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Time and Risk Analysis for Acute Type A Aortic Dissection Surgery Performed by Hypothermic Circulatory Arrest, Cerebral Perfusion, and Open Distal Aortic Anastomosis

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ABSTRACT

Background: Hypothermic total circulatory arrest, retrograde or antegrade cerebral perfusion, and open distal anastomosis are important stages of surgical management and cerebral protection for acute type A dissections. Among the factors that influence survival are the transfer time to hospital from the onset of symptoms, in-hospital transfer time to operation, organ malperfusion, preoperative risk factors, and intraoperative variables. The aim of this study was to analyze time and risk factors during surgical management.

Methods: Between September 1996 and March 2002, a total of 26 patients with acute type A aortic dissection were operated. Sixteen patients (61.5%) were male and mean age was 49 (13.1 years (range: 26-68). The diagnosis was based on clinical examination, telecardiography, transthoracic echocardiography, computerized tomography, and angiography. Hypothermic total circulatory arrest, retrograde or antegrade cerebral perfusion and open distal anastomosis were used during the procedures. Operative techniques were as follows: supracoronary ascending aortic replacement (17 patients), aortic root and ascending aortic replacement with flanged composite grafting technique (5 patients), replacement of ascending aorta and hemiarcus (1 patient), aortic root and ascending aortic replacement with modified Bentall technique (1 patient), replacement of ascending aorta and arcus (1 patient), and total arcus replacement with elephant trunk technique and modified Bentall procedure (1 patient).

Results: The early postoperative mortality rate within the first 30 days was 26.9%, and the late postoperative mortality rate was 15.8%. Two patients (7.7%) developed major neurological complications during the postoperative period. Time to admission, durations of total circulatory arrest, cross-clamp, cardiopulmonary bypass, and intubation were longer, and postoperative blood loss was greater in patients who died during early postoperative period, although the differences did not reach statistical significance. Duration of total circulatory arrest was longer in patients who developed neurological dysfunction compared to patients without this complication; this difference also did not reach statistical significance.

Conclusions: Total circulatory arrest, cerebral perfusion, and open distal anastomosis are reliable options in the surgical management of acute type A aortic dissections. With open distal anastomosis aortic arcus can be evaluated, distal anastomosis can be performed more easily, and postoperative neurological recovery is hastened. In the present study, although statistical significance could not be reached due to limited sample size, the time to admission, durations of total circulatory arrest, cross-clamp, and cardiopulmonary bypass, and the amount of postoperative chest output seem to influence postoperative survival.

INTRODUCTION

Acute type A aortic dissection surgery requiring ascending aorta and arcus operations is a substantial challenge for the cardiovascular surgeon. The time to admission, hemodynamics at the time of admission, malperfusion, in-hospital transfer time to operation, the timing of operation, surgical techniques, myocardial and cerebral protection methods, and the management of possible perioperative complications affect mortality and morbidity [Stowe 1998, Deep 1999, Ogino 2001, Apaydin 2002]. Retrograde cerebral perfusion (RCP) via vena cava superior or antegrade cerebral perfusion (ACP) through brachiocephalic vessels during total circulatory arrest (TCA), which allowed for the first successful aortic arc operations, are important steps in the history of surgical management strategies for aortic dissections [Cooley 1990, Ueda 1992, Uchida 1997].

Other parameters regarding general management include the intensity of pain perceived by the patient at the onset of symptoms, the time spent before admission and in the initial health care facility that does not have adequate surgical equipment, and the level of difficulties experienced during the transfer to a cardiovascular surgery unit. A successful perioperative time-management that encompasses the time from onset of symptoms to completion of operation has a strong influence on the postoperative outcome.

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Table 1. Pre-, Peri-, and Postoperative Characteristics of Patients*

No.	Age	Gender	S-H Time, h	H-O Time, h	TTE	CT	Anj	DeBakey Dis Type	Operation	Result
1	55	F	70	10	+	+	–	Type I	Modified Bentall	Exitus (E)
2	58	M	24	8	+	+	+	Type I	AAR	Exitus (E)
3	55	M	20	9	+	+	–	Type II	AAR	Exitus (E)
4	59	M	49	11	–	+	+	Type I	AAR + AV resusp	Alive
5	38	M	13	5	+	+	–	Type II	AAR + AV resusp	Exitus (L)
6	63	M	10	4	–	+	+	Type I	AAR	Exitus (L)
7	65	F	6	6	+	+	–	Type II	AAR	Alive
8	60	F	11	4	+	+	–	Type I	AAR + AV resusp	Alive
9	28	M	4	3	+	+	–	Type II	AAR	Alive
10	64	M	15	5	+	+	–	Type I	AAR + total arcus repl + AV resusp	Alive
11	48	F	8	3	+	+	–	Type II	AAR + AV resusp	Alive
12	52	M	4	2	–	+	+	Type I	AAR + AV resusp	Alive
13	28	M	2	1	+	–	–	Type II	Flanged technique	Alive
14	35	M	3	2	+	+	–	Type I	Flanged technique	Alive
15	26	F	4	3	–	+	–	Type I	Flanged technique	Alive
16	68	F	5	2	–	+	+	Type I	AAR + AV resusp + RCA bypass	Exitus (E)
17	32	M	8	4	–	+	+	Type II	Flanged technique	Exitus (E)
18	60	M	4	5	+	+	–	Type I	AAR	Alive
19	49	F	9	3	+	+	–	Type I	AAR	Alive
20	55	M	11	6	+	+	–	Type I	Modified Bentall + total arcus repl + Elephant trunk	Alive
21	63	F	5	3	+	+	–	Type II	AAR + AV resusp	Alive
22	56	M	7	2	+	+	–	Type I	AAR + AV resusp	Exitus (L)
23	46	F	8	1	+	+	–	Type I	AAR	Exitus (E)
24	32	M	4	4	+	+	–	Type II	AAR	Alive
25	52	M	6	3	+	+	–	Type I	Flanged technique	Alive
26	48	F	7	4	+	+	+	Type I	AAR + hemiarcus repl	Exitus (E)

*S-H indicates symptom-hospitalization; H-O, hospitalization-operation; TTE, transthoracic echocardiography; CT, computerized tomography; Anj, angiography; dis, dissection; F, female; E, early; M, male; AAR, ascending aorta replacement; AV resusp, aortic valve resuspension; L, late; repl, replacement; RCA, right coronary artery.

