Preoperative Shock Determines Outcome for Acute Type A Aortic Dissection

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Background. **Acute type A aortic dissection is a life-threatening catastrophe. Surgical results have not improved.**

Methods. **The charts of all 70 patients surgically treated for acute type A primary aortic dissection during the period of January 1988 through April 2001 were reviewed.**

Results. **Average age was 59 ± 2 years. Comorbidities included hypertension (66%), coronary artery disease (17%), and Marfan's syndrome (11%). At presentation, 23% were in shock, 17% had neurologic dysfunction, and 36% had coronary ischemia. The aortic valve was preserved in 55. Distal aortic anastomosis was performed under aortic cross-clamp ("closed") in 32 and "open" under circulatory arrest in 38 patients. Operative mortality was 18.6% (13 of 70 patients). Patients in shock had an operative mortality of 50% compared with stable patients of 9% ($p = 0.0002$). Mortality was similar regardless of technique. Univariate analysis revealed preoperative shock ($p = 0.0002$), tamponade ($p = 0.003$), and neurologic deficit ($p = 0.02$) to be associated with mortality. Multivariate analysis revealed hemodynamic stability (odds ratio = 0.10, $p = 0.04$) and outside transfer (odds ratio = 0.12, $p = 0.03$) to be negative predictors of mortality. Of 57 survivors, follow-up was 93% complete for an average of 46 ± 6 months. The overall late reoperation rate was 24.6% (14 of 57 patients) at 50.3 ± 12.3 months. Twelve patients (21%) underwent future aortic aneurysmal repair. No difference in reoperation rate was seen comparing "closed" (26%) with "open" (18%; $p = 0.46$). Of 42 preserved native valves, only 3 (7.1%) needed future valve replacement.**

Conclusions. **In our experience, operative mortality was determined by preoperative hemodynamic instability. Technique did not impact survival or late reoperation. Early diagnosis and repair is critical to improving survival.**

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Acute Stanford type A aortic dissection is a true cardiovascular emergency with a high potential for death. The natural history is almost uniformly fatal, with 80% mortality at 2 weeks. Surgical treatment is aimed at preventing life-threatening aortic rupture and lethal pericardial tamponade. Resections of the dissected aorta and graft replacement are the current surgical treatment. Often the dissection process involves the aortic sinuses and valve commissures leading to acute aortic insufficiency and heart failure. Either valve resuspension or repair must correct this state. The advent of hypothermic circulatory arrest and retrograde brain perfusion has given the surgeon the option of more aggressive aortic resections beyond the innominate artery. Beyond eliminating the immediately life-threatening problem, the more aggressive arch or hemiarch procedures are aimed at preventing the high rate of reoperations for future aneurysm development of the residual abnormal aorta. At the University of Virginia, surgeons have adopted the use of hypothermic circulatory arrest with retrograde cerebral protection more recently. Our policy is to preserve the native aortic valve if possible. Recent reports from the internationanl registry document the high morbidity and mortality of aortic dissection [1]. We reviewed our experience to determine the primary predictors of mortality for our patients as well as to compare the outcomes of patients' distal anastomosis performed under aortic cross-clamp with those repaired in the "open" fashion under hypothermic circulatory arrest.

Patients and Methods

Patient Population

The records of all 70 consecutive patients who underwent surgical treatment for acute type A dissection at the University of Virginia Hospital from January 1988 through April 2001 were reviewed. By DeBakey classification, 61 patients were type 1 and 9 were type 2. Medical history, presentation data, operative techniques, complications, mortality, postoperative aortic valve status, and the need for future reoperation were noted. Of 57 survivors, follow-up was 93% complete for an average of 46.4 ± 6.6 months.

There were 49 men and 21 women whose ages ranged

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Table 1. Univariate Analysis for Hospital Death (n = 70)

