Clinical Profiles and Outcomes of Acute Type B Aortic Dissection in the Current Era: Lessons From the International Registry of Aortic Dissection (IRAD)

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Background—Clinical profiles and outcomes of patients with acute type B aortic dissection have not been evaluated in the current era.

Methods and Results—Accordingly, we analyzed 384 patients (65±13 years, males 71%) with acute type B aortic dissection enrolled in the International Registry of Acute Aortic Dissection (IRAD). A majority of patients had hypertension and presented with acute chest/back pain. Only one-half showed abnormal findings on chest radiograph, and almost all patients had computerized tomography (CT), transesophageal echocardiography, magnetic resonance imaging (MRI), and/or aortogram to confirm the diagnosis. In-hospital mortality was 13% with most deaths occurring within the first week. Factors associated with increased in-hospital mortality on univariate analysis were hypotension/shock, widened mediastinum, periaortic hematoma, excessively dilated aorta (≥6 cm), in-hospital complications of coma/altered consciousness, mesenteric/limb ischemia, acute renal failure, and surgical management (all $P<0.05$). A risk prediction model with control for age and gender showed hypotension/shock (odds ratio [OR] 23.8, $P<0.0001$), absence of chest/back pain on presentation (OR 3.5, $P=0.01$), and branch vessel involvement (OR 2.9, $P=0.02$), collectively named 'the deadly triad' to be independent predictors of in-hospital death.

Conclusions—Our study provides insight into current-day profiles and outcomes of acute type B aortic dissection. Factors associated with increased in-hospital mortality ("the deadly triad") should be identified and taken into consideration for risk stratification and decision-making. **(*Circulation*. 2003;108[suppl II]:II-312-II-317.)**

Key Words: aortic dissection ■ aorta ■ peripheral vascular disease ■ outcomes ■ stents

Aortic dissection is a catastrophic cardiovascular disease associated with high morbidity and mortality.[1–4] Advances in the understanding of this disease have established that lesions limited to the descending aorta (type B) generally have better survival compared with those involving the ascending aorta.[5,6] Introduction of newer diagnostic techniques and management strategies have shown potential to improve diagnosis and management.[7,8] Most studies evaluating type B aortic dissection have preceded the routine incorporation of newer diagnostic techniques and management strategies in the care of these patients. Thus, the clinical presentation, utilization patterns of diagnostic imaging modalities as well as their findings, management strategies including the factors influencing the use of these strategies (ie, medical, surgical, or percutaneous), and in-hospital outcomes of patients with acute type B aortic dissection in the current era have not been fully elucidated.[9–15]

Using the International Registry of Acute Aortic Dissection (IRAD) database,[16] we analyzed the clinical features, diagnosis, imaging findings, management and in-hospital outcomes of patients with acute type B aortic dissection. Factors associated with in-hospital mortality and their quantitative relative risks were also assessed to aid in risk stratification and decision making.

Methods

Patient Selection and Data Collection

Patients with acute type B aortic dissection enrolled in the IRAD between January 1, 1996 and December 31, 2000 were included in the present analysis.[16] IRAD is an ongoing multi-national multicenter registry started in 1996 that includes consecutive patients with acute aortic dissection at 18 large referral centers (IRAD centers; Appendix I). The founding objective of IRAD was to assess the etiology, mode of presentation, clinical features, management, and outcomes of patients with acute aortic dissection. Acute type B aortic

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On behalf of the International Registry of Acute Aortic Dissection (IRAD) investigators (Appendix I).