In this article, we present our surgical experience in patients with acute type A aortic dissection who were admitted to a university hospital located in an area with limited transportation facilities. This experience includes the components of modern aortic surgery such as deep hypothermic TCA, RCP or ACP, and open aortic distal anastomosis technique. Also, the effect of preoperative risk factors and perioperative conditions on mortality was analyzed as well as the significance of time to admission and in-hospital transfer time.

METHODS

Between September 1996 and March 2002, a total of 26 patients with acute type A aortic dissection were operated. All patients were Type A according to Stanford classification, whereas 17 patients (65.4%) were Type I and 9 patients (34.6%) were Type II according to DeBakey classification. Sixteen patients (61.5%) were male and the mean age was 49 ± 13 years (range: 26-68) (Table 1).

The Time from Onset of Symptoms to Admission

Overall, the time to admission ranged from 2 to 70 hours (average 12.2 ± 15.1 hours; median 7.5 hours) (Tables 1 and 2).

The Symptoms and Signs at Admission

Pain: Chest pain (all patients), pain in the left arm accompanying chest pain (4 patients), pain in the right arm and right leg (1 patient), syncope and chest pain (1 patient), and pain in the left leg together with chest pain (1 patient) were noted among patients.

Neurological Symptoms: Preoperatively, 2 patients (7.7%; patients no. 3 and 6) had a history of previous cerebrovascular accident (recovered); 1 patient (patient no. 15) had left hemiparesis and confusion, and 2 patients (patients no. 18 and 19) had right hemiparesis and confusion (total 5 patients, 19.2%) (Table 3).

Preoperative Myocardial Infarction, Coronary Artery Dissection, and Coronary Artery Disease: Two patients (patients no. 16 and 17) presented with acute myocardial infarc-

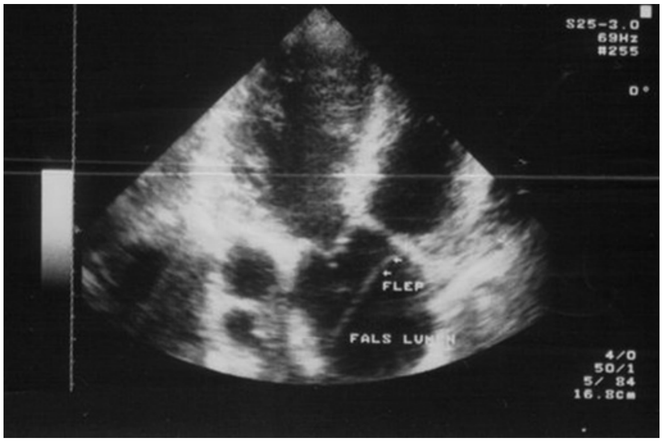


Figure 1. Preoperative echocardiographic appearance of the dissection flap (patient no. 21).

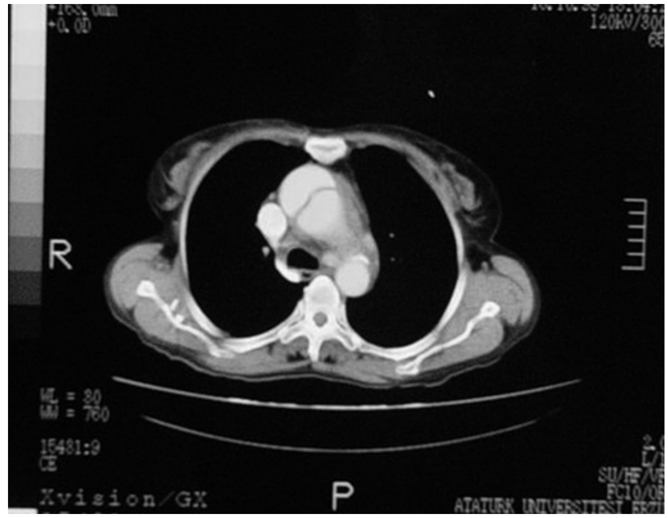


Figure 2. Appearance of the dissection flap. Preoperative image obtained by computerized tomography (patient no. 24).

tion. In the 16th patient, the dissection was extending up to the ostium of right coronary artery (RCA). This, along with the compression caused by the hematoma resulting from intimal tear, led to coronary malperfusion. In 3 patients (patients no. 13, 15, and 25), the dissection also involved the coronary ostia, without electrocardiographic changes showing myocardial malperfusion. The 17th patient had a lesion in the left anterior descending coronary artery (LAD) (5 patients, 19.2%).

Limb Ischemia: As a result of organ malperfusion due to dissection, pulse deficit was present in the left lower extremity of one patient (no. 6) and in the left upper extremity in another patient (no. 10) (7.7%) (Table 3).

Shock: Four patients (patients no. 2, 4, 11, and 15) had cardiogenic shock and collapse (15.4%) (Table 3).

Preoperative Cardiac and Non-cardiac Morbidities: Preoperative cardiac morbidities included cardiac tamponade (13 patients), aortic insufficiency (severe in 5 patients, moderate in 13 patients), and hypotension (4 patients); non-cardiac morbidities were diabetes mellitus (5 patients), hypertension (23 patients), chronic obstructive pulmonary disease (4 patients), previous cerebrovascular accident (2 patients), and Marfan syndrome (3 patients) (Table 3).

Preoperative Diagnostic Approach

Preoperatively, the diagnosis was based on telecardiography, transthoracic echocardiography (TTE) (Figure 1), computerized tomography (CT) (Figure 2), angiography, and combination of these techniques. In our emergency unit, we routinely perform CT imaging with contrast agent in patients with suspected dissection (18 patients) as the initial approach for diagnosis. However, in patients with chest pain and signs of myocardial infarction, initially TTE is performed (7 patients) by the cardiologist, and if flap and false lumen are detected, CT is performed as the next diagnostic step. In equivocal cases, angiography is used to definitively diagnose dissection (7 patients) (Table 1).