Variable	Survivors (%) (n = 57)	Mortality (%) (n = 13)	*p* Value
Age (y)	59 + 2	62 + 3	0.45
Outside transfer (58%)	37 (65%)	4 (31%)	0.02
Hypertension (66%)	37 (65%)	9 (69%)	0.77
CAD (17%)	10 (18%)	2 (15%)	0.85
Marfan's syndrome (11%)	7 (12%)	1 (8%)	0.64
COPD (11%)	5 (9%)	3 (23%)	0.14
Shock (23%)	8 (14%)	8 (62%)	0.002
Preoperative stroke (17%)	7 (12%)	5 (39%)	0.02
Tamponade (18%)	6 (11%)	7 (54%)	0.0003
AI (moderate–severe) (40%)	24 (42%)	4 (31%)	0.45
Time to OR (h)	22 ± 4	17 ± 4	0.37
AXC time (min)	84 ± 7	101 ± 16	0.25
CPB time (min)	145 ± 11	151 ± 18	0.81
Circulatory arrest time (min)	36 ± 4	34 ± 4	0.79
OR temp (°C)	22 ± 0.6	20 ± 2	0.42
Aortic cross-clamp (79%)	45 (79%)	10 (77%)	0.87
Circulatory arrest (53%)	27 (47%)	10 (77%)	0.05
Retrograde cerebral perfusion (38%)	23 (40%)	3 (25%)	0.32
Coronary manipulation (27%)	18 (32%)	1 (8%)	0.08
Aortic valve replacement (21%)	14 (25%)	1 (8%)	0.18
Tear in aortic arch (20%)	12 (21%)	2 (15%)	0.64
Intimal tear not found (7%)	3 (5%)	2 (15%)	0.20
Tear resected (74%)	41 (75%)	9 (69%)	0.70
Reexploration (21%)	12 (21%)	3 (23%)	0.87
Coagulopathy (10%)	4 (7%)	3 (23%)	0.08
Postoperative MI (7%)	4 (7%)	1 (8%)	0.93
Postoperative heart failure (14%)	4 (7%)	6 (46%)	0.0003
Postoperative neurologic dysfunction (21%)	11 (19%)	4 (31%)	0.36
Pulmonary failure (21%)	11 (19%)	4 (31%)	0.36
Hemodialysis (13%)	6 (11%)	3 (23%)	0.22
Postoperative sepsis (14%)	6 (11%)	4 (31%)	0.06

AI = aortic insufficiency; AXC = aortic cross-clamp; CAD = coronary artery disease; COPD = chronic obstructive pulmonary disease; CPB = cardiopulmonary bypass; MI = myocardial infarction; OR = operating room.

from 11 to 82 years (mean, 59 ± 2 years). The majority (58%) of patients were transferred from an outside referring institution. The average time from the onset of symptoms to operation was 21 ± 3 hours. The most common comorbidity was hypertension (66%). A history of coronary artery disease was present in 12, chronic obstructive pulmonary disease in 8, and Marfan's syndrome in 8.

Preoperative complications analyzed are listed in Table 1. Aortic insufficiency was most common being moderate to severe in 40%. Coronary ischemia defined by electrocardiographic criteria or elevated myocardial enzymes was evident in 36% patients. Shock defined as systolic blood pressure less than 90 mm Hg occurred in 23%. Dissection-related neurologic dysfunction defined as any new neurologic deficit consistent with stroke or coma was evident in 17%. The location of the intimal tear was in the ascending aorta in 73% of patients, the arch in 20%, and not found in 7%.

Diagnostic modalities included echocardiography (69%), angiography (54%), and computed tomographic scanning or computed tomographic angiography (45%). Angiography visualized the false channel in 46%, and the location of the tear was noted 38% of the time. The consulting surgeon determined selection of appropriate diagnostic modalities. Our use of angiography was predominantly early in our series. Our current diagnostic study of choice is either transesophageal echocardiography or computed tomographic angiography.

Operative Techniques

Although variability existed in specific operative techniques among surgeons and with time, all patients underwent median sternotomy with institution of cardiopulmonary bypass. The majority of surgeons initially cannulated the femoral artery and then switched to antegrade perfusion directly through the graft or through a sidearm in the graft after the distal anastomosis. However, one surgeon cannulated the ascending aorta directly (22 patients). Our current technique is axillary artery cannulation, which was used in the majority of the more recent patients. A segment of the ascending aorta, containing the intimal tear (if present), was resected and replaced with a tubular prosthetic graft. The primary intimal tear was resected in 51 (73%) patients. In most cases, polytetrafluoroethylene felt strips were used liberally for a sandwich type reinforcement of the proximal and distal anastomosis. The majority (51) of patients had no manipulation of the coronary arteries. Six underwent concomitant coronary artery bypass grafting, and 9 had coronary arteries reimplanted.

