Predicting In-Hospital Mortality in Acute Type B Aortic Dissection
Evidence From International Registry of Acute Aortic Dissection

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Background—The outcome of patients with acute type B aortic dissection (ABAD) is strongly related to their clinical presentation. The purpose of this study was to investigate predictors for mortality among patients presenting with ABAD and to create a predictive model to estimate individual risk of in-hospital mortality using the International Registry of Acute Aortic Dissection (IRAD).

Methods and Results—All patients with ABAD enrolled in IRAD between 1996 and 2013 were included for analysis. Multivariable logistic regression analysis was used to investigate predictors of in-hospital mortality. Significant risk factors for in-hospital death were used to develop a prediction model. A total of 1034 patients with ABAD were included for analysis (673 men; mean age, 63.5±14.0 years), with an overall in-hospital mortality of 10.6%. In multivariable analysis, the following variables at admission were independently associated with increased in-hospital mortality: increasing age (odds ratio [OR], 1.03; 95% confidence interval [CI], 1.00–1.06; P=0.044), hypotension/shock (OR, 6.43; 95% CI, 2.88–18.98; P=0.001), periaortic hematoma (OR, 3.06; 95% CI, 1.38–6.78; P=0.006), descending diameter ≥5.5 cm (OR, 6.04; 95% CI, 2.87–12.73; P<0.001), mesenteric ischemia (OR, 9.03; 95% CI, 3.49–23.38; P<0.001), acute renal failure (OR, 3.61; 95% CI, 1.68–7.75; P=0.001), and limb ischemia (OR, 3.02; 95% CI, 1.05–8.68; P=0.040). Based on these multivariable results, a reliable and simple bedside risk prediction tool was developed.

Conclusions—We present a simple prediction model using variables that are independently associated with in-hospital mortality in patients with ABAD. Although it needs to be validated in an independent population, this model could be used to assist physicians in their choice of management and for informing patients and their families. (Circulation. 2014;130[suppl 1]:S45-S50.)

Key Words: aorta ■ aortic dissection ■ risk model ■ type B dissection

The morbidity and mortality of acute type B aortic dissection (ABAD) are strongly related to the clinical presentation.1,2 In contrast to patients with ascending involvement, medical treatment is the preferred therapy in all uncomplicated type B dissection patients, because current randomized controlled trials have failed to demonstrate a beneficial outcome of prophylactic endovascular repair in the short-term.3,4 Surgical and endovascular approaches are reserved for patients presenting with complications such as shock, periaortic bleeding, organ malperfusion, limb ischemia, and rapidly expanding false lumen. However, these procedures are still associated with high mortality rates between 20% and 30% for surgery and 10% and 20% for endovascular repair in the acute setting, especially in the elderly.3,5 Because of the various clinical features of ABAD, the progress and outcome of individual patients with ABAD admitted to the emergency department remain unpredictable.5-8 Therefore, more insights into the early prognosis of ABAD based on patient characteristics and presenting symptoms are needed to optimize treatment strategies and inform patients and their family. A
preoperative predictor model for in-hospital mortality could be of use in decision making regarding the necessity of intervention and to highlight the real risk of poor outcome for physicians, patients, and their families.

The International Registry of Acute Aortic dissection (IRAD) offers the unique opportunity to analyze the largest cohort of patients with ABAD to identify independent predictors of in-hospital mortality. An early IRAD report on this subject demonstrated that the deadly triad of hypotension/shock, absence of chest/back pain on presentation, and branch vessel involvement was predictive of in-hospital mortality in patients with ABAD. A decade later, with >1000 patients enrolled, we sought to provide a more elaborate model that could give us better insight into this condition. Based on clinical, diagnostic, and treatment characteristics, a simple bedside model to predict in-hospital mortality was developed.

**Methods**

**Patient Selection**

Patients presenting with ABAD without arch involvement, enrolled in IRAD between January 1996 and April 2013, were included for these analyses. IRAD is an ongoing multinational, multicenter registry, and the rationale, design, and methods have been previously published. Institutional review board approval was obtained for each center, with the need for informed consent determined independently by the ethics board at each center. Clinical, diagnostic, and treatment characteristics of patients who expired during hospitalization were compared with those who were discharged alive.