CT scans were obtained in 25 patients. One patient (no. 13) was diagnosed by TTE and the patient was transferred to emergency operation without a CT scan due to time constraints. In 23 patients, along with CT, a TTE was also performed. Three patients (patients no. 15, 16, and 17) had only CT and these were the patients who were taken for emergency operation. Two patients with negative CT findings (patients no. 6 and 12) and one patient (patient no. 4) with negative TTE findings were diagnosed with angiography. In angiography, presence of flap with the development of false lumen, aorta dimensions, and coronary lesions were evaluated (Table 1).

The diagnosis was acute type A aortic dissection in all patients. Aortic diameter was within normal limits in 19 patients, and 7 patients (patients no. 9, 13, 14, 15, 20, 25, 26) had acute dissection developing on the grounds of an aneurysm.

In-hospital Transfer Time to Operation: In-hospital transfer time to operation ranged from 1 to 11 hours (mean 4.3 (2.6 hours, median 4 hours) (Tables 1 and 2).

Time from Onset of Symptoms to Operation: The mean duration from onset of symptoms to operation was 16.5 ± 17.4 hours (Table 2).

Operative Data

Cerebral Protection: The temperature during TCA was 16ºC. RCP via vena cava superior (23 patients) or ACP via right axillary artery (3 patients) were performed. For RCP, the cannulation of superior vena cava was performed with coronary sinus cardioplegia cannula. The rate of blood flow was 250-350 mL/min during RCP. The pressure was adjusted to ≤30 mm Hg. ACP technique was used in 3 patients. For ACP, a pressure less than or equal to 50 mm Hg and a blood flow rate of 500 mL/min were preferred.

Patients were kept in Trendelenburg position during TCA. Topical cooling was applied to head and neck for cerebral protection. Thiopental sodium, corticosteroids, and mannitol were used for pharmacological cerebral protection during cooling and heating periods. Thiopental sodium was used both during cooling (at 23°C) and warming (again when 23°C was reached) phases at a dose of 15 mg/kg.

Myocardial Protection: Retrograde and antegrade coronary cardioplegic perfusion were used in all patients for myocardial protection. Upon starting TCA, retrograde (via

Table 2. Time Factor Analysis for Patients Died Early and Survived

Times	Survived Patients, n = 19	[Median (interquartile range)]	Early Died Patients, n = 7	[Median (interquartile range)]	*P*
Transfer time to hospital from the onset of symptoms, h	9.2 ± 10.3	6 (4-11)	20.3 ± 23.1	8 (7-24)	.09
In-hospital transfer time to operation, h	3.9 ± 2.2	3 (3-5)	5.4 ± 3.6	4 (2-9)	.46
Time from onset of symptoms to operation, h	13.1 ± 12.2	9 (7-11)	25.7 ± 25.9	12 (9-32)	.18

coronary sinus) cardioplegic solution (blood) was initiated and administered continuously. Antegrade blood cardioplegia was given with selective cardioplegia cannula at a dose of 5 cc/kg every 20 minutes. Also, topical cooling was applied with cold saline for myocardial protection. Membrane oxygenator, roller pump, and non-pulsatile flow were used in all patients.

Operative Procedures

Left radial and pulmonary artery catheters were placed. A median sternotomy was made. Venous cannulation was performed via right atrium with a two-stage venous cannula. For arterial cannulation, femoral artery (23 patients, 88.5%) or axillary artery (3 patients, 11.5%) were used.

Regarding the surgical technique, ascending aortic replacement was used in 17 patients (65.5%; aortic valve re-suspension was performed in 8 patients, and bypass with saphenous vein graft was used in one of these 8 patients), aortic root and ascending aorta replacement with flanged composite graft technique in 5 patients (19.3%) [Yakut 2001], aortic root and ascending aorta replacement with modified Bentall technique in 1 patient (3.8%), ascending aorta and hemiarcus replacement with aortic valve re-suspension and anastomosis of innominate artery and left carotis artery to the main graft by Y graft in 1 patient (3.8%), and modified Bentall procedure and total arcus replacement with Elephant trunk procedure in 1 patient (3.8%) (Table 1).

During the cooling phase, aortic cross-clamping was avoided in all patients. Including patients for whom only ascending aortic replacement was performed, distal anastomosis was done under deep hypothermic TCA without cross-clamping. Then, arterial cannula was transferred onto the graft. Cardiopulmonary bypass was commenced with antegrade perfusion by placing a cross-clamp on the graft, and proximal anastomosis was performed during the warming phase. In 17 patients (patient no. 1, 3, 4, 5, 7, 9, 11-16, and 19-23) proximal and distal grafts were joined in the middle. Some of these patients (no. 1, 13, 14, 15, 17, 20, and 25) were the patients in whom modified Bentall and flanged technique were used with separate anastomosis of proximal and distal grafts. In others, proximal aortic anastomosis was done directly with the same graft.

3/0 Prolene sutures were used for distal and proximal anastomoses. Teflon stripes and tissue adhesive were used to support the lines of anastomosis. Arcus anastomoses were performed in islet shape. In patients with arcus anastomosis, the surface of the graft in close proximity with the arcus was only incised without removing any part of the graft for anastomosis. 6/0 Prolene suture material was used for the modified Bentall and flanged composite techniques during coronary anastomoses.

Grafts Used: Sulzek Vascutek (PA4 9RR, Scotland) and Hemashield gold (Meadox Medical, Inc. 112 Bauer Drive, Oakland, NJ) grafts were used.

Statistical Analysis

Descriptive data are expressed as means ± standard deviation. Statistical analyses were performed by using SPSS 10.0 (Statistical Package for the Social Sciences SPSS Inc, Chicago, IL) statistical program. Effects of durations (time to admission from the onset of symptoms and in-patient transfer time to operation), demographic characteristics, preoperative cardiac and non-cardiac morbidities, intraoperative and postoperative variables on patient outcome were analyzed by using Mann–Whitney-U, Fisher Exact, and Chi Square tests, where appropriate. Early mortality was the main outcome measure and was defined as the hospital deaths occurring within the first 30 days. A P value less than .05 was considered to indicate statistical significance.

Kaplan–Meier survival analysis was used to assess the survival during 53.7 ± 14.3 months of follow-up in 19 patients who survived postoperatively (Figure 3). The survival rates by time and the proportion of patients under risk are depicted.

