Cardiovascular Surgery

Sensitivity of the Aortic Dissection Detection Risk Score, a Novel Guideline-Based Tool for Identification of Acute Aortic Dissection at Initial Presentation

Results From the International Registry of Acute Aortic Dissection

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Background—In 2010, the American Heart Association and American College of Cardiology released guidelines for the diagnosis and management of patients with thoracic aortic disease, which identified high-risk clinical features to assist in the early detection of acute aortic dissection. The sensitivity of these risk markers has not been validated.

Methods and Results—We examined patients enrolled in the International Registry of Acute Aortic Dissection from 1996 to 2009. The number of patients with confirmed acute aortic dissection who presented with 1 or more of 12 proposed clinical risk markers was determined. An aortic dissection detection (ADD) risk score of 0 to 3 was calculated on the basis of the number of risk categories (high-risk predisposing conditions, high-risk pain features, high-risk examination features) in which patients met criteria. The ADD risk score was tested for sensitivity. Of 2538 patients with acute aortic dissection, 2430 (95.7%) were identified by 1 or more of 12 proposed clinical risk markers. With the use of the ADD risk score, 108 patients (4.3%) were identified as low risk (ADD score 0), 927 patients (36.5%) were intermediate risk (ADD score 1), and 1503 patients (59.2%) were high risk (ADD score 2 or 3). Among 108 patients with no clinical risk markers present (ADD score 0), 72 had chest x-rays recorded, of which 35 (48.6%) demonstrated a widened mediastinum.

Conclusions—The clinical risk markers proposed in the 2010 thoracic aortic disease guidelines and their application as part of the ADD risk score comprise a highly sensitive clinical tool for the detection of acute aortic dissection. (Circulation. 2011;123:2213-2218.)

Key Words: aorta • aortic dissection • risk factors • risk score • screening

A
cute aortic dissection (AD), among the most lethal of cardiovascular catastrophes, is suspected at initial evaluation in fewer than half of patients ultimately diagnosed with the disease.1–5 Although multiple factors undoubtedly complicate early and accurate identification of the acute AD patient, principal among them is a signal-to-noise phenomenon.

Clinical Perspective on p 2218

The incidence of acute AD in the United States is estimated at 10 000 cases annually, whereas emergency department visits are ≈100 000 000 during the same time period.6–8 Accordingly, a single case of acute AD would be expected in only 1 in 10 000 emergency department presentations. This relatively weak signal is easily overwhelmed by the background noise of patients presenting with complaints that could, but do not, represent acute AD. To accurately identify all cases of acute AD, the clinician must consider the diagnosis in patients presenting not only with chest pain, but also with back pain, abdominal pain, syncope, or complaints related to a perfusion deficit including stroke, myocardial infarct, limb ischemia, and mesenteric ischemia.9 Furthermore, accurate identification or exclusion of the disease requires an advanced imaging study. If every patient presenting with symptoms that might represent AD were imaged, the cost and radiation exposure would be prohibitive.
Recently, the American Heart Association, American College of Cardiology, and other professional societies published guidelines for the diagnosis and management of thoracic aortic disease (TAD).\textsuperscript{10} Included in the guidelines is a risk assessment tool that was developed on the basis of an extensive review of the literature on acute AD combined with the collective experience of the writing committee. The aortic dissection detection (ADD) risk score was adapted from this tool to provide clinicians with a simple, systematic method for screening large volumes of patients at the bedside. By focusing on specific high-risk predisposing conditions, pain features, and physical examination findings, patients are grouped into 1 of 3 categories on the basis of their pretest risk of acute AD. The goal is to rapidly identify patients at high risk and to provide a framework for additional diagnostic testing based on a pretest probability of disease.

Because this guideline-based tool has not been validated in a clinical setting, it is not known whether it will effectively identify patients with a high probability of acute AD. The purpose of the present study is to apply the ADD risk score to the International Registry of Acute Aortic Dissection (IRAD) database to determine the percentage of this group of patients with diagnosed AD that would have been identified.

Methods

The IRAD database is a multinational registry designed to provide a representative population of patients with acute AD. Treatment during the index hospitalization or in follow-up was not standardized, but at the discretion of each patient’s treating physician. Full details of the IRAD methods have been published previously.\textsuperscript{4} All sites have institutional review board approval to participate in IRAD.

Study Population

We examined data on all patients with acute AD enrolled in IRAD centers between January 1, 1996, and December 31, 2009 (24 centers). Acute AD was defined as any nontraumatic dissection within 14 days of symptom onset. Patients were identified prospectively at presentation or retrospectively via discharge diagnoses, imaging, and hospital databases. Diagnosis was based on imaging, surgical visualization, or autopsy.