**Data Collection and Measures**

Standardized data forms were used to collect data on patient demographics, medical history, clinical presentation, physical findings, imaging studies, management, adverse events, and in-hospital outcomes. Each submission was forwarded to the coordinating center, where the forms were reviewed for internal consistency and face validity and then entered into the online database.

**Statistical Analysis**

Summary statistics are presented as frequencies, percentages, mean±SD, or median as appropriate. Denominators represent only reported cases because missing data were not defaulted to negative. The association with in-hospital mortality was compared for categorical variables using the χ² test and Fisher exact test, when appropriate. The Student t test was used to compare continuous variables between all groups, and the Mann-Whitney U test was used in the absence of a normal distribution. Variables with a marginal association with mortality (P<0.20) were entered in stepwise multivariable logistic regression model for in-hospital mortality. If variables were missing in >20% of patients or only positive in <5% of the cohort, they were excluded from multivariable analysis. Both age and sex variables were forced into our model. The calibration of the multivariable model was evaluated by the Hosmer–Lemeshow goodness-of-fit test. A value of P<0.05 was considered significant. Data analysis was performed with the use of SPSS statistical analysis software (SPSS Inc, Chicago, IL).

**Simple Bedside Risk Prediction Tool**

The variables that were significantly associated with in-hospital mortality in the multivariable analyses were assigned a score equal to their coefficients in the fitted model (natural logarithm of their odds ratios [ORs] rounded to the nearest decimal). The sum of this numeric score could then be used to predict the operative mortality in individual patients. A risk prediction tool that plotted the risk score against the corresponding predicted death rate was developed to assist surgeons who are considering whether to proceed with surgical correction in high-risk patients.

**Results**

**Patient Characteristics**

A total of 1034 patients with ABAD were included for this study (673 men; mean age, 63.5±14.0 years). Common comorbidities included history of hypertension (80.5%), atherosclerosis (32.3%), known aneurysm (19.7%), and prior cardiac surgery (18.9%; Table 1). Medical therapy was received by 65.4% of the patients compared with 10.3% of patients who received surgical and 23.3% of those who received endovascular treatment (Table 2). Of the 241 patients treated in an endovascular manner, 183 underwent thoracic stent graft placement, 38 underwent aortic fenestration, and 64 patients had branch vessel stent placement, resulting in 42 patients receiving multiple interventions. Overall mortality was 10.6% of all patients with ABAD.