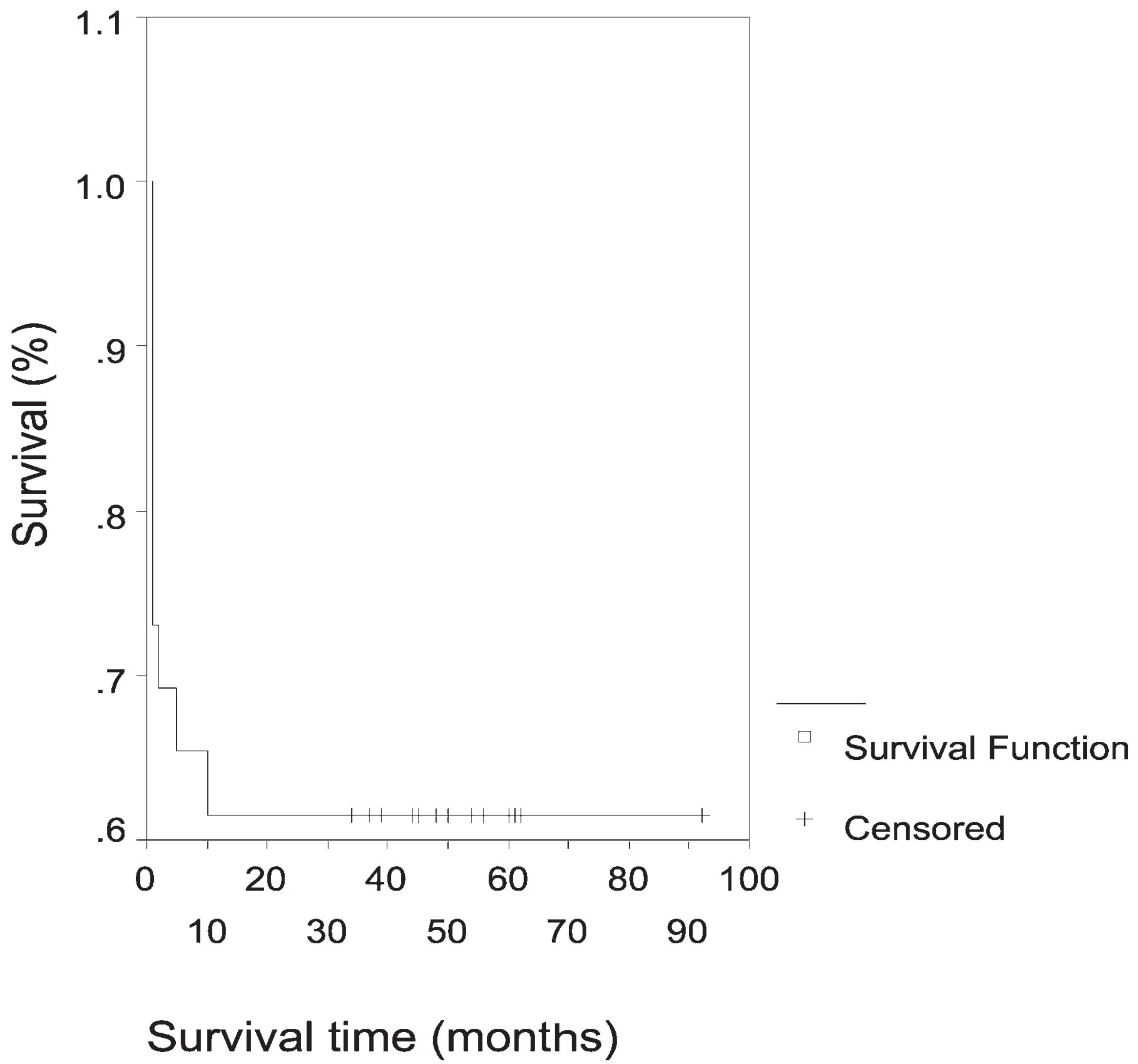
RESULTS

Analysis of Preoperative Period

The average time spent before admission to hospital was 20.3 ± 23.1 hours [median 8 hours (interquartile range: 7-24)] and 9.2 ± 10.3 hours [(median 6 hours (interquartile range: 4-11)], respectively, for patients who died during the early postoperative period and for patients who survived. Although the transfer time was shorter in patients who survived during early postoperative period, the difference was not statistically significant (P = .09) (Table 2).

The in-hospital transfer time to operation in patients who died and in patients who survived during the early postoperative period were 5.4 ± 3.6 hours [median 4 hours (interquartile range: 2-9)] and 3.9 ± 2.2 hours [median 3 hours (interquartile range: 3-5)], respectively, again with no statistical difference (P = .46) (Table 2).

The average time from onset of symptoms to operation was 25.7 ± 25.9 hours [median 12 hours (interquartile range:



months	0 2 10	34 39 45 50 56 61	92 100
	1 5	37 44 48 54 60 62	
number of patients at risk	26 18 16	15 13 10 8 5 3	1 0
	19 17	14 11 9 7 4 1	

Figure 3. Actuarial survival rate (Kaplan–Meier) of patients (including hospital mortality).

9-32)] and 13.1±12.2 hours [median 9 hours (interquartile range: 7-11)], respectively for the two groups. Although the difference was shorter in favor of surviving patients, the difference was not statistically significant (P = .18) (Table 2).

Analysis of Preoperative Data

The distribution of early mortality (7 patients) was compared among age groups. There was no mortality below age 30, while the number of deaths by decades were 1, 2, 3, and 1 in patients in their 30s, 40s, 50s, and above 60 years of age, respectively. Age did not significantly influence mortality (P = .62). Mortality rate was highest in the 50-59 year age group (Table 3).

Of these 7 patients who died early, 3 were male and 4 were female (P = .23), and 5 patients were Type I and 2 patients were Type II according to DeBakey classification (P = .54) (Table 3).

