Routine Helical Computed Tomographic Evaluation of the Mediastinum in High-Risk Blunt Trauma Patients

Demetrios Demetriades, MD; Hugo Gomez, MD; George C. Velmahos, MD; Juan A. Asensio, MD; James Murray, MD; Edward E. Cornwell III, MD; Kathleen Alo, RN; Thomas V. Berne, MD

Background: The indications and method of evaluation of the mediastinum in blunt deceleration trauma are controversial and vary among centers. Most centers practice a policy of angiographic evaluation only in the presence of an abnormal mediastinum on chest radiography. Routine aortography in the absence of any mediastinal abnormality is not widely practiced. Helical computed tomographic (CT) scan has been successfully used in recent studies in the evaluation of the thoracic aorta.

Objective: To determine the role of routine helical CT scan evaluation of the mediastinum in patients involved in high-speed deceleration injuries, irrespective of chest radiographic findings.

Design: A prospective study over a 1-year period. Included in the study were patients with high-speed deceleration injuries who required CT evaluation of the head or abdomen. This group of patients underwent routine helical CT evaluation of the mediastinum irrespective of chest radiographic findings.

Setting: Large, urban, academic level I trauma center.

Results: A total of 112 trauma patients fulfilled the criteria for study inclusion. Overall, there were 9 patients (8.0%) with aortic rupture. Four (44.4%) of these patients had a normal mediastinum on the initial chest x-ray film and the diagnosis was made by CT scan. The CT scan was diagnostic in 8 of the aortic ruptures (intimal tear or pseudoaneurysm) and was suggestive of aortic injury but not diagnostic in 1 patient with brachiocephalic artery injury. In 42 patients (37.5%), there was a widened mediastinum: an aortic rupture was diagnosed in 5 of them (11.9%) and a spinal fracture in 9 (21.4%). One patient had both aortic rupture and spinal injury.

Conclusions: The incidence of aortic injury in patients with high-speed deceleration injury is high. A significant proportion of patients with aortic injury have a normal mediastinum on the initial chest radiograph. There is a high incidence of spinal injuries in the presence of a widened mediastinum. We recommend that all trauma patients with high-risk deceleration injuries undergo routine helical CT evaluation of the mediastinum irrespective of chest radiographic findings.

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THE INDICATIONS and technique for evaluation of the mediastinum in patients with severe multiple trauma are still controversial and vary among centers and surgeons. Some recommend routine aortographic evaluation irrespective of chest radiographic findings. Others practice a policy of angiography only in the presence of an abnormal mediastinum on plain radiography. More recently, some reports suggested a liberal use of helical computed tomographic (CT) scan, either as a triage tool for selecting patients for angiography or for definitive evaluation. In the present study, we investigated the value of routine mediastinal evaluation of patients involved in high-speed deceleration injuries irrespective of radiographic findings.

RESULTS

From October 1996 through October 1997, 112 patients with blunt trauma fulfilled the criteria for inclusion for the study. Sixty patients (53.6%) were involved in a high-speed car crash, 26 (23.2%) were pedestrians involved in high-impact automobile collisions, and 26 (23.2%) fell from a height of more than 4.5 m. Most of the patients (78 patients [69.6%]) were male and the mean age was 39.8 years (range, 3-85 years). The admission systolic blood pressure was 90 mm Hg or less in 9 pa-
PATIENTS AND METHODS

This prospective study was performed at the Los Angeles County+University of Southern California Medical Center, a large academic level I trauma center, during a 1-year period. Included in the study were patients with blunt trauma with any of the following mechanisms of injury: (1) motor vehicle crash at greater than 56 km per hour, (2) falls of greater than 4.5 m, and (3) automobile hitting pedestrian with pedestrian thrown more than 3 m. The patients were evaluated and resuscitated according to Advance Trauma Life Support protocols and they all required a CT scan of the head and/or abdomen or spine or pelvis as part of their evaluation. If the patient required an emergency procedure because of hemodynamic instability, the CT evaluation was performed postoperatively.

Computed tomographic examinations were performed with a helical scanner (model 2000, Picker, Cleveland, Ohio) by certified technologists and were supervised by radiology residents, fellows, and staff. Computed tomographic scans of the head were performed first without intravenous contrast. The chest CT scan was then performed after injection of nonionic contract medium. The chest was evaluated from the base of the neck to the diaphragm. The CT scan reports were classified as follows: (1) normal mediastinum and normal aorta, (2) mediastinal hematoma with normal aorta, (3) definite aortic injury (extravasation or dissection), and (4) nondiagnostic study suggestive of aortic injury.

If the CT revealed aortic injury in the first 7 months of the study, a confirmation aortogram was performed. In the following 5 months, the aortic repair was performed without aortography. With CT scan findings of a normal aorta, no aortography was performed irrespective of the presence or absence of a mediastinal hematoma. Aortography was reserved only for nondiagnostic CT studies suggestive of aortic abnormalities.