**Table 1. Demographics and Patient History of All Patients With Type B Aortic Dissection**

<table>
<thead>
<tr>
<th>In-Hospital</th>
<th>Survived n (%)</th>
<th>Died n (%)</th>
<th>Odds Ratio</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>History</td>
<td>1034 (100)</td>
<td>924 (89.4)</td>
<td>110 (10.6)</td>
<td></td>
</tr>
<tr>
<td>Mean age, y</td>
<td>63.5±14.0</td>
<td>63.0±13.9</td>
<td>67.8±14.6</td>
<td>1.42 (1.22–1.82)</td>
</tr>
<tr>
<td>Age ≥70 y</td>
<td>371 (59.9)</td>
<td>315 (49.6)</td>
<td>50 (30.9)</td>
<td>2.00 (1.35–2.98)</td>
</tr>
<tr>
<td>Sex (female)</td>
<td>363 (35.1)</td>
<td>323 (35.0)</td>
<td>40 (36.4)</td>
<td>1.06 (0.71–1.60)</td>
</tr>
<tr>
<td>History of hypertension</td>
<td>818 (80.5)</td>
<td>735 (80.8)</td>
<td>83 (78.3)</td>
<td>0.86 (0.56–1.40)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>84 (8.5)</td>
<td>75 (8.5)</td>
<td>9 (8.7)</td>
<td>1.02 (0.49–2.11)</td>
</tr>
<tr>
<td>Marfan</td>
<td>34 (3.4)</td>
<td>31 (3.5)</td>
<td>3 (2.9)</td>
<td>0.82 (0.25–2.73)</td>
</tr>
<tr>
<td>Atherosclerosis</td>
<td>320 (32.3)</td>
<td>283 (31.9)</td>
<td>37 (35.6)</td>
<td>1.18 (0.77–1.81)</td>
</tr>
<tr>
<td>Known aneurysm</td>
<td>196 (19.7)</td>
<td>174 (19.5)</td>
<td>22 (21.0)</td>
<td>1.09 (0.67–1.80)</td>
</tr>
<tr>
<td>Family history of aortic disease</td>
<td>50 (12.4)</td>
<td>47 (12.8)</td>
<td>3 (8.1)</td>
<td>0.99 (0.55–1.80)</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td>53 (12.3)</td>
<td>49 (12.7)</td>
<td>4 (9.3)</td>
<td>0.71 (0.58–3.66)</td>
</tr>
<tr>
<td>Chronic renal insufficiency</td>
<td>44 (10.2)</td>
<td>38 (9.8)</td>
<td>6 (13.6)</td>
<td>1.45 (0.24–2.07)</td>
</tr>
<tr>
<td>Prior cardiac surgery</td>
<td>184 (18.9)</td>
<td>167 (19.3)</td>
<td>17 (16.0)</td>
<td>0.80 (0.46–1.38)</td>
</tr>
</tbody>
</table>
The clinical presentation of ABAD in aortic dissection is known to have a great impact because it drives management and affects patient outcome.\textsuperscript{1,2,9} Our study identified several clinical variables that are associated with increased risk of in-hospital mortality, and we provided a simple risk prediction tool that can be used at presentation to make a careful decision regarding management and patient counseling.

Despite the fact that a majority of patients with ABAD have a vatable outcome with medical treatment alone, our study showed that about one third of all patients required intervention, with an overall ABAD mortality of 10.6%. Interventions are reserved for complicated ABAD (eg, patients with aortic rupture, visceral ischemia, extension of dissection, refractory pain/hypertension) because recent randomized controlled trials have shown that despite increased aortic remodeling, thoracic endovascular aortic repair does not lead to improved survival of patients with uncomplicated ABAD at 2 years of follow-up.\textsuperscript{1,4} Not surprisingly, surgical patients had the worst outcome among the ABAD cohort (22.6% mortality, compared with 11.2% after endovascular treatment and 8.6% for patients treated medically). However, the difference in mortality rates is likely related to a selection bias, because patients treated with endovascular management may have had less catastrophic complications than surgical patients. Recent studies have demonstrated that thoracic endovascular aortic repair in complicated ABAD has low early mortality and an acceptable rate of neurological complications, emphasizing the benefits of such therapy.\textsuperscript{11–14} However,
comparison of the different surgical techniques remains challenging, because patients prone to develop complications in the long-term (ie, patients with connective tissue disease and young patients) might benefit from open surgical repair in the long-term. Unfortunately, randomized controlled trials comparing endovascular and surgical therapies in complicated ABAD have not yet been performed. Therefore, a patient-specific approach, including an estimated in-hospital mortality based on our model, might help in the decision making regarding the preferred treatment. Most importantly, providing a more accurate prognosis for the individual patient with ABAD could be helpful for physicians, patients, and their families. Furthermore, a risk model might be useful to assess benefits from novel therapies, because risk-adjusted outcome estimates can be used to better stratify for different subgroups of patients with ABAD.