The examination of non-cardiac morbidities in patients who died early revealed the following: 6 patients had hypertension (P = .63), 1 patient had hyperlipidemia (P = .59), 5 patients had a smoking history (P = .28), 1 patient had

Table 3. Preoperative Demographic Data, Type of Dissection, and Co-morbidities

Characteristic	Present/ Absent	Number of the patients (%) n = 26	Survived patients (%) n = 19	Number of early deaths (%) n = 7	*P*
Age					
Mean		49±13.1	49.1±13.6	51.7±11.3	0.95
Median (interquartile range)		53.5	52 (35-60)	55 (46-58)	
Age groups		26-68	26-65	32-68	0.62
Less than 30	Present	3 (11.5)	3 (100)	0	
	Absent	23 (88.5)	16 (69.6)	7 (30.4)	
30 to 39	Present	4 (15.4)	3 (75)	1 (25)	
	Absent	22 (84.6)	16 (72.7)	6 (27.3)	
40 to 49	Present	4 (15.4)	2 (50)	2 (50)	
	Absent	22 (84.6)	17 (77.3)	5 (22.7)	
50 to 59	Present	8 (30.8)	5 (62.5)	3 (37.5)	
	Absent	18 (69.2)	14 (77.8)	4 (22.2)	
60 to 69	Present	7 (26.9)	6 (85.7)	1 (14.3)	
	Absent	19 (73.1)	13 (68.4)	6 (31.6)	
Sex					0.23
Male	Present	16 (61.5)	13 (81.2)	3 (18.8)	
Female	Present	10 (38.5)	6 (60)	4 (40)	
Type of dissection					0.54
Type I	Present	17 (65.4)	12 (70.6)	5 (29.4)	
Type II	Present	9 (34.6)	7 (77.8)	2 (22.2)	
Non-cardiac co-morbidity					
Hypertension (diastolic pressure ≥ 90 mmHg, systolic pressure > 130 mmHg)	Present	23 (88.5)	17 (73.9)	6 (26.1)	0.63
	Absent	3 (11.5)	2 (66.6)	1 (33.4)	
Hyperlipidemia (cholesterol > 200 mg/dL)	Present	5 (19.2)	4 (80)	1 (20)	0.59
	Absent	21 (80.8)	15 (71.4)	6 (28.6)	
Diabetes mellitus	Present	5 (19.2)	5 (100)	0	0.17
	Absent	21 (80.8)	14 (66.6)	7 (33.4)	
Neurological disorders	Present	3 (11.5)	3 (100)	0	0.37
	Absent	23 (88.5)	16 (69.6)	7 (30.4)	
Smoking history	Present	22 (84.6)	17 (77.3)	5 (22.7)	0.28
	Absent	4 (15.4)	2 (50)	2 (50)	
Chronic obstructive pulmonary disease	Present	4 (15.4)	3 (75)	1 (25)	0.71
	Absent	22 (84.6)	16 (62.7)	6 (27.3)	
Limb ischemia	Present	2 (7.7)	2 (100)	0	0.53
	Absent	24 (92.3)	17 (70.8)	7 (29.2)	
Marfan Syndrome	Present	3 (11.5)	2 (66.6)	1 (33.4)	0.63
	Absent	23 (88.5)	17 (73.9)	6 (26.1)	
Cardiac co-morbidity					
Aortic valve insufficiency	Present	5 (19.2)	5 (100)	0	0.18
	Absent	21 (80.8)	14 (66.6)	7 (33.4)	
Tamponade	Present	13 (50)	8 (61.5)	5 (38.5)	0.19
	Absent	13 (50)	11 (84.6)	2 (15.4)	
Cardiogenic shock	Present	4 (15.4)	3 (75)	1 (25)	0.71
	Absent	22 (84.6)	19 (86.4)	3 (13.6)	

chronic obstructive pulmonary disease (P = .71), 1 patient had Marfan syndrome (P = .71); there was no mortality among patients with diabetes mellitus, neurological disorders, or extremity ischemia (P = .17, P = .37, and P = .53, respectively). With regard to cardiac morbidities, 5 patients had tamponade (P = .19) and 1 patient had cardiogenic shock (P = .71). There were no early deaths among patients who had aortic valve insufficiency (P = .18) (Table 3).

Analysis of Intraoperative Variables

The association with mortality was analyzed for the following: operative time variables such as TCA time above 30 minutes, CC time above 100 minutes, and CPB time above 200 minutes; hematological variables such as blood loss and amount of transfusion, and variables such as location of arterial cannulation (femoral and axillary), extent of aortic replacement, and the type of proximal repair. There were no

Table 4. Analysis of Intraoperative Variables*

Variable	Present/ Absent	Number of the patients (%) n = 26	Survived patients (%) n = 19	Number of early died patients (%) n = 7	*P*
Operative time variables					
TCA time > 30 min	Present/	24 (92.3)	17 (70.8)	7 (29.2)	0.53
	Absent	2 (7.7)	2 (100)	0	
CC time > 100 min	Present/	17 (65.4)	11 (64.7)	6 (35.3)	0.54
	Absent	9 (34.6)	8 (88.9)	1 (11.1)	
CPB time > 200 min	Present/	23 (88.5)	16 (69.6)	7 (30.4)	0.53
	Absent	3 (11.5)	3 (100)	0	
Blood variables					
Chest output > 500 mL	Present/	18 (69.2)	12 (66.6)	6 (33.4)	0.27
	Absent	8 (30.8)	7 (87.5)	1 (12.5)	
Transfusion of blood > 2 units	Present/	7 (26.9)	5 (81.4)	2 (28.6)	0.64
	Absent	19 (73.1)	14 (73.7)	5 (26.3)	
Arterial cannulation site					0.63
Femoral artery	Present	23 (88.5)	17 (73.9)	6 (26.1)	
Axillary artery	Present	3 (11.5)	2 (66.6)	1 (33.4)	
Extent of aortic replacement					
Ascending aorta	Present/	17 (65.4)	13 (76.5)	4 (23.5)	0.46
	Absent	9 (34.6)	6 (66.6)	3 (33.4)	
Ascending aorta+Aortic root	Present/	6 (30)	4 (66.6)	2 (33.4)	0.53
	Absent	20 (70)	15 (75)	5 (25)	
Ascending+Hemiarcus	Present/	1 (3.8)	0	1 (100)	-
	Absent	25 (96.2)	19 (76)	6 (24)	
Ascending+Arcus	Present/	1 (3.8)	1 (100)	0	-
	Absent	25 (96.2)	18 (72)	7 (28)	
Bentall+Arcus+Elephant trunk	Present/	1 (3.8)	1 (100)	0	-
	Absent	25 (96.2)	18 (72)	7 (28)	
Type of proximal repair					
Aortic valve re-suspension	Present/	9 (34.6)	8 (88.9)	1 (11.1)	0.20
	Absent	17 (65.4)	11 (64.7)	6 (35.3)	
Aortic valve replacement	Present/	6 (30)	4 (66.6)	2 (33.4)	0.53
	Absent	20 (70)	15 (75)	5 (25)	
Aortic root replacement	Present/	7 (26.9)	5 (71.4)	2 (28.6)	0.64
	Absent	19 (73.1)	14 (73.7)	5 (26.3)	
No surgical intervention for aortic valve	Present/	10 (38.5)	6 (60)	4 (40)	0.23
	Absent	16 (61.5)	13 (81.2)	3 (18.8)	