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TABLE 1. Demographics and Patients History for all Patients with Type B Aortic Dissection

Variable	Overall	Survived	Died	*P*-value
N (%)	384 (100)	336 (87.5)	48 (12.5)	
Demographics				
Age-mean (±SD), years	64.6 (13.3)	64.1 (13.2)	68.1 (13.1)	0.05
Age ≥70 years (%)	159 (41.6)	133 (39.8)	25 (54.2)	0.06
Gender-male (%)	274 (71.4)	196 (71.7)	28 (68.8)	0.67
Transferred to IRAD sites (%)	241 (64.4)	209 (63.9)	32 (68.1)	0.57
Etiology and patients' history				
Marfan's syndrome (%)	11 (2.9)	10 (3.0)	1 (2.2)	1.00
Hypertension (%)	303 (79.9)	266 (79.9)	37 (80.4)	0.93
Atherosclerosis (%)	140 (37.6)	119 (37.3)	21 (47.7)	0.23
Iatrogenic dissection: Cardiac Cath/PTCA (%)	9 (2.3)	7 (2.1)	2 (4.2)	0.31
Prior aortic dissection (%)	33 (8.8)	28 (8.5)	5 (11.1)	0.57
Prior aortic aneurysm (%)	68 (18.1)	60 (18.2)	8 (17.4)	0.89
Diabetes (%)	24 (6.5)	19 (5.8)	5 (11.1)	0.19
Prior cardiovascular surgery (%)	62 (17.1)	55 (17.4)	7 (15.6)	0.76
Aortic valve replacement	19 (5.2)	17 (5.3)	2 (4.4)	1.00
Mitral valve replacement	3 (0.8)	3 (1.0)	0 (0.0)	1.00
Coronary bypass surgery	14 (3.9)	14 (4.4)	0 (0.0)	0.39
Aortic surgery (dissection, aneurysm)	45 (12.3)	37 (11.6)	8 (17.0)	0.29

dissection was defined as an acute aortic dissection involving the descending aorta with an entry tear beyond the origin of the left subclavian artery, sparing the ascending and arch segment and presenting within 14 days of symptom onset.[6,16] Intramural hematoma was defined as presence of a regionally thickened aortic wall in the absence of evidence of a double lumen and/or intimal flap regardless of imaging modality.[17,18] Diagnosis was based on history and physical examination, and confirmed by imaging, visualization at surgery, and/or postmortem examination.

Data were collected using a standard form on 290 clinical variables including patient demographics, history, clinical presentation, physical findings, imaging studies, details of medical and surgical management, in-hospital clinical events, length of stay, and in-hospital mortality. Standard American College of Cardiology/American Heart Association definitions were used to denote various in-hospital complications.[19] Hypertension was defined with documented history and treatment with medication, diet, and/or exercise by a physician; blood pressure readings >140 mm Hg systolic or >90 mm Hg diastolic pressure were required on 2 occasions or on antihypertensive medication. Data forms were reviewed for analytical internal validity, and external validation was performed through a random (5%) field selection and error audit. The forms were computer-scanned and converted into an Access database by the IRAD coordinating center at the University of Michigan.

Statistical Analysis

Data are shown as frequencies and percentages, and mean±SD. Missing data were not defaulted to negative, and denominators reflect only reported cases. Associations of death among nominal variables were compared using the Chi-square test and Fisher's exact test when appropriate, and among continuous variables using the t-test. Stepwise multivariable logistic regression models were fitted using variables found to have marginal association with death on univariate testing ($P<0.20$). Odds ratios, 95% confidence intervals, probability values and model c-statistics are reported. SAS 8.1 software (Cary, NC) was used for all analyses.

Results

Demographics and Clinical Presentations

Of 1007 patients with acute aortic dissection enrolled in IRAD, 384 patients (38%) had acute type B aortic dissection. Mean age was 65±13 years with male predominance (71%). Approximately two-thirds of the patients (64%) had initially presented elsewhere and were transferred to an IRAD center for further assessment and management; and 36% presented directly to an IRAD center. A majority (80%) had a history of hypertension. Comorbid conditions frequently included atherosclerosis (38%) and prior aortic aneurysm (18%). Other etiologies of aortic dissection such as connective tissue disease, prior dissection or prior cardiac surgery were less frequently seen (Table 1).

While chest and/or back pain (86%) of abrupt nature (89%), and hypertension (69%) were common on presentation, migrating pain was uncommon and found in only one of four patients (25%). Pulse deficits were seen in one of five patients (21%), whereas spinal cord ischemia and ischemic peripheral neuropathy were seen in only a minority at presentation (3% and 2% of patients, respectively). Similarly, hypotension/shock on presentation, suggesting hemodynamic instability, was seen in only 3% (Table 2).