With respect to the extent of distal resection, the majority (64) of patients only had the ascending aorta replaced. Four patients underwent hemiarch replacement, for which the graft was tailored obliquely and sewn into the lesser curve of the aortic arch. Two patients underwent full arch replacement. Of the 64 in the ascending only group, 16 were conduit valve grafts and 48 were ascending only. Proximally, the native aortic valve was preserved in 56 (80%) patients, with 37 of these requiring resuspension of the valve commissures. Valve replacement was performed at the discretion of the operating surgeon with the goal to preserve the valve whenever possible.

The distal "top end" aortic anastomosis was performed in under aortic cross-clamp (AXC) in 32 patients. The mean cross-clamp time (myocardial ischemia) was 66 ± 6 minutes with mean cardiopulmonary bypass time of 114 ± 8 minutes. Some surgeons used AXC routinely, whereas others used AXC only for limited dissections. The remaining 38 patients underwent hypothermic circulatory arrest (HCA) to allow for anastomosis without a cross-clamp in the "open" distal fashion. The mean myocardial ischemia time was 112 ± 10 minutes with mean cardiopulmonary bypass time of 182 ± 17 minutes. For the open group, the mean circulatory arrest time was 35 ± 3 minutes with mean core temperature of 19.6° ± 0.5°C. Retrograde cerebral perfusion through the superior vena cava was used in 77% of patients undergoing HCA. The AXC time (myocardial ischemia) and CPB time were significantly longer in the open distal HCA group than the closed under AXC group (Table 2; $p < 0.001$).

Table 2. Patient Characteristics Related to Distal Anastomotic Technique

Variable	Closed Under AXC	Open With HCA	p Value
Age (y)	56 ± 3	61 ± 2	0.19
Outside transfer	18	23	0.43
Hypertension	21	22	0.81
Coronary artery disease	3	9	0.08
Hemodynamic compromise	4	11	0.06
Preoperative neurologic dysfunction	4	7	0.41
Tamponade	4	8	0.27
AI (moderate–severe)	10	17	0.15
Time to OR (h)	26 ± 5	14 ± 4	0.08
AXC (myocardial ischemia) time (min)	66 ± 6	112 ± 10	<0.001
CPB time (min)	114 ± 8	182 ± 8	0.001
Circulatory arrest time (min)	0 ± 0	35 ± 3	<0.001
OR temperature (°C)	25.1 ± 0.8	19.6 ± 0.5	<0.001
Aorta cross-clamp	32	20	<0.001
Retrograde cerebral perfusion	0	26	<0.001
Coronary manipulation	8	11	0.56
Aortic valve replacement	7	8	0.92
Intimal tear not found	4	1	0.13
Tear resected	22	26	0.76
Reexploration	5	9	0.31
Coagulopathy	2	4	0.46
Postoperative myocardial infarction	1	4	0.20
Postoperative heart failure	2	7	0.09
Postoperative stroke or coma	3	10	0.05
Pulmonary failure	6	8	0.68
Renal failure requiring dialysis	3	5	0.54
Postoperative sepsis	4	5	0.83
Mortality	3	10	0.14
Future reoperation	8	5	0.46

AI = aortic insufficiency; AXC = aortic cross-clamp; CPB = cardiopulmonary bypass; HCA = hypothermic circulatory arrest; OR = operating room.

Data Analysis

Univariate analyses were performed to determine if there were statistically significant differences between the two treatment groups with respect to each variable of interest. Categorical variables were analyzed using a χ^2 test, and continuous variables were analyzed using a two-tailed Student's t test with equal or unequal variances based on the findings of an initial F test for equality of variances. All probability values are two-tailed, and values less than or equal to 0.05 are considered statistically significant. Values are expressed as mean ± standard error of the mean or percentage of the group of origin.

The following variables were analyzed: age, hypertension, Marfan's syndrome, coronary artery disease, history of myocardial infarction, diabetes mellitus, chronic obstructive pulmonary disease, peripheral vascular disease, cardiac reoperation, previous aortic operation, preoperative neurologic dysfunction, shock, angina, tamponade, aortic insufficiency (AI), visceral ischemia, outside transfer, location of tear, resection of tear, time to operation, AXC time, cardiopulmonary bypass time, circulatory arrest time, retrograde cerebral perfusion, reexploration, coagulopathy, postoperative neurologic dysfunction, postoperative myocardial infarction or failure, delayed tamponade, postoperative AI, pulmonary failure, renal failure, hemodialysis, limb ischemia, and sepsis.