*TCA indicates total circulatory arrest; CC, cross clamping; and CPB, cardiopulmonary bypass.

significant differences with respect to these variables between patients who died during early postoperative period and patients who survived (Table 4). On the other hand, the distribution of results in patients who died during early postoperative period was interesting. In that patient group, TCA time was above 30 minutes in all patients (n = 7), CC time was above 100 minutes in 6 patients, CPB time was above 200 minutes in 6 patients, and blood loss was above 500 mL in 6 patients.

Extent of aortic replacement was not associated with increased risk of mortality (for the ascending aorta *P* = .46, ascending aorta + aortic root *P* = .53). Also, the proximal repair type was investigated as a potential risk factor. Mortality was seen in 1 patient with aortic valve re-suspension (*P* = .20), in 2 patients with aortic valve replacement (*P* = .53), and in 1 patient with aortic root replacement (*P* = .64). Of the patients with no procedure performed on the aortic valve, 4 died (*P* = .23) (Table 4).

The Critical Perioperative Variables (Mean TCA, CC, and CPB Times)

The mean TCA, CC, and CPB times for the entire group, for patients who died during the early postoperative period and for patients who survived were 52.9 ± 21.6 minutes, 46.8 ± 46.8 minutes, and 288.5 ± 69.4 minutes; 52 ± 17.5 minutes, 111.9 ± 37.5 minutes, and 263.4 ± 53.1 minutes; and 51.9 ± 23.4 minutes, 132.1 ± 49.6 minutes, and 297.7 ± 66.7 minutes, respectively. There were no significant differences with respect to TCA, CC, and CPB times between patients who died during early postoperative period and patients who survived (*P* = .91, *P* = .31, *P* = .36, respectively) (Table 5).

Table 5. The Data for Cardiopulmonary and Cerebral Support*

Variable	Survived Patients, n = 19	[Median (interquartile range)]	Patients Died Early, n = 7	[Median (interquartile range)]	*P*
Cerebral support					
TCA time (RCP time), min	51.9 ± 23.4	46 (40-60)	52 ± 17.5	45 (39-64)	.91
Cardiopulmonary support					
Perfusion time (CPB time), min	297.7 ± 66.7	311 (240-339)	263.4 ± 53.1	245 (224-325)	.31
Ischemia time (CC time), min	132.1 ± 49.6	135 (88-170)	111.9 ± 37.5	112 (87-124)	.36

*TCA indicates total circulatory arrest; RCP, retrograde cerebral perfusion; CPB, cardiopulmonary bypass; and CC, cross clamping.

Postoperative Chest Output

Postoperatively 3 patients (patients no. 6, 16, and 21) needed revision operation due to hemorrhage (average 1133 cc, range: 1550-1800 cc). The average drainage volume of all patients was 732 cc (250-1880 cc/day). There were no significant differences between patients who died during early postoperative period and patients who survived with respect to a drainage volume above 500 mL (*P* = .27) (Table 4).

Criteria for Blood Transfusions

Blood transfusions were performed to keep the hematocrit value ≥30%. The mean number of blood units transfused was 2.3 ± 1.1, whereas the corresponding value for fresh frozen plasma was 2 U. Again, there were no significant differences between patients who died during early postoperative period and patients who survived with respect to a blood transfusion greater than 2 U (*P* = .64) (Table 4).

Postoperative Intubation Time

The mean intubation time was 23.6 ± 22.5 hours [median 18 hours (interquartile range: 10-26)] and 12.9 ± 9.9 hours [median 11 hours (interquartile range: 8-18)] in patients who died early and in patients who survived, with no significant differences (*P* = .43).

Early Mortality (In-hospital Mortality)

The early mortality rate within the first 30 days of the procedure was 26.9% (7 patients) and the causes of death were low cardiac output (3 patients), peri- and post-operative bleeding (2 patients), multi-organ dysfunction (1 patient), and gastrointestinal bleeding and respiratory failure (1 patient) (Table 6).

Postoperative Morbidity

Nineteen patients were discharged with cure during early postoperative period. Revision was required due to mediastinitis on the 20th and 12th days, respectively, in two patients (patients no. 4 and 5), and due to sternal dehiscence in 1 patient (no. 6) on the 9th day. Two patients (no. 6 and 21) were re-admitted on the 18th and 36th days, respectively, due to lung infection and pleural effusion and they were discharged with cure after medical therapy following thoracocentesis (Table 6).

Re-operation

Ascending aortic replacement and aortic valve re-suspension were performed in one patient (no. 9), and 8 months later root replacement with flanged technique was required due to severe aortic insufficiency.

Late Mortality

Late mortality rate was 15.8% (3/19) and these were due to neurological complications and infection (1 patient on the 54th day; paraplegia, monoplegia in the left arm, pneumonia and sepsis), and congestive heart failure (2 patients; 5th and 10th months) (Table 6).

New Neurological Symptoms and Neurological Recovery

Minor: Disorientation (no. 4 and 10) and temporary confusion (no. 15 and 18) were noted in two patients each. These neurological complications resolved during the hospital stay.

Major: Major neurological complications occurred in 2 patients (7.7%; no. 21 and 22) during postoperative period. The patient no. 21 had left hemiplegia and dysarthria; she was referred to a rehabilitation clinic after discharging. The other patient had paraplegia, monoplegia in the left arm, and dysarthria and died on the 54th postoperative day due to sepsis.