Sixty-six patients (58.9%) had a chest injury (32 patients had rib fractures, 28 had hemothorax, 32 had lung contusions, 6 had scapular fractures, 6 had clavicular fractures, and 4 had sternal fractures). Overall, 82 patients (73.2%) had fractures, including long bones (n = 36), pelvis (n = 16), and spine (n = 12). Eighteen patients (16.1%) did not have any significant injury.

All patients had a supine chest film obtained in the emergency department. In 42 (37.5%) of them, the mediastinum was judged by the attending trauma surgeon to be widened. The CT scan, and in some cases angiographic evaluation, of these patients with widened mediastinum revealed aortic rupture in 5 (11.9%) and a splenic fracture in 9 (21.4%). One patient had both aortic rupture and spinal fracture. In 4 patients, the CT scan showed a mediastinal hematoma secondary to sternal, clavicular, or upper rib fractures. In 18 patients (42.9%) with a widened mediastinum, there was no chest abnormality (no fractures or hemothorax).

Overall, 9 patients (8.0%) had an aortic rupture. Epidemiological, clinical, and radiological characteristics of these 9 patients are given in the Table. The CT scan was diagnostic of aortic injury in 8 of them. In 1 patient with intimal tear of the brachiocephalic artery, the CT scan cuts did not include the injured area and, although the CT scan was reported as being suggestive of a local hematoma, the vascular injury itself was not seen. Angiography revealed an intimal tear. In the remaining 8 patients, the CT scan showed clearly a false aneurysm and/or intimal tear. In 5 patients, the CT diagnosis was confirmed by aortography. In the remaining 3 patients, aortic repair was successfully performed without angiographic confirmation. The sensitivity of plain films in diagnosing aortic injuries was 55.5%, the specificity was 64.1%, and the accuracy was 63.4%. The sensitivity of helical CT in diagnosing or suspecting aortic injuries was 100%, the specificity was 95.1%, and the accuracy was 95.5%.

Overall, aortography was performed in 17 patients (15.2%). This intervention was reserved for patients with associated severe pelvic fractures (6 patients) or in patients whose CT scan was suggestive of an aortic abnormality (11 patients). In 6 (35.3%) of the 17 aortograms, there was an aortic injury, and all of them were diagnosed or suspected on CT scan. Five patients with a CT scan suggestive of abnormality did not have an aortic injury. In another 6 patients, angiographic embolization of pelvic (5 patients) or hepatic bleeding (1 patient) was successfully performed.

In addition to the 9 aortic injuries that were diagnosed preoperatively, during the 1-year period, there were another 10 patients who arrived at the hospital in extremis or dead and a thoracotomy performed in the emergency department or the autopsy revealed aortic rupture. Three (30%) of these patients had associated thoracic spine fracture.

The incidence of aortic rupture following high-speed deceleration injuries varies significantly in various series and depends on the criteria for inclusion in the study.

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population. In an autopsy study of 530 motor vehicle fatalities, aortic injury was found in 90 victims (17%). In a prospective study of 155 injured patients involved in high-speed crashes (>96 km per hour), falls greater than 6 m, pedestrian collisions with vehicles moving faster than 32 km per hour, and motor vehicle crashes in which there was a fatality, Durham et al performed routine aortography and found aortic injury in 9%. Garant et al, in a retrospective study of 3229 patients with “nontrivial blunt chest trauma” who underwent helical CT screening, found aortic injuries in 38 patients (1.2%). In the present study, chest trauma who underwent helical CT screening, found aortic injuries in 38 patients (1.2%). In the present study, we used criteria similar to those of Durham et al and found a similar incidence (8%) of aortic injury. The real incidence of blunt aortic rupture can only be estimated if a combined autopsy and clinical study with routine mediastinal evaluation is performed in a single geographical area, and such a study does not exist.

Most patients with traumatic aortic injury die at the scene and are never admitted to any hospital. Those patients reaching a trauma center alive are a self-selected group with minor or contained ruptures. The first few hours after admission can be critical because many contained injuries may rupture and cause rapid death. Early diagnosis and treatment of these patients is critical for a good outcome.

Aortography has been the criterion standard for many years in the evaluation of the thoracic aorta after a blunt trauma. However, there have been many concerns about the use of aortography as a routine investigation for all patients with a suspected deceleration injury. Besides being a major invasive, time-consuming, and expensive investigation with a very low yield, there are other logistical and clinical concerns. Routine use of this procedure may overwhelm busy hospitals and interfere with the care of other patients. An even more important concern is the potential risk of subjecting a severe multitrauma patient to a low-yield, time-consuming investigation, away from the optimal environment of the resuscitation room, the intensive care unit, or the operating room. Critical monitoring and urgent therapeutic procedures may be delayed with serious consequences.

