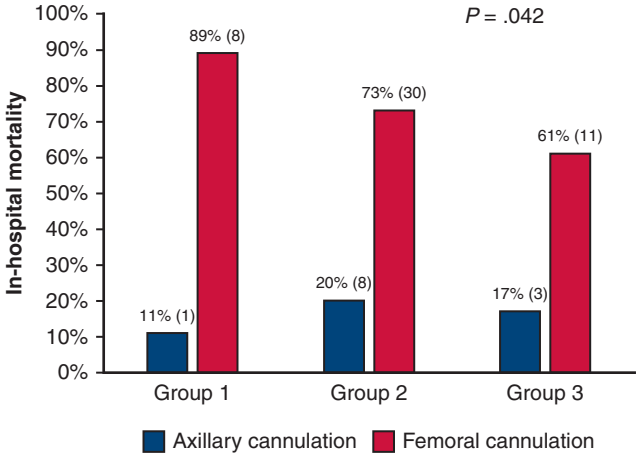


FIGURE 4. In-hospital mortality related to the cannulation strategy. Cannulation of the axillary artery resulted in lower mortality in all groups ($P = .042$). Central cannulation was excluded because of the low sample size.

(18%) and 36% of them had postoperative PND (7 patients with coma and 11 with focal deficit). However, in this subset the axillary artery approach for CPB was protective when compared with femoral artery cannulation. On the basis of these results, we believe that reperfusion through the axillary artery may represent an optimal surgical strategy in patients with A-AAD, particularly in the presence of SAB dissection, regardless of the severity of preoperative neurological deficit.

Dumfarth and colleagues[4] identified a relation between the presence of preoperative PND and the specific patterns of postoperative neurological injury, showing that strokes mainly involved the right hemisphere, whereas patients with normal preoperative neurological functions presented bilateral lesions more frequently. Other authors reported findings of bilateral perioperative strokes revealed by CT or magnetic resonance imaging, suggesting that intraoperative factors such as thrombotic or air microembolism play a significant role.[2,20]

In the present study, we did not focus our attention on the influence of specific surgical techniques used in arch replacement in functional results; in this respect, ET and frozen ET, currently adopted with increasing frequency in the treatment of A-AAD,[21,22] were used in a small number of patients. Because we more specifically evaluated the type of cerebral protection, our data suggest that an antegrade systemic perfusion established from the right axillary artery directly in the true lumen may be effective for restoring the normal flow to the brain and reducing the risk of thrombotic or air microembolism mainly related to retrograde systemic perfusion.

Finally, although patients presenting with coma showed the highest in-hospital mortality and incidence of permanent postoperative neurological deficits, regardless of the type of cannulation site and cerebral perfusion, 50% of them had a complete neurological recovery, whereas coma was persistent in 34% of patients. It must be underlined that patients presenting with coma enrolled in our study had a higher-risk profile, more frequently having concomitant multiorgan malperfusion, cardiac tamponade, or shock, as reported by others.[5,6,10,16,23,24]

Study Limitations

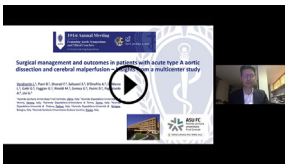
This study presents some limitations that are common to many multicenter reports. First, it is an analysis of retrospectively collected data; therefore, it is possible that patient selection for A-AAD repair may have varied among the various participating centers. Second, despite special attention in careful preoperative neurological assessment, definition of neurological deficit was mainly based on clinical grounds and not on specific scales, such as Glasgow Coma Scale or Rankin Score, and without the support of preoperative cerebral imaging in many patients; this may have resulted in a nonuniform classification of the neurological status so that some patients with altered consciousness without coma might have included in the coma group. Third, although CT scans were used to study SAB in all patients, a systematical perioperative study of SAB with sonography was not performed; therefore, possible changes occurring from the CT scan diagnosis to the beginning of operation might have been missed. Fourth, different operative and cerebral protection strategies used by participating centers might have influenced the results. However, it must be underlined that all centers participating in this study are experienced Italian institutions for the treatment of aortic pathologies, as specified by the European guidelines.[25] We believe this has contributed to minimize any possible bias deriving from patient selection, treatment strategies, and surgical techniques.

CONCLUSIONS

Our data showed that patients presenting with A-AAD and CM without preoperative coma had acceptable in-hospital mortality. In those patients, the use of the right axillary compared with femoral artery cannulation for establishing CPB appeared to be protective. Patients presenting with coma had a high in-hospital mortality regardless of the surgical strategy for systemic perfusion and brain protection. Early and medium-term results were influenced by the severity of neurological presentation. Further analysis of this, together with experiences by others, should stimulate the development of a specific risk score system of mortality and neurological outcomes for patients with A-AAD and CM.