Data Collection

Data on 290 variables were recorded on a standardized form that included information on patient demographics, history, clinical presentations, physical findings, imaging study results, details of medical and surgical treatment, and patient outcomes, including mortality. Data forms were reviewed for internal consistency and validity and then scanned electronically into a Microsoft Access database.

Imaging was interpreted at each patient’s respective tertiary care center by specialized radiologists and echocardiographers and entered into the data form. Helical computed tomography, transesophageal echocardiography, magnetic resonance imaging, and/or angiography was obtained. Data contained in IRAD are identical to those reported to the physicians caring for the patients.

Statistical Analysis

We assessed the presenting characteristics of patients with confirmed acute AD to evaluate the sensitivity of the TAD guideline diagnostic algorithm. High-risk clinical markers that were tested include the following: history of Marfan syndrome, family history of aortic disease, history of known aortic valve disease, history of recent aortic manipulation, history of known thoracic aortic aneurysm, abrupt onset of pain, severe pain intensity, ripping or tearing pain, pulse deficit or systolic blood pressure differential between extremities, focal neurological deficit (in conjunction with pain), new murmur of aortic insufficiency (in conjunction with pain), and hypotension or shock state. After determining the frequency of each individual risk marker among patients with acute AD, we aggregated the risk markers into 3 categories (high-risk predisposing conditions, high-risk pain features, and high-risk examination features) on the basis of the algorithm proposed in the TAD guidelines (Figure 1).

We assigned an ADD risk score of 0, 1, 2, or 3 to patients on the basis of the number of categories in which at least 1 risk marker was present. The sensitivity of each clinical risk marker, risk category, and ADD risk score was calculated.

In all cases, missing data were defaulted to negative, which should bias toward a conservative estimate of sensitivity. Bivariate analysis was performed with the use of $\chi^2$ analysis or 2-sided Fisher exact tests where appropriate to identify clinical features more commonly present in patients not identified by the algorithm. PASW version 18.0.1 (SPSS Inc) was used for all analyses.

Results

Of 2538 patients with acute AD, 2430 (95.7%) were identified by 1 or more of 12 proposed clinical risk markers, whereas 2123 (83.6%) had at least 2 clinical risk markers present. A large percentage of patients (46.4%) had either 3 or 4 risk markers identified at the time of presentation (Table 1).

High-risk pain features, such as abrupt onset of pain (79.3%), severe intensity of pain (72.7%), and pain described as ripping or tearing (21.7%) were most frequently present in patients with acute AD. The most common high-risk predisposing conditions identified were known thoracic aortic aneurysm (14.7%) and known aortic valve disease (11.9%), whereas the most common high-risk examination features included a new murmur of aortic insufficiency in conjunction with pain (23.6%) and a pulse deficit or systolic blood pressure differential between extremities (20.3%) (Table 2).

Among the 3 risk categories, 713 patients (28.1%) had at least 1 of the high-risk predisposing conditions present, 2220 patients (87.5%) had at least 1 of the high-risk pain features present, and 1294 patients (51.0%) had at least 1 of the high-risk examination features present (Figure 2). With the use of an ADD risk score of 0 to 3 based on the number of risk categories for which criteria were met, 108 patients (4.3%) scored 0 and would have been considered low risk, 927 patients (36.5%) scored 1 and would have been considered intermediate risk, and 1503 patients (59.2%) scored 2 or 3 and would have been considered high risk (Figure 2).

Among 927 patients (36.5%) with an intermediate risk score of 1, high-risk pain features, including abrupt onset of pain (72.0%) and severe pain intensity (68.5%) were most commonly identified (Table 3). Cases of AD were identified with each of the 12 clinical risk markers present in isolation.

Of the 108 patients (4.3% of total population) with no clinical risk markers present (ADD risk score 0), 72 had chest x-rays recorded, of which 35 (48.6%) were noted to have a widened mediastinum (Figure 2). Compared with patients identified by the algorithm, those 108 not identified were more frequently of nonwhite race (23.5% versus 12.0%; $P=0.001$), had a history of diabetes mellitus (12.9% versus 5.9%; $P=0.006$), and presented as normotensive (49.4% versus 36.8%; $P=0.017$), whereas they less frequently presented with chest pain (40.5% versus 77.6%; $P<0.001$), back pain (24.1% versus 54.5%; $P<0.001$), head or neck pain (5.3% versus 18.1%; $P=0.001$), leg pain (3.8% versus 12.8%; $P=0.008$), radiating pain (12.7% versus 38.9%;
P<0.001), or with a history of prior cardiac surgery (8.4% versus 17.6%; P=0.020). Patients not identified by the algorithm were more frequently enrolled in the IRAD database from US hospitals compared with European hospitals (6.0% versus 2.5%; P<0.001).