Logistic regression was performed to identify possible predictors of mortality. To reduce the number of variables considered for the model, a test of association was run individually for each of the 35 variables with mortality. Only those variables that yielded a $p \leq 0.10$ were considered for the model. Once these potential predictors were identified, a backward stepwise procedure was used to establish the final model. From this model, the odds ratios were determined. An initial Pearson correlation coefficient was first determined for all continuous variables to screen for highly correlated variables. Statis-

Table 3. Multivariate Analysis for Mortality

Variable	Odds Ratio	CI	*p* Value
Hypothermic circulatory arrest	3.75	0.63–22.3	0.15
Preoperative neurologic dysfunction	4.32	0.5–37.0	0.18
Hemodynamic stability	0.107	0.012–0.929	0.04
Coronary artery manipulation	0.025	0.001–0.66	0.02
Preoperative tamponade	3.76	0.5–27	0.18
Outside transfer	0.122	0.018–0.821	0.03

CI = confidence interval.

tical analysis was performed using SAS software (SAS Institute Inc., Cary, NC) and GB-STAT Version 6.5 (Dynamic Microsystems, Silver Spring, MD).

Surgical outcome was measured in terms of operative morbidity (neurologic complications, reexploration for bleeding or delayed tamponade, coagulopathy, cardiac failure, pulmonary failure, renal failure, or sepsis), operative mortality, and rate of late reoperation. Neurologic complications included permanent cerebral vascular accident, transient ischemic attacks, and delirium or prolonged coma (greater than 24 hours). Operative mortality included death during the initial hospitalization or the first 30 days postoperatively, whichever was longer. Reoperations were noted for future aortic valve or aneurysm surgical procedures. An aneurysm was defined as a 50% increase in the diameter of a vessel in comparison with its expected normal diameter.

Results

Operative Mortality

Overall operative mortality was 18.6% (13 of 70 patients). Patients presenting in shock had an operative mortality of 61.5% compared with stable patients at 8.7% ($p < 0.0002$). No difference was seen between the closed distal anastomosis technique under AXC and the open distal technique under HCA.

Univariate analysis revealed preoperative shock ($p = 0.0002$), tamponade ($p = 0.003$), and neurologic deficit ($p = 0.02$) to be associated with mortality. Outside transfer was associated with survival ($p = 0.02$). Multivariate analysis revealed hemodynamic stability (odds ratio = 0.10, $p = 0.04$) and outside transfer (odds ratio = 0.12, $p = 0.03$) to be negative predictors of mortality (Tables 1 and 3).

Operative Morbidity

Postoperative neurologic dysfunction for all patients was 21%. Specifically, postoperative neurologic dysfunction was significantly higher in patients who underwent open distal anastomosis under HCA (29%) compared with those who were repaired in closed fashion under AXC (9%; $p = 0.04$). Reexploration was required in 15 patients (21%), with delayed tamponade being the cause in 7. Postoperative heart failure occurred in 10 patients (14%), with postoperative myocardial infarction diagnosed in 7 patients. Pulmonary failure (defined as prolonged ventilation > 72 hours, need for reintubation, or tracheotomy) occurred in 21%. Renal failure requiring hemodialysis occurred in 9 patients. The average length of stay was 20 ± 3 days.

Late Reoperation

Of 57 survivors, follow-up was 93% complete for an average of 46 ± 6 months. The overall reoperation rate was 24.6% (14 of 57 patients) at an average 50.3 ± 12.3 months. Twelve (21%) of the survivors underwent late aortic aneurysmal repair. These included two aortic roots, one arch, seven descending or thoracoabdominal aortas, and two abdominal aorta replacements. No difference in the need for reoperation rate was seen comparing closed under AXC (25.8%) with open distal (17.9%; $p = 0.46$). Postoperative aortic arch size was similar after closed under AXC (46 ± 3 mm) or open distal technique (42 ± 3 mm; $p = 0.39$). Of the survivors, 42 had valve preservation, with 3 patients (7.1%) needing future valve replacement. The average AI grade for patients with preserved valves was 1.43 ± 0.12 at 30.0 ± 9 months. No patient treated with a composite valve graft performed acutely required anterior reoperation in the ascending aorta (Table 2).

