Plain-Film Criteria for Excluding Aortic Rupture in Blunt Chest Trauma

Kenneth E. Marnocha[1]
Dean D. T. Maglinte[1,2]

Emergency room supine chest films of 86 consecutive patients with blunt chest trauma and possible aortic rupture were reviewed. Sixteen radiographic signs were analyzed independently and in combination. Only two signs associated with aortic rupture were statistically significant: deviation of the nasogastric tube to the right at the T4 level and depression of the left main-stem bronchus below 40° from the horizontal. False positives and false negatives occurred with each individual radiographic sign. However, if the aortic knob and contour appeared normal and the trachea and nasogastric tube were not deviated, no case was found of aortic rupture in 4 consecutive years of experience. These four signs can be used to exclude the diagnosis of aortic rupture in patients with blunt chest trauma.

Previous reports have suggested various findings on the plain chest radiograph to be signs of aortic rupture in patients with blunt chest trauma. Signs reported include widening of the mediastinum, blurring of the aortic knob or contour, hemothorax, rib fractures, tracheal shift to the right, left apical cap, depression of the left main-stem bronchus below 40°, nasogastric tube displacement to the right, pneumothorax, pulmonary contusion, widened left paraspinous line, and abnormal mediastinal width–chest width (M/C) ratio [1–13]. Other reports point out the lack of reliability of these signs, citing false negatives and false positives with each radiographic sign [14–21].

Since rupture of the thoracic aorta is a highly lethal injury, with only 7%–16% of patients surviving 24 hr, rapid diagnosis and prompt surgical intervention is mandatory [22–25]. The lack of a highly sensitive and specific plain radiographic finding in suspected aortic rupture makes decisions concerning the need for arteriography or other imaging methods difficult. Some authors recommend that arteriography is indicated in all patients with a history of blunt chest trauma, regardless of the clinical or plain-film findings [26, 27]. Previous reports have focused on the positive diagnosis of aortic rupture from the plain film. Our study was undertaken to identify reliable criteria on chest radiographs that could be used to exclude aortic rupture.

Materials and Methods

The chest radiographs of 86 consecutive patients admitted to Methodist Hospital of Indiana, Indianapolis, in a 4 year period with blunt chest trauma and suspected aortic rupture were analyzed separately and in combination using the Fisher exact test. Sixteen radiographic signs were reviewed by both authors for each case without knowledge of arteriographic findings nor clinical outcome. Consensus was reached by discussion of differing initial interpretations. The arteriograms, surgical records, and clinical follow-ups were then reviewed. Seventy-three patients had no evidence of aortic rupture on aortography or, in three cases, surgical exploration. Thirteen had aortic rupture at the aortic isthmus; all were confirmed surgically.

All chest films analyzed were anteroposterior (AP) supine with a 100 cm focal-film distance, 75 kVp and 2–3 mAs, which is our standard emergency room portable technique. For this

Received April 24, 1984; accepted after revision July 13, 1984.

[1] Department of Radiology, Methodist Hospital of Indiana, P.O. Box 1367, Indianapolis, IN 46202. Address reprint requests to K. E. Marnocha.

[2] Department of Radiology, Indiana University School of Medicine, Indianapolis, IN 46202.

AJR 144:19–21, January 1985
0361–803X/85/1441–0019

study 8 cm was considered to be the maximal normal mediastinal width, and all cases with a measurement greater than 8 cm were recorded as positive. Nasogastric tube and tracheal displacement were considered positive if their left lateral walls were positioned to the right of the T4 spinous process on a nonrotated film. Depression of the left main-stem bronchus was judged positive if the bronchus was greater than 40° below the horizontal. The aortic knob and the contour of the descending aorta were evaluated separately for distinctness and ability to clearly see the outline. Only if the aortic knob or contour of the descending aorta was not seen or was blurred was the sign recorded as positive. All clearly defined ectatic aortas were considered negative. Widening of the left paravertebral stripe was recorded as positive if the left paravertebral stripe was greater than one-half the width of the descending thoracic aorta. The M/C ratio was measured by dividing the width of the mediastinum by the chest width at the level of the aortic arch [11]. Slightly overpenetrated chest films aided greatly in determining the positions of the left paravertebral stripe, trachea, and left main-stem bronchus, as well as aiding in the determination of the other mediastinal signs and measurements.