Webcast

You can watch a Webcast of this AATS meeting presentation by going to:https://aats.blob.core.windows.net/media/21%20AM/AM21_A32/AM21_A32_02.mp4.



Conflict of Interest Statement

The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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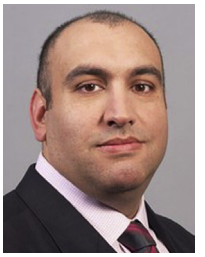
Key Words: acute aortic dissection, axillary artery, cerebral malperfusion, neurological deficit

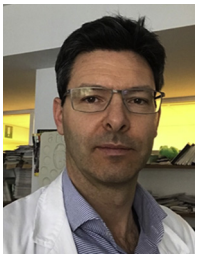
Discussion

Presenter: Dr Igor Vendramin



Dr Mohamad Bashir (*Liverpool, England*). We're all appreciative of the fact that when one's faced with malperfusion of the A-AAD it is a challenge. Not only personal results, but also in patients' eventuality and outcome. My question to you, Igor, is it a balance between confounder and collider? Confounder is basically a type A dissection with a malperfusion that has effects on the exposure and the outcome, and the collider is the neurological deficit per se and how it relates to the type A dissection. How did you separate these 2 groups because the majority of the patients, as you alluded to in the article, came in blue lighted or ventilated on mechanical ventilation and you were not able to assess them

neurologically preoperatively. How did you make sure those neurological deficits that were present in all 3 groups, that were present preoperatively, did not potentiate the effect as a collider postoperatively by the extent of the pathology or the operating performance, operating scale? What's your take on that Igor?



Dr Igor Vendramin (*Udine, Italy*). The issue is a big problem in any kind of study regarding the malperfusion because only in a single-center study can we perform selective CT scans, for example, preoperatively to analyze the data. In the multicenter study, you have to stay with the general description of the SABs. We have the description of these CT scans, but you cannot analyze every CT scan. So you can't be 100% sure the selection is done correctly. But the neurological presentation with paraplegia or some typical neurological deficit is described. You see from our general population, we have excluded a lot of patients because we were not sure about the description of the neurological dysfunction before the operation.

Also, with the first group we could be more critical. Group 1 patients with syncope is an interesting group because the results are not good. From this study, we see that we have 80% mortality in this group. It is not expected, not for me. Also, postoperative neurological deficit with almost 36% of patients with persistent PND and 6 patients with coma. It means that something happened during the operation, and maybe the brain protection was not ideal. It is true, we are not sure that the selection of patients is correct 100%, but the results show us that something more could be done in that kind of patient.

For example, our study with axillary artery cannulation resulted in a significant protective factor for both groups: the syncope and the focal neurological function groups. This is the topic of our study. Regardless of the clinical presentation, we can move on and easily and routinely start with axillary artery cannulation strategy to significantly reduce the outcome.

It is true that it is not easy to classify correctly all these patients because the CT scan preoperatively of the brain is not so usable everywhere. I prefer to go as quick as possible to the operating room instead of studying the brain. You can underestimate the problem because if the interval time is only 4 hours, for example, you think that the reason is a problem with the brain, but it is not correct.

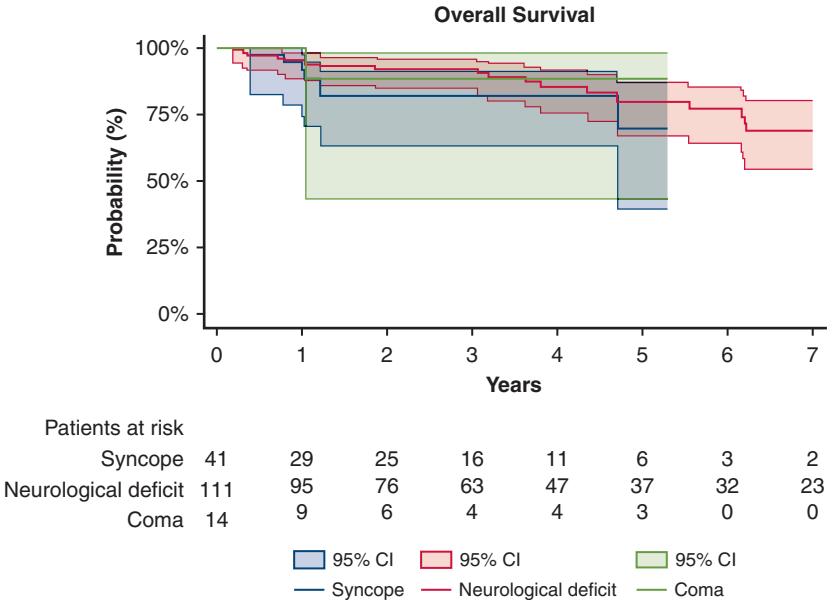


FIGURE E1. Overall survival for hospital patients who survived was not significantly different among the 3 groups ($P = .366$). *CI*, Confidence interval.