Comment

Predictors of Mortality

Operative mortality and morbidity for acute type A aortic dissection remains high despite advancements in cardiovascular technology. The recent International Registry published the mortality of acute type A aortic dissection to be 26% after surgical therapy compared with 58% for medical management alone [1]. We report an operative mortality of 18.6% for primary acute type A aortic dissection. This is similar to that reported in 1976 from the University of Alabama, in which Applebaum and associates [2] reported a surgical mortality of 24% for acute type A dissections in contrast to an 88% medical mortality with death being most commonly from tamponade. Moon and colleagues [3] recently reported a mortality of 20% (24 of 119 patients) with no significant change being seen during the reported period from 1984 to 1999. Similarly, at our institution, we have not seen a decrease in mortality with time. Recently the Cleveland Clinic reported their experience as a 14% mortality; however, they included chronic type A and excluded iatrogenic dissections [4]. Overall, our findings are in general agreement with the reported literature.

In our series, preoperative hemodynamic status was an independent predictor of outcome. This variable is very unlikely to be influenced by operative technique and so it is not suprising that operative mortality has been fairly constant for the last few decades. Recent data from the International Registry examining acute type A dissections also found "hypotension/shock/tamponade" to be an independent predictor of mortality [5]. Other recent investigators found preoperative tamponade to be an independent predictor [6]. We found this to be significant in our univariate analysis, but in our study population it was not independent of preoperative shock. However, in their study they subdivided tamponade into those with and without palpable pulses and we did not, which may account for the differences. Interestingly, drained pericardial tamponade preoperatively has recently been reported as a negative predictor of mortality [7]. Likewise, at our institution being transferred in from an outside hospital portends a lower mortality. Obviously, this represents a selection bias as the patients who survive transfer to make it to the operating room have selected themselves out from the entire group of patients presenting with acute dissections at our referring institutions. In light of this finding, future authors should include this variable in describing their patient population. Nevertheless, this finding also adds evidence to hemodynamic stability being the key predictor of operative success. Again this emphasizes the need for urgent surgical repair in patients with acute type A dissection before the onset of hemodynamic instability if at all possible.

Technique of Distal Anastomosis

At most centers, operation for acute type A aortic dissection has undergone a modification to a no-clamp technique. Mt. Sinai recently reported a mortality of 15.3% when performing distal anastomosis under HCA, and suprisingly they did not find duration of HCA to be a risk factor [8]. Likewise, David and colleagues [9] are proponents of no clamp, having described a mortality with no-clamp technique of 9% compared with that using an aortic cross-clamp of 20% ($p = 0.10$). In addition, they also reported a lower stroke rate for the no-clamp group. In contrast, we had more complications and postoperative neurologic dysfunction in our patients who underwent circulatory arrest. We did not find retrograde cerebral perfusion to significantly contribute to neurologic outcome.

Freedom From Reoperation

Another issue involving the acute repair of the dissected aorta is preventing the need for reoperation in the future that historically has been associated with a high mortality as well. The pathophysiology of the weakened aortic tissue leads to further dilation of the false lumen as well as aortic valvular incompetence. We much prefer preserving the native aortic valve to avoid the anticoagulation risk of mechanical valves whenever possible. We were able to preserve the native aortic valve in 80% of patients, of whom 40% had moderate to severe AI preoperatively. In our series we found a late reoperation rate of 25%. Three aortic valves were redone. Two of these were because of sinus dilation and subsequent AI, which were revised to a conduit valve graft. Preoperatively these 2 patients had preoperative insufficiency of mild and moderate degrees. A third patient presented with moderate to severe (3+) AI, and the valve was resuspended successfully by intraoperative echocardiography only to later develop AI with congestive heart failure; the patient required a mechanical valve. Recently, Casselman and associates [10] reported a late reoperation rate of 10% at 4 years for their patients with valve resuspension, which is similar to ours of 7.5%. Recently, severe AI has been shown to increase the risk for proximal reoperation [11]. However, in our 3 patients only 1 had severe AI preoperatively. With regards to the thoracic aorta, we have only replaced two aortic roots and one full arch replacement in our series. In addition, we did have 11 descending aortas electively replaced. We saw no difference in our experience between techniques of open versus closed distal anastomosis in terms of decreased reoperation rate.

Conclusions

In our experience, preoperative shock is the most important predictor of outcome after surgical treatment of acute primary type A aortic dissection regardless of surgical technique. These patients should benefit from an early diagnosis and expedient repair. Future reoperations can then be dealt with in an elective manner under optimized circumstances.

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