Table 6. Postoperative Early Mortality (Hospital Mortality) and Morbidity, and Late Mortality*

Characteristic	N	%
Early mortality	n = 7	
Low cardiac output	3	42.9
Hemorrhage	2	28.5
Respiratory insufficiency + GIS bleeding	1	14.3
Multiorgan failure	1	14.3
Morbidity	n = 15	
Neurological complication		
Major	2	7.7
Minor	4	15.4
Atelectasis	6	23.1
Lung infection-pleural effusion	3	11.5
Late mortality	n = 3	
Congestive heart failure	2	66.7
Neurological complication + sepsis	1	33.3

*GIS indicates gastrointestinal system.

The Relationship between TCA Time and Postoperative Neurological Dysfunction

The relationship between postoperative development of neurological dysfunction and TCA time was assessed. The mean TCA time in patients who developed neurological dysfunction (n = 6; minor 4, major 2) was 61.8 ± 32.2 minutes [median 55 minutes (interquartile range: 41.8-77.3)]. On the other hand, after early deaths (n = 7) were excluded, the mean TCA time for patients surviving without neurological dysfunction was 47.3 ± 17.6 minutes [median 44.4 minutes (interquartile range: 39.3-57.8 minutes)]. Although TCA time was shorter in patients without development of neurological dysfunction, the difference did not reach statistical significance ($P = .27$). The remaining patients had an uneventful postoperative course with regard to neurological complications.

Postoperative Follow-up

Echocardiography was performed in all patients during the first postoperative week. CT scans were obtained from all patients after week 1 during hospitalization and it was performed for all patients 2 months after discharge. Of these, three patients (no. 6, 18, and 25) had a false lumen; no other patients had any pathological finding.

Control TTE was particularly used for patients who underwent re-suspension. Three patients (no. 4, 5, and 8) had second degree, and 6 patients (no. 10, 11, 12, 16, 21, and 22) had first degree aortic valve insufficiency.

During the follow-up period, 3 patients had residual false lumen patency. Patients without malperfusion and recurrent dissection are still in the follow-up phase. The patient who had an Elephant trunk procedure is also still being followed, and at the present time re-operation is not required for this patient's descending aorta.

Survival Analysis

The mean duration of follow-up for 19 patients who were discharged from the hospital was 57.5 months [(40.8-74.3 Confidence interval = CI)]. After 92 months of follow-up, 61.5 ± 0.09% of patients were still alive as shown by Kaplan–Meier survival analysis. The survival rate during the first, second, fifth, and tenth months were 73.1 ± .08%, 69.2 ± .09%, 65.3 ± .09% and 61.5 ± .1%, respectively.

DISCUSSION

Aortic dissection is associated with a high morbidity and mortality rate due to the weakened aortic tissues, tendency to rupture, and organ malperfusions. Aortic root displacement resulting from aneurysms, increased aortic pulsations due to hypertension, cystic medial necrosis, and medial degeneration due to atherosclerosis play a role in the pathogenesis of aortic dissection and are associated with elevated stress on ascending aorta [Cooley 1990, Beller 2004].

The major determinants of survival in acute type A aortic dissections are preoperative complications, organ malperfusions, and perioperative characteristics. Studies examining the preoperative factors that influence survival have found that malperfusion signs such as renal or visceral ischemia are independent predictors of high operative mortality [Deep 1999, Apaydin 2002]. According to risk scoring systems based on risk stratification using the "International Registry of Acute Aortic Dissection Analysis," ruptures and visceral malperfusion are among the most common causes of in-hospital mortality in type A acute aortic dissections [Hagan 2000]. In the present study, no patients had clinical signs of renal malperfusion or presented with acute abdomen due to mesenteric ischemia. Thirteen patients had pericardial effusion and tamponade caused by aortic leakage. Of these, 5 (38.5%) died. When the effect of preoperative risk factors on postoperative mortality was examined, we did not detect any significant association ($P > .05$). Also no significant association was detected between mortality and demographic characteristics, type of dissection, and preoperative non-cardiac and cardiac morbidities, when patients who died during the early preoperative period and patients who survived ($P > .05$) are compared, possibly due to low number of patients.

The timely and proper use of diagnostic techniques, evaluation of signs, and establishment of an appropriate management strategy are of utmost importance for effective management of dissection. In patients with suspected acute aortic dissection, a CT scan, which was the most readily available diagnostic method in our institution, was obtained initially in 69.2% of our patients. Whereas in patients presenting with signs of myocardial infarction, the percentage of patients for whom TTE was used initially was 30.8%. Angiography was performed in 26.9% of patients due to the difficulty in diagnosing the dissection. Overall, 96.2% of patients had a CT scan eventually. Due to time constraints, the diagnosis was based on TTE only in one patient (3.8%) who had been taken immediately to the operation theater. CT was used in conjunction with TTE in 88.5% of patients, while 11.5% of patients had only CT scans.

At the present time, surgical techniques have been largely standardized except for minor modifications. Appropriate, aggressive, and well-timed surgical management encompasses successful organization, early diagnosis, deep hypothermic TCA, RCP or ACP, and open distal aortic anastomosis. Expanding surgical expertise, advances in the vascular prosthetic grafts with zero porosity, decrease in hemorrhagic complications, and more successful myocardial and cerebral protection techniques have played an important role in the standardization of surgical management [Stowe 1998]. David and colleagues [1999] have suggested that aortic cross-clamping, a component of surgical management, should be avoided during the initial cooling phase; and they recommend that aortic cannula on the femoral artery should be transferred onto the graft and antegrade perfusion be initiated after the resection of the primary tear in the ascending aorta and aortic arc and completion of distal anastomosis. Our practice is in concert with literature data.

Deep hypothermic arrest is a reliable and effective technique that allows for an adequate time frame for complex aortic operative procedures, and it also provides a clear exposure, permitting open anastomosis of the fragile aorta without cross-clamping. RCP is a safe procedure that can be simultaneously performed with systemic deep hypothermia. It decreases the temperature during circulatory arrest and cleanses toxic metabolites, air and particle emboli [Uchida 1997, Ogino 2001]. TCA can be used for distal anastomosis even if the arc would not be intervened. This procedure allows for the control of aortic arc with respect to dissection, facilitates distal anastomosis, and improves the neurological recovery during the postoperative period [Ueda 1992, Kumral 2001, Ogino 2001]. We used the technique of TCA, cerebral perfusion and open distal anastomosis in all patients, including patients who only had ascending aortic replacement. For cardiopulmonary bypass, retrograde perfusion with femoral artery cannulation was used in 88.5% of our patients and antegrade perfusion with axillary artery cannulation was used in 11.5%. After completion of distal anastomosis, antegrade perfusion was commenced in the femoral artery group. There are literature data supporting the use of both these arteries for arterial cannulation [Fusco 2004, Strauch 2004]. Griepp's group reported ACP as a more effective method to support the brain [Spielvogel 2002]. The mortality rate reported in recent studies ranges between 16% and 28% [Coselli 1995, Stowe 1998, Apaydin 2002]. In the present 26 patients with type A aortic dissection, the early mortality rate was 26.9%, while it was 15.8% during a mean follow-up of 53.7 ± 14.3 months.