Discussion
The diagnostic algorithm proposed in the TAD national guidelines is highly sensitive (95.7%) for the detection of acute AD at initial presentation. The ADD risk score was adapted from this diagnostic algorithm to provide clinicians...
Table 1. Number of Patients With Acute Aortic Dissection Presenting With 1 or More Clinical Risk Markers (n=2538)

<table>
<thead>
<tr>
<th>No. of Risk Markers</th>
<th>No. of Patients</th>
<th>Percentage of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>108</td>
<td>4.3</td>
</tr>
<tr>
<td>1</td>
<td>307</td>
<td>12.1</td>
</tr>
<tr>
<td>2</td>
<td>666</td>
<td>26.2</td>
</tr>
<tr>
<td>3</td>
<td>750</td>
<td>29.6</td>
</tr>
<tr>
<td>4</td>
<td>426</td>
<td>16.8</td>
</tr>
<tr>
<td>5</td>
<td>187</td>
<td>7.4</td>
</tr>
<tr>
<td>6</td>
<td>79</td>
<td>3.1</td>
</tr>
<tr>
<td>7</td>
<td>15</td>
<td>0.6</td>
</tr>
<tr>
<td>Total</td>
<td>2538</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 2. Number of Patients With Acute Aortic Dissection Identified by Each Clinical Risk Marker (n=2538)

<table>
<thead>
<tr>
<th>Risk Marker</th>
<th>No. of Patients</th>
<th>Percentage of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>01: Marfan syndrome</td>
<td>110</td>
<td>4.3</td>
</tr>
<tr>
<td>02: Family history of aortic disease</td>
<td>48</td>
<td>1.9</td>
</tr>
<tr>
<td>03: Known aortic valve disease</td>
<td>303</td>
<td>11.9</td>
</tr>
<tr>
<td>04: Recent aortic manipulation</td>
<td>70</td>
<td>2.8</td>
</tr>
<tr>
<td>05: Known thoracic aortic aneurysm</td>
<td>374</td>
<td>14.7</td>
</tr>
<tr>
<td>06: Abrupt onset of pain</td>
<td>2012</td>
<td>79.3</td>
</tr>
<tr>
<td>07: Severe pain intensity</td>
<td>1845</td>
<td>72.7</td>
</tr>
<tr>
<td>08: Ripping or tearing pain</td>
<td>551</td>
<td>21.7</td>
</tr>
<tr>
<td>09: Pulse deficit or SBP differential</td>
<td>515</td>
<td>20.3</td>
</tr>
<tr>
<td>10: Focal neurological deficit (in conjunction with pain)</td>
<td>273</td>
<td>10.8</td>
</tr>
<tr>
<td>11: Murmur of aortic insufficiency (new in conjunction with pain)</td>
<td>599</td>
<td>23.6</td>
</tr>
<tr>
<td>12: Hypotension or shock state</td>
<td>407</td>
<td>16.0</td>
</tr>
</tbody>
</table>

SBP indicates systolic blood pressure.
existing or novel biomarker to further risk stratify patients identified as intermediate risk by the ADD risk score. Conceptually, this approach is somewhat analogous to the way in which Wells criteria and D-dimer testing combine to identify a low-risk population that does not require definitive radiological testing to rule out pulmonary embolism. Analyses including the recent International Registry of Acute Aortic Dissection Substudy on Biomarkers (IRAD-Bio) offer preliminary evidence to suggest that D-dimer may have relevance in patients with acute AD as well. Further study is warranted to investigate whether D-dimer or another biomarker could complement the ADD risk score in the initial triage of patients with suspected acute AD.

**Conclusion**

The clinical risk markers proposed in the 2010 TAD guidelines and their application as part of the ADD risk score comprise a highly sensitive clinical tool for the detection of acute AD.

**Sources of Funding**

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**Disclosures**

Dr Froehlich reports the following conflicts: consultant: Pfizer, Sanofi-aventis; Speakers Bureau: Pfizer, Sanofi-aventis, Merck; contracted research: Blue Cross/Blue Shield of Michigan, Mardigian Foundation, Fibromuscular Disease Society of America. Dr Eagle
reports the following conflicts: grant/research support: Gore Inc, Hewlett Foundation, Mardigan Fund, Verbedian Fund; consultant: National Institutes of Health/National Heart, Lung, and Blood Institute. The other authors report no conflicts.

References

CLINICAL PERSPECTIVE
Acute aortic dissection is known to be an underrecognized condition at presentation, yet the mortality associated with delayed or missed diagnosis is substantial. The American Heart Association, American College of Cardiology, and other professional societies recently published the 2010 thoracic aortic disease guidelines, which include recommendations for the initial bedside screening of at-risk patients. The goal of these recommendations is to improve physician recognition and facilitate prompt diagnostic testing in those at risk. In our study, we modified this guideline-based screening tool to define the aortic dissection detection risk score, which divides patients into low-, intermediate-, and high-risk groups on the basis of historical and examination features. We then tested the aortic dissection detection risk score for sensitivity among 2538 patients enrolled in the International Registry of Acute Aortic Dissection. Our results indicate that the aortic dissection detection risk score is 95.7% sensitive for the detection of acute aortic dissection and may help to facilitate prompt evaluation if applied at the bedside. Additional studies are needed to determine the specificity of the aortic dissection detection risk score and provide prospective validation.