Although some centers advocate liberal use of angiography for all patients with a history of significant deceleration blunt trauma regardless of clinical or chest radiographic findings, most others practice a policy of selective angiographic evaluation on the basis of mechanism of injury and the chest radiographic findings. It is currently a widespread policy to perform aortography only in the presence of an abnormal mediastinum. However, with such a policy there is a significant risk of missing many aortic injuries.

It has been shown that an aortic rupture may be present without any mediastinal abnormality on chest radiography. In a review of 52 articles with 656 patients with aortic or brachiocephalic artery injuries, the mediastinum was normal in 73% of the patients. In another multicenter study of 274 patients with traumatic aortic rupture, Fabian et al reported similar figures. It is likely that the real figures are higher because many patients with normal mediastinum and aortic rupture were never screened and were missed. In the present study where routine CT evaluation of the mediastinum was performed irrespective of chest radiographic findings, one third of the patients with aortic rupture had a normal mediastinum on chest radiography.

With the above concerns about the role of routine use of angiography in mind, other diagnostic alternatives such as CT scan and transesophageal echocardiogram have been suggested. The ideal investigation should be fast, noninvasive, reliable, and readily available. In the past 15 years, many authors studied the role of chest CT in selecting patients who would benefit from angiography or even eliminate angiography completely. Although some studies supported the use of CT scan in high-risk patients, many others were critical and reported poor results. In a meta-analysis of 18 studies in the English-language literature for 1983 through 1995, Mirvis et al reported a sensitivity of 97.0% for aortic injury and 99.3%

### Epidemiological, Clinical, and Radiological Characteristics in 9 Patients With Aortic Rupture*

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Mechanism of Injury</th>
<th>Age, y</th>
<th>GCS Score</th>
<th>Systolic BP on Admission, mm Hg</th>
<th>Mediastinal Width, cm</th>
<th>Findings on Chest X-ray Film</th>
<th>CT Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Auto vs ped</td>
<td>60</td>
<td>13</td>
<td>100</td>
<td>8.0</td>
<td>Fractured clavicle, sternum, multiple bilateral ribs</td>
<td>Intimal flap</td>
</tr>
<tr>
<td>2</td>
<td>MVC</td>
<td>80</td>
<td>14</td>
<td>80</td>
<td>6.7</td>
<td>Multiple rib fractures, left hemithorax, fractured scapula</td>
<td>Intimal flap</td>
</tr>
<tr>
<td>3</td>
<td>MVC</td>
<td>26</td>
<td>6</td>
<td>120</td>
<td>8.5</td>
<td>Normal</td>
<td>Aortic disruption</td>
</tr>
<tr>
<td>4</td>
<td>MVC</td>
<td>66</td>
<td>9</td>
<td>107</td>
<td>7.0</td>
<td>Normal</td>
<td>Aortic disruption, intimal flap</td>
</tr>
<tr>
<td>5</td>
<td>MVC</td>
<td>23</td>
<td>15</td>
<td>134</td>
<td>6.5</td>
<td>Normal</td>
<td>Aortic disruption, intimal flap</td>
</tr>
<tr>
<td>6</td>
<td>MVC</td>
<td>55</td>
<td>6</td>
<td>130</td>
<td>9.0</td>
<td>Rib fractures</td>
<td>As chest x-ray film, periaortic hematoma, lung contusion</td>
</tr>
<tr>
<td>7</td>
<td>Auto vs ped</td>
<td>29</td>
<td>13</td>
<td>105</td>
<td>8.5</td>
<td>Rib fractures, left hemithorax</td>
<td>As chest x-ray film, periaortic hematoma, lung contusion, and aortic disruption</td>
</tr>
<tr>
<td>8</td>
<td>MVC</td>
<td>31</td>
<td>14</td>
<td>150</td>
<td>11.5</td>
<td>Rib fractures, bilaterally, clavicle fracture, bilateral hemithorax</td>
<td>As chest x-ray film, periaortic hematoma, lung contusion, and aortic disruption</td>
</tr>
<tr>
<td>9</td>
<td>MVC</td>
<td>50</td>
<td>13</td>
<td>90</td>
<td>7.0</td>
<td>Left apical cap</td>
<td>Upper mediastinal hematoma</td>
</tr>
</tbody>
</table>