Diagnostic Modalities and Findings

Chest radiograph was performed in 94% of patients of which only approximately one-half (56%) showed widened mediastinum or abnormal aortic contour (49%). Electrocardiograms were performed in 96%, with normal findings in only one-third (31%). An imaging study in the form of transesophageal echocardiography, computerized tomography (CT),

TABLE 2. Clinical Presentations, Signs, and Diagnostic Imaging Results of all Patients with Type B Aortic Dissection

Variable	Overall	Survived	Died	*P*-value
Clinical presentations and signs				
Chest/Back pain (%)	328 (86.3)	298 (89.2)	30 (65.2)	<0.0001
Abrupt onset of pain (%)	332 (89.2)	298 (91.1)	34 (75.6)	0.002
Migrating pain (%)	90 (24.7)	86 (26.6)	4 (9.8)	0.02
Spinal Cord Ischemia (%)	10 (2.7)	9 (2.8)	1 (2.2)	1.00
Ischemic peripheral neuropathy (%)	8 (2.2)	7 (2.2)	1 (2.2)	1.00
Hypotension/shock (%)	13 (3.4)	5 (1.5)	8 (16.7)	<0.0001
Hypertension (%)	260 (69.1)	235 (71.4)	25 (52.1)	0.007
Any pulse deficit (%)	73 (21.1)	61 (20.0)	12 (29.3)	0.17
Diagnostic imaging results				
Chest radiograph (%)	360 (93.8)	315 (93.8)	45 (93.8)	1.00
Normal (%)	74 (20.6)	65 (20.6)	9 (20.0)	1.00
Widened mediastinum (%)	202 (56.4)	170 (54.1)	32 (72.7)	0.02
Abnormal aortic contour (%)	171 (49.4)	159 (52.0)	12 (30.0)	0.009
Periaortic hematoma (%)	72 (19.2)	53 (16.8)	19 (45.2)	<0.0001
Electrocardiogram (%)	369 (96.1)	324 (96.4)	45 (93.8)	0.37
Normal (%)	113 (30.6)	101 (31.2)	12 (26.7)	0.54
Findings on diagnostic imaging				
Aorta diameter ≥6 cm**	44 (15.9)	22 (9.5)	12 (27.3)	0.001
Intramural hematoma (%)*†	60 (18.0)	55 (18.4)	5 (14.7)	0.60
False lumen closure status				
Patent	158	138 (87.3)	20 (12.7)	*0.71
Partially thrombosed	107	94 (87.9)	13 (12.1)	
Completely thrombosed	48	44 (91.7)	4 (8.3)	

**P*-value for Chi-square test for survival by lumen closure status; †intramural hematoma of the aorta as defined in references 18 and 25; **108 patients are missing.

magnetic resonance imaging (MRI), and/or aortography was done in almost all patients (99%). Computerized imaging was the most commonly utilized imaging modality (93%), followed by transesophageal echocardiography (59%), MRI (31%) then aortography (24%). Multiple imaging was performed in 76% of patients. The initial imaging technique most frequently employed was computerized tomography in 81%. The diameter of ascending aorta exceeded 6 cm in 16% of patients. False lumen was identified in 82% of patients of which 50% were patent, 34% partially thrombosed and 15% completely thrombosed. Periaortic and intramural hematoma were seen in 19% and 18% of patients, respectively (Table 2).

Management and Outcomes

Most patients were managed medically (73%) with beta-blockers used in 79% of nonhypotensive patients. Surgery and percutaneous intervention were performed in 15% and 12%, respectively. Stenting was reserved for patients who had undergone at least eight weeks of medical management. Acute intervention was limited to fenestration In-hospital complications of branch vessel involvement (compromise of iliac, mesenteric, or renal arteries) were found in 22% of patients. Hypotension/shock (including postoperative) was found in 12% of patients; malperfusion (renal, mesenteric, or limb) was seen in 21% (Table 3).

Medical treatment was associated with better survival as compared with surgical treatment. Mortality was lowest among patients selected for percutaneous intervention (Table 3; Figure 1), but was not statistically different between percutaneous intervention and medical therapy.