Neurological injury is one of the most feared complications of type A aortic dissection surgery, and the presence of new preoperative neurological symptoms is an independent risk factor for postoperative stroke. Preoperatively, neurological symptoms were present in 11.5% of our patients. Ergin et al [1999] propose that TCA duration greater than 30 minutes is associated with temporary neurological dysfunction, and these authors consider this complication as a reflection of inadequate cerebral protection. The duration of hypothermic TCA is a risk factor for temporary neurological dysfunction. Kumral et al [2001] examined 154 patients who had a procedure involving the ascending aorta, aortic arc, or both, and assessed the incidence of neurological complications occurring after deep hypothermic circulatory arrest performed during aortic surgery. In this series, temporary postoperative neurological dysfunction and stroke occurred in 5.8% and 1.9% of patients, respectively. Similarly, in our study, the surgical technique consisting of deep hypothermic TCA, RCP or ACP, and open distal anastomosis were used in all patients, including those undergoing an ascending aortic replacement only. In 5 patients, the TCA time was between 22 and 34 minutes. Overall, the mean duration of TCA was 52.9 ± 21.6 minutes, while postoperative major neurological complications occurred in 7.7%. The effect of TCA time (greater than 30 minutes) on mortality was investigated; however, due to our limited sample size, comparison of patients who died during the early postoperative period and patients who survived did not reach statistical significance ($P > .05$). But, it is important to note that all the patients who died early had a TCA time greater than 30 minutes. On the other hand, in a retrospective analysis, Hirotani et al [2000] found no association between the duration of circulatory arrest and the incidence of neurological complications, indicating the possibility that the pharmacological combination administered might have positively influenced the safety limits of hypothermic circulatory arrest. Similarly, we also used thiopental sodium, corticosteroids, and mannitol for pharmacological cerebral protection.

Teflon stripes and tissue adhesive may be required to support sutures in fragile and tiny aortic tissues [Hata 2004]. In the present study, Teflon-pledged and tissue adhesives were used in all cases to support the lines of anastomosis. Only 3 patients needed re-operation due to bleeding at the postoperative period.

Time is a critical factor for the success of surgery in aortic dissections. Success depends on an effective time-management strategy for which the time from onset of symptoms to admission, the in-hospital transfer time to operation, TCA time, CC time, and CPB time are important variables. The time from onset of symptoms to admission and the duration of intubation was longer in patients who died during the early postoperative period; however, statistical significance could not be reached. Increased duration of TCA, CC, and CPB and significant blood loss exceeding physiologically tolerable limits in this patient group also did not reach statistical significance.

CONCLUSION

In conclusion, the pre-, peri-, and post-operative success in the management of patients with acute type A aortic dissection is not only dependent upon the quality of care provided by the health care facility, but also upon the awareness of patients, their relatives and friends, and upon the pre-hospital circumstances with respect to transportation facilities. Even today, acute type A aortic dissections are associated with high morbidity and mortality, and transportation facilities, pre-operative risk level, and organ malperfusions are critical factors for survival. Also, the time from onset of symptoms to admission and the in-hospital transfer time to operation influence the postoperative survival. Increased public awareness about this condition may shorten the transfer time to an institution with adequate facilities. The modern surgical technique encompassing TCA, RCP or ACP, and open distal anastomosis allows for an evaluation of the aortic arc with respect to intimal tear and malperfusion, facilitates distal aortic anastomosis, and may decrease the postoperative neurological complication rate.

REVIEW AND COMMENTARY

1. Editorial Board Member PB44 writes:

a) I believe major changes are needed before publication. The statistical analysis is inappropriate for such a small study. Descriptive stats are all that is needed. They have pointed out the reasons for lack of significance - low numbers. What this does do is gives an overview of a unit's practice with an uncommon condition which is usually fatal without treatment.

b) What determined the use of RCP versus ACP?

Author's Response by Dr. Ibrahim Yekeler:

a) Due to the limited number of cases statistical significance could not be reached. So, mainly descriptive statistics are given and only some statistical results (although not significant) are mentioned in the text. The statistical analysis section has been shortened.

b) Antegrade cerebral perfusion was used in the last three cases, parallel with the evolution of methods for brain support. Antegrade cerebral perfusion may unfavorably affect the comfort of the surgeon, and to be able to apply this technique the surgeon must be sure that branches of the arcus aorta are uninvolved and patent. We also believe that the antegrade method is superior to retrograde method, and we currently prefer this method in appropriate cases.

2. Editorial Board Member MB134 writes:

a) Due to small size of the cohorts, most tests did not reach statistical significance so the authors are cautioned not to make statements that indicate clinical significance if there is no statistical significance. The purpose of performing statistical analysis is to determine if the results are likely due to chance or not. If the results did not achieve significance, then there remains a possibility the results are due to chance. The authors cannot claim more than that.

b) Under Operative Data section/Cerebral protection, the authors mention that "Thiopental, phenobarbital...." etc. It is not clear if patients received both barbiturates, but I would assume not. Please clarify if they received either thiopental or phenobarbital, or if the protocol administered both to the same patient (in which case we need dosages).

Author's Response by Dr. Ibrahim Yekeler:

a) Due to the limited number of cases statistical significance could not be reached. So, mainly descriptive statistics are given and only some statistical results (although not significant) are mentioned in the text. The term 'clinical significance' is completely removed from the text and lack of statistical significance is attributed to the low number of cases.

b) Thiopental sodium (15 mg/kg dose both during cooling and warming) was the only barbiturate used in our patients for pharmacological cerebral perfusion. Corrections have been made in 'Operative Data section/Cerebral protection' and 'Discussion' sections, accordingly.

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