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김용진 교수 서울대학교병원 순환기내과

Summary

배경
2010년 미국심장협회 가이드라인에서는 급성 대동맥박리중의 빠른 진단을 돕기 위하여 고위험인을 선별할 수 있는 위험지표들을 제시하였다. 하지만 이 위험지표들의 민감도는 아직 검증된 바 없다.

방법 및 결과
1996-2009년까지 International Registry of Acute Aortic Dissection(IRAD)에 포함된 환자들을 대상으로 하였다. 급성 대동맥박리중으로 확진된 환자 중 가이드라인에서 제시한 12개의 위험지표를 나타낸 환자의 수를 분석하였다. 그리고 각 환자에서 대동맥박리중 진단(aortic dissection detection, ADD) 위험스코어를 계산하였다. 급성 대동맥박리증이 있었던 2,538명의 환자 중 2,430명(95.7%)이 임상적 위험지표 12개 중 1개 이상에 합당한 소견을 보였다. ADD 위험스코어를 사용하였을 때, 108명(4.3%)은 낮은 위험도(ADD 스코어 0), 927명(36.5%)은 중간 위험도(ADD 스코어 1), 1,501명(59.2%)에 이르는 낮은 위험도(ADD 스코어 2)를 보였다.

결론
2010년 가이드라인에서 제시된 임상적 위험지표와 ADD 위험스코어는 급성 대동맥박리중 진단에 높은 민감도를 보였다.
Commentary

실험결과에서 가장 지명적인 절단 중 하나인 급성 대동맥박리증은 초기에는 절단 정도의 환자에서만 암성적인
심장병과 함께 일정한 전단적 검사가 이루어질 정도로 임
상적 심장병과 전단이 어려운 질환이다. 미국에서 급성 대
동맥박리증의 발생 건수는 연간 10,000건 정도이다. 하
지만, 연간 응급실 내원 환자는 100,000,000명을 넘기
따라서 신속적으로 응급실을 방문하는 환자 10,000명
당 1명에서 급성 대동맥박리증이 발생한다고 볼 수 있
다. 이렇게 도달할 시간이 반면, 특이증상이 있기 때
문에 진단이 어려움이 있다고 한다. 즉, 모든 급성 대동
맥박리증 환자는 가능하면 정확하게 진단하기 위해서는
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uled in Table 1. The number of patients with ADD with different conditions is summarized as follows:

<table>
<thead>
<tr>
<th>Condition</th>
<th>No. of Patients</th>
<th>Percentage of Parents</th>
</tr>
</thead>
<tbody>
<tr>
<td>01: Marfan syndrome</td>
<td>110</td>
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<td>05: Known thoracic aortic aneurysm</td>
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<td>14.7</td>
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</table>
| 06: Abru
g onset of pain              | 2012            | 79.3                  |
| 07: Severe pain intensity              | 1845            | 72.7                  |
| 08: Rippling or tearing pain           | 551             | 21.7                  |
| 09: Pulse deficit or SBP differential  | 515             | 20.3                  |
| 10: Focal neurological deficit (with pain) | 273            | 10.8                  |
| 11: Murmurt or aortic insufficiency (with pain) | 599         | 23.6                  |
| 12: Hypotension or shock state         | 407             | 16.0                  |
에서 95.7%의 환자에서 오랜 또는 높은 위험도를 보여 일관된 유용한 지표로 생각된다. 하지만 본 연구는 몇 가지 제한점을 갖는데, 우선 이 연구는 대동맥박리증 등록사업에 의해 확진된 환자만을 대상으로 하였으므로 비전단의 사례로 발생하여 제대로 진단되지 못한 환자들이 모두 제외되었을 것이다. 비정형적인 임상양상을 보이는 환자에서는 ADD 스코어의 유효성이 드러날 것이라는 것은 쉽게 점죄할 수 있다. 또한, ADD 위험스코어가 임상적으로 유용하게 활용되어야 만성도뿐 아니라 희귀도도 중요하다. 본 연구결과로 ADD 스코어는 대동맥박리증이 있는 거의 모든 환자를 발견해낼 수 있는 매우 에용한 방법이라는 것은 알 수 있지만, 희귀도는 알 수 없다. 희귀할에서 많은 수의 환자를 대상으로 추가적인 영상검사를 여부를 결정하려면 실제적으로 희귀도가 매우 중요하므로, 이에 대한 추가적인 연구가 필요하다고 한다.

Figure 1. 대동맥박리증의 평가 순서도