Mortality and Risk Prediction Model for Acute Type B Aortic Dissection

In-hospital mortality was 13% and highest for patients who required surgery at 32%; 85% of patients dying in-hospital did so during the first week (Table 3). 70% of patients died from rupture with visceral ischemia being the next frequent cause at 19%; neurological causes resulted in only 8% of deaths.

A risk prediction model fitting hypotension/shock, absence of chest/back pain, malperfusion, age 70 and up, and gender was developed. Multivariate logistic regression analysis identified hypotension/shock (odds ratio [OR] 23.8, $P<0.0001$) absence of chest/back pain on presentation (OR 3.5, $P<0.01$), and branch vessel involvement (OR 2.9, $P=0.01$) to be independent predictors of in-hospital death. The c-statistic for the model was 0.86 and the Hosmer-Lemeshow goodness of fit probability value was 0.82 (with 6 df) confirming that these 3 factors discriminate well in death prediction and that there was little departure from a good fit with the data. A

TABLE 3. In-Hospital Management and Outcomes of all Patients with Type B Aortic Dissection

Variable	Overall	Survived	Died	*P*-value
Definitive Management				
Surgery (%)	56 (15)	38 (67.9)	18 (32.1)	*<0.0001
Medical Rx (%)	282 (73)	255 (90.4)	27 (9.6)	
Percutaneous Intervention (stent, fenestration) (%)	46 (12)	43 (93.5)	3 (6.5)	
Initial medical treatment (excluding hypotensive patients)				
Beta-blockers (%)	277 (78.7)	253 (79.6)	24 (70.6)	0.22
All in-hospital complications (including post-operative)				
Coma/altered consciousness (%)	19 (5.1)	8 (2.5)	11 (23.9)	<0.0001
Branch vessel involvement (%)	76 (21.6)	56 (18.1)	20 (46.5)	<0.0001
Hypotension/shock (%)	40 (11.7)	15 (5.0)	25 (61.6)	<0.0001
Malperfusion (%)*	72 (20.6)	52 (17.0)	20 (45.5)	<0.0001
Acute renal failure (%)	46 (13.5)	36 (11.8)	10 (26.3)	0.01
Mesenteric ischemia/infarction (%)	18 (5.3)	12 (4.0)	6 (15.8)	0.002
Limb ischemia (%)	24 (7.1)	17 (5.7)	7 (17.5)	0.006

*Chi-square *P*-value for differences in survival by management.

**Malperfusion is defined for a patient having one of the three conditions listed below.

deviance probability value was 0.38 indicating little difference from the saturated model (Table 4).

Moreover, patients were subclassified into three risk groups (Table 5, Figure 2): low risk (4 or fewer observed deaths per group), intermediate risk (13 observed deaths) and the highest risk group (16 deaths). The model could correctly predict death in risk-stratified groups for observed (versus predicted) death percents, respectively: for the low risk group 4.2% (versus 4.0%), for the intermediate risk group 35.1% (versus 34.5%) and for the highest risk group 69.6% (versus 73.6%). A multiplicity of the 3 model risk factors of hypotension/shock, lack of chest/back pain and branch vessel involvement was highly predictive of death in patients with acute type B aortic dissection.

Discussion

Our study provides improved understanding of the clinical profile and outcomes of patients with acute type B aortic dissection in the current era. Further, it identifies variables associated with increased risk of in-hospital mortality that may help clinicians in early risk stratification and decision-making. The (distal) type B lesion is generally associated with a favorable outcome as compared with the (proximal) type A lesion, which is more often associated with an aortic valve insufficiency, pericardial rupture with tamponade, or rupture into pleural space. In contrast to type A dissection which requires immediate surgical attention, medical management (eg, anti-hypertensive, cardiac output suppressive) is currently the preferred method of treatment for uncomplicated type B lesions. Complicated type B lesions (eg, containing rupture, occlusion of major branch, extension or enlargement, etc) may require surgical management at times emergent (eg, rupture, enlargement) whereas others (eg, intractable pain, visceral malperfusion) may allow more time for medical/interventional management.