This study demonstrated several clinical variables that significantly predicted in-hospital mortality in patients with ABAD, including advanced age, syncope, hypotension/shock, spinal cord ischemia, mesenteric ischemia, acute renal failure, periaortic hematoma, and limb ischemia, supporting the validity of current clinical practice. Early intervention is the preferred treatment to minimize ischemic time, and often it is the only option to provide a reasonable chance of survival in these patients. However, each of these complications may justify nonintervention in these patients in the case of advanced age or extensive pre-existing comorbidities because their prognosis is dismal. In addition, patients presenting with descending aortic diameter ≥5.5 cm also tended to have worse outcomes. This finding, together with the previously mentioned complications, has therapeutic implications because current guidelines state that an intervention should be performed in the presence of complications or when aortic diameter reaches 5.5 cm to prevent rupture.15 Most interestingly, we found, in contrast with our previous report, that none of the presenting symptoms (eg, the absence of chest/back pain) had significant influence on in-hospital mortality. It was then suggested that these patients lacked the ability to report pain because of the presence of severe complications such as coma/altered consciousness, mesenteric ischemia, syncope, and hypovolemic shock. Our current evaluation may support this hypothesis by showing that these complications are independent predictors of mortality as separate inclusions in the model. Other important symptoms such as refractory pain and hypertension, which are considered risk factors for adverse events and therefore indications for operation, were not evaluated in this model because they may develop over days rather than at presentation.

**Bedside Risk Prediction Tool for In-Hospital Mortality**

In the present study, we developed a simple risk prediction tool that incorporates the most important variables at presentation associated with mortality. This model proved to be relatively accurate in predicting risk of death in patients with ABAD and can be used as a bedside tool. This prediction model might assist clinicians in important treatment decisions, especially for invasive treatment options in the individual patient.

<table>
<thead>
<tr>
<th>Complications</th>
<th>Number</th>
<th>In-Hospital</th>
<th>Survived</th>
<th>Died</th>
<th>Odds Ratio</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spinal ischemia</td>
<td>23 (2.5)</td>
<td>17 (2.0)</td>
<td>6 (6.5)</td>
<td>3.34 (1.28–8.68)</td>
<td>0.009</td>
<td></td>
</tr>
<tr>
<td>Mesenteric ischemia/infarction</td>
<td>71 (7.4)</td>
<td>45 (5.2)</td>
<td>26 (26.8)</td>
<td>6.69 (3.90–11.48)</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Acute renal failure</td>
<td>174 (17.9)</td>
<td>134 (15.4)</td>
<td>40 (40.0)</td>
<td>3.67 (2.36–5.70)</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Hypotension</td>
<td>94 (9.7)</td>
<td>37 (4.3)</td>
<td>57 (54.8)</td>
<td>27.21 (16.4–45.2)</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Limb ischemia</td>
<td>91 (9.5)</td>
<td>69 (8.0)</td>
<td>22 (22.4)</td>
<td>3.34 (1.95–5.69)</td>
<td>&lt;0.001</td>
<td></td>
</tr>
</tbody>
</table>

IMH indicates intramural hematoma.
Realistic survival estimates in terms of mortality, especially in high-risk patients, can be of considerable use for counseling patients and their families. In addition, a risk model might also be useful to assess the quality of care and possible benefits from novel therapies. Risk-adjusted outcome estimates can be used to stratify for different subgroups of patients with ABAD in future studies.

IRAD offers insight into this relatively uncommon life-threatening disease. Although most studies focus on single-center experiences with certain therapies, these analyses included the largest unselected consecutive patient cohort up-to-date. Regardless of their clinical status or treatment strategy, all patients with ABAD were included in this study, making it possible to generalize these findings for all patients with ABAD presenting at the emergency department.

The results of our study should not be generalized for patients with chronic dissection or those with connective tissue disorders. We evaluated only in-hospital mortality, which is the most important outcome but does not reflect the full scale of outcome variables, such as nonfatal events, patient functional status, and long-term outcomes. In addition, the model and risk scores need to be validated in an independent population. Therefore, additional studies are needed to address the best therapeutic approaches for specific complications to further optimize short-term and long-term outcomes.

**Conclusions**

The clinical presentation of ABAD is heterogeneous and strongly predicts in-hospital results. Our study identified several variables associated with increased in-hospital mortality, including advanced age, syncope, hypotension/shock, spinal cord ischemia, mesenteric ischemia, acute renal failure, periaortic hematoma, limb ischemia, and descending aortic diameter ≥5.5 cm. We provided a useful bedside risk prediction tool that can assist physicians in their choice of management and can help in counseling of patients and their families.

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**Disclosures**

None.

**References**


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