* GCS indicates Glasgow Coma Scale; BP, blood pressure; CT, computed tomographic; auto vs ped, automobile hitting pedestrian; and MVC, motor vehicle crash.
for mediastinal hemorrhage and a specificity of 99.8% and 87.1%, respectively. The authors suggested that all patients with a mechanism of injury suggestive of aortic injury should undergo a chest CT evaluation and supplementary angiographic evaluation should be reserved only for patients with CT findings of periaortic, middle, or superior mediastinal hemorrhage. The authors concluded that patients with CT findings of only anterior or only posterior mediastinal hemorrhage need no angiography if the contour of the thoracic aorta appears normal. However, other series reported disappointing results with chest CT scans and suggest a very limited role. Durham et al. in a prospective study of 155 patients who underwent both CT scan and aortography, concluded that chest CT scan is observer dependent and therefore not reliable. Miller et al. reported a CT scan sensitivity of 55% and a specificity of 65% in the diagnosis of major thoracic arterial injury and concluded that aortography had the advantage of additional quality of life at minimal cost when used as a screening method for all patients with blunt chest trauma and that with a normal initial chest radiograph the chest CT was associated with increased cost and loss of quality-adjusted life.

All studies that reported poor results used conventional CT scans. The development of the new helical CT scans in the early 1990s has revolutionized trauma radiology with its speed and superior definition. Mixing results obtained with conventional and helical scans may lead to false conclusions. The role of this new technology in the evaluation of suspected aortic injuries has been examined in a few studies with uniformly excellent results. It has been suggested that helical CT scan of the chest can replace transcatheter aortography in most patients and that aortography should be reserved only for patients with indeterminate or abnormal CT studies. Garant et al. suggested that if they had used these criteria for angiographic evaluation, 67% of all the angiographic examinations in their study could have been avoided.

At our trauma center, aortography has largely been replaced by helical CT scan of the mediastinum in the evaluation of the aorta in patients with a mechanism of injury suggestive of aortic abnormality, irrespective of findings on the initial chest radiography. As shown in the present series, one third of our patients with an aortic rupture did not have any mediastinal abnormality. In the group of patients with a widened mediastinum, CT evaluation may be useful in evaluating not only the aorta but also the spine. Spinal fractures may be the cause of a widened mediastinum. In our study, 21.4% of the 42 patients with a widened mediastinum had a spinal fracture (1 patient had both aortic and spinal injury). In another patient, the CT scan showed that the widened mediastinum on chest radiography was due to a sternal fracture with retrosternal hematoma. This patient avoided aortography. Persons involved in high-speed deceleration accidents almost always require CT evaluation of the head or abdomen. Addition of a chest CT scan prolongs the evaluation process by only a few minutes as compared with the time-consuming angiography.

There has been some concern that a CT scan may miss intimal tears of the aorta. There is evidence that the helical scan identifies such tears, perhaps as accurately as aortography. In the study by Garant et al., the helical CT scan was more sensitive than aortography (100% vs 94.4%) in the detection of aortic injuries. Like angiography, helical CT scan may be indeterminate in certain conditions, such as in the presence of prominent vessels adjacent to the aorta or atheromatous plaques that may mimic intimal flaps, or small ductus diverticula that may mimic a pseudoaneurysm. Supplementary aortography is recommended in these indeterminate cases. New 3-dimensional CT reconstruction may be helpful in these patients. Another potential limitation of the helical scan is detection of injuries to the great vessels of the aortic arch. Although injuries to the origin of these vessels should be obvious on CT scan, more distant injuries may not

Figure 1. Widened mediastinum on chest radiography. The computed tomographic scan shows a fracture of the sternum with a retrosternal hematoma. Aortography was avoided.
be seen, but they should be suspected by the presence of a local hematoma. Such a finding should be evaluated by angiography. In the present study, 1 patient fell in this category.

It has been a widespread practice to perform preoperative aortography in patients with a confirmed aortic injury on CT scan. Such practice is probably not necessary in most patients. Three patients in the present study were operated on without any angiographic studies (Figure 2 and Figure 3).

Although many authors, including ourselves, are enthusiastic about the role of helical CT in the evaluation of patients with potential aortic injuries, many others remain skeptical. The definitive answer could come from a large multicenter study in which all patients with deceleration injuries undergo both helical CT and angiographic evaluation. Trerotola estimated that assuming 98% negative predictive value, with 90% statistical power, about 1500 subjects would be needed to perform such a study. In our opinion, such study may be scientifically valid but ethically we would be very hesitant subjecting all patients with high-speed deceleration injury to routine aortography.

In summary, we believe that all patients with a mechanism of injury suggestive of potential aortic injury should undergo CT evaluation of the mediastinum, irrespective of chest radiographic findings. We suggest that aortography can be replaced by helical mediastinal CT scan in most of the patients. Angiography should be reserved only for patients whose CT scan is indeterminate or those with severe pelvic fractures, where angiography may have therapeutic value.

Corresponding author: Demetrios Demetriades, MD, PhD, Department of Surgery, Healthcare Consultation Center, University of Southern California, 1510 San Pablo St, Suite 514, Los Angeles, CA 90033 (e-mail: demetria@hsc.usc.edu).

REFERENCES