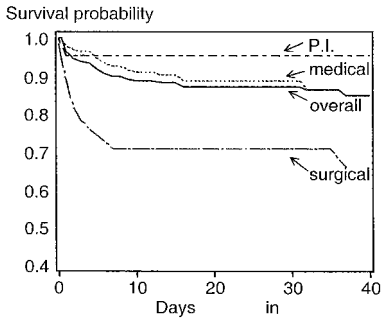

Figure 1. Survival curves due to acute type B aortic dissection for all patients and by management group based on Kaplan-Meier analysis of 40-day mortality (P.I.=percutaneous intervention).

Clinical Presentation, Diagnosis, Management, and Outcomes

Our study confirms that the typical profile of type B dissection is the elderly male, hypertensive, presenting with abrupt onset of chest and/or back pain. Most patients with type B dissection do not present with hemodynamic instability, hypotension, or spinal cord ischemia, and even pulse deficit is uncommon. Physical findings in combination with sudden chest or back pain should therefore help emergency department physicians identify a subset of patients with chest pain who have a high likelihood of acute aortic dissection. How-

TABLE 4. Risk Prediction Model for Type B Dissection

Variable	OR	95% CI	*P*-value
Age ≥70 years	1.56	0.67–3.61	0.3
Male gender	0.96	0.39–2.36	0.92
Branch vessel involvement	2.92	1.21–6.99	0.02
Lack of chest/back pain	3.51	1.3–9.52	0.01
Hypotension/shock	23.8	10.31–54.94	<0.0001

TABLE 5. Frequencies (%) of Model Variables for Predicted Risk Groups

	Highest	Intermediate	Lowest
Patient number*	N=23	N=37	N=286
Estimated death probability range (%)	61–90 (71)	11–61 (36)	2–11 (3)
Age ≥70 years	56.5	54.1	38.1
Male gender	34.8	29.7	27.3
Branch vessel involvement	73.9	18.9	17.5
Lack of chest/back pain	52.2	29.7	8.0
Hypotension/shock	100	70.3	0

*There were 346 patients without missing data included in analysis.

ever, even lack of symptoms are not uncommon and may in fact delay presentation and diagnosis.

Widened mediastinum on chest radiograph that is a classical sign of acute aortic dissection was present in only one-half of patients. The chest radiograph can therefore, not be solely relied on to exclude the diagnosis of acute type B aortic dissection.[16,18] Computerized tomography was the most commonly used imaging modality likely reflective of its wide availability and sensitivity. A majority of the patients were managed medically, with most patients receiving intravenous then oral beta-blockers in line with current recommendations. The use of percutaneous intervention, such as aortic fenestration or stent-graft placement, has been increasing steadily over the last 5 years in IRAD and was performed in a similar proportion of patients as those undergoing surgery.

In-hospital mortality with type B dissection, although not as high as type A dissection (33%), is still 13% despite technological advances in diagnosis and treatment. Most patients dying in-hospital did so during the first week (85%). Not surprisingly, as surgery was performed in patients at highest risk, the mortality was highest for this cohort due to selection bias. Mortality was lowest among patients selected for percutaneous intervention reflecting inherent selection bias.

Risk Factors Associated with In-Hospital Death

Risk-stratification by assessing factors associated with increased mortality is frequently useful in appropriate management of patients with a potentially lethal cardiovascular disease. Our study identified a number of factors associated with increased risk of in-hospital mortality in patients with acute type B aortic dissection that may aid clinicians in management and decision making.

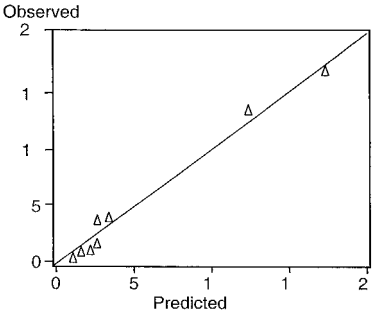

Figure 2. Plot of observed versus predicted deaths using our model. Hosmer-Lemeshow Chi-sq (6 df)=2.89. Prob>Chi-sq is 0.82.

While hemodynamic instability and vascular compromise are established risk factors for death,[20–22] our study for the first time identifies the lack of typical symptom of chest or back pain to predict increased risk of in-hospital mortality. We speculate that the sudden onset of classic symptoms of dissection fortunately allows for recognition of the disease and thus earlier initiation of treatment leading to improved survival, while lack of symptoms delay the time from symptom onset to presentation as well as delay in diagnosis after presentation. In separate tests, 77% and 51% of those without pain were diagnosed after six hours or after two days from symptom onset in contrast to 49% and 27% for those with pain ($P=0.01$ and 0.001, respectively). As a breakdown of presenting symptoms for painless patients, they had nearly twice as much coma/altered consciousness (8.2% versus 4.4%, $P=0.28$), more malperfusion (27.7% versus 19.7%, $P=0.21$), twice as much hypotension/shock (26.9% versus 12.2%, $P=0.005$), more with ≥6 cm aortic diameter (23.8% ≥6 cm versus 14.5% ≥6 cm, $P=0.13$), and more syncope (12.0% versus 2.8%, $P=0.009$). Patients free of chest/back pain showed more condition severity and in some cases the lack of ability to report pain. Collectively, painless patients were diagnosed later and in some ways had more lethal conditions as well as a varied and ambiguous presentation. It is also of interest to point out that in contrast to hypotension/shock which was associated with death, hypertension at presentation was associated with better survival, and prior cardiac surgery[23] was not associated with higher mortality.

Widened mediastinum on chest radiograph and periaortic hematoma on imaging study were three and four times more common, respectively, among patients who died. Excessive widening of the aorta (≥6 cm) was associated with nearly 3 times more death. These findings identify patients with a dilated and/or ruptured aorta, both of which have been known to be associated with worse outcomes to be at greater risk for death.[21,22,24] False lumen patency (relative to partially and completely thrombosed lumen status) showed no significant association with death, in disagreement with prior studies.[23–25] Finally, it is not surprising that patients experiencing any in-hospital complications (hypotension, mesenteric ischemia/infarction, coma/altered consciousness, limb ischemia, and acute renal failure) are at the greatest risk of in-hospital mortality.

Risk Stratification by Quantification of Risk Factors

Multivariate analysis showed hypotension/shock, lack of abrupt chest/back pain, and branch vessel involvement, though relatively uncommon in patients with acute type B aortic dissection, to be strong and independent predictors of in-hospital mortality in this order for likelihood for death. Strikingly, despite the use of these limited factors, death prediction could be highly discriminated by our risk prediction model. There was a clear tendency for intermediate and highest risk categories to be older, and high risk patients to give no report of chest/back pain in one-half and have branch vessel involvement in almost three-fourths of patients. Hypo-

tension/shock was concentrated entirely in the intermediate and highest risk patients. Leriche syndrome and other scenarios were not reported. A combination of the three factors of hypotension/shock, lack of chest/back pain and branch vessel involvement was especially lethal for type B dissection patients. Therefore, we refer to these 3 factors as 'the deadly triad' to increase awareness and to show its importance of appreciation in early risk stratification of the disease.

Study Limitations

There is inherent study bias because of the study design of an observational registry based mainly on data of tertiary referral centers that may not necessarily be applicable to the general population. In-hospital death was the outcome parameter that was assessed in this registry analysis. Although assessment of mortality is necessary and important in the management of the disease, it is not sufficient for full evaluation that would also take into consideration factors such as nonfatal adverse events, patient functional status, patient satisfaction, and resource use. Prospective studies are needed to address the best approach for evaluating the predictors on long-term survival.

Conclusions

Current-day profiles and outcomes of acute type B aortic dissection worldwide as analyzed using the IRAD database were described. Hypotension/shock, absence of chest/back pain on presentation, and branch vessel involvement ('the deadly triad') were identified to be associated with an increased risk of in-hospital mortality, and should be considered in the risk stratification and decision-making.

Appendix I

The International Registry of Acute Aortic Dissection (IRAD) Investigators

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