Results

Ten signs were not statistically significant in predicting aortic rupture: M/C ratio ($p = 0.63$), right pneumothorax ($p = 0.35$), left pneumothorax ($p = 0.23$), right hemothorax ($p = 0.17$), left hemothorax ($p = 0.34$), right rib fractures ($p = 0.28$), left rib fractures ($p = 0.20$), lung contusion ($p = 0.23$), widened mediastinum ($p = 0.15$), and widened left paravertebral stripe ($p = 0.13$).

Six signs approached statistical significance ($p \leq 0.05$) when analyzed individually: nasogastric tube deviation ($p = 0.0002$), left main-stem bronchus depression ($p = 0.0025$), tracheal deviation ($p = 0.01$), left apical cap ($p = 0.01$), loss of aortic contour ($p = 0.04$), and loss of aortic knob ($p = 0.06$).

Because analysis of these separate radiographic signs consists of multiple tests, each performed at $p = 0.05$, the experiment-wise error rate (i.e., the probability that one or more of the tests reached statistical significance by chance alone) is actually much higher than $p = 0.05$. To keep the experiment-wise error rate at $p = 0.05$, a new alpha (α) level was used. The formula, $\alpha^* = \alpha/K$, provides this new experiment-wise level, where α^* = experiment-wise alpha level, $\alpha = 0.05$, and K = the number of variables analyzed (in this report, 16). Thus, a new α^* level of 0.003 is calculated. Using this criterion, aortic rupture is significantly associated with only two signs used individually: nasogastric tube deviation and depression of the left main-stem bronchus.

When combinations of signs were analyzed, four signs were found to be useful: (1) nasogastric tube deviation, (2) tracheal deviation, (3) loss of the aortic knob, and (4) loss of the aortic contour. If all four signs were negative our results showed a 0% chance of aortic rupture. Furthermore, all but one patient with aortic rupture, in whom nasogastric tubes were present, had at least three of the four signs identified as positive. There were also four patients who had normal aortograms and clinical follow-up in whom three of the four signs were positive.

Discussion

The patient with blunt chest trauma and suspected aortic rupture poses a serious diagnostic challenge. Clinical findings are nonspecific and positive in at best 45% of cases [19, 28, 29]. Thus, chest-film findings have been sought to detect aortic rupture. Previous reports have indicated that many signs may be used to strongly suspect aortic rupture [1–13], but few reports have focused on eliminating patients from consideration for further diagnostic testing on the basis of plain-film findings.

TABLE 1: **Chest-Film Findings in Patients with Blunt Chest Trauma**

Radiographic Sign	Rupture ($n = 13$)		No Rupture ($n = 73$)	
	True Positive	False Negative	False Positive	True Negative
Nasogastric tube displacement*	5	2	3	49
Depressed left main-stem bronchus†	5	7	4	67
Tracheal displacement‡	5	6	8	64
Left apical cap	8	5	18	55
Loss of aortic contour	12	1	47	26
Loss of aortic knob	11	2	42	31
Mediastinal/chest ratio > 0.25	13	0	72	1
Right pneumothorax	2	11	6	67
Left pneumothorax	2	11	4	69
Right hemothorax	0	13	10	63
Left hemothorax	5	8	21	52
Right rib fractures	1	12	14	59
Left rib fractures	6	7	22	51
Lung contusion	5	8	17	56
Wide mediastinum	11	2	48	25
Widened left paravertebral stripe§	2	3	4	35

* Twenty-seven patients did not have a nasogastric tube.
† In three patients the location of the left main-stem bronchus could not be assessed accurately.
‡ In three patients rotation prevented accurate determination of tracheal position.
§ In 39 patients the paravertebral stripe could not be assessed accurately.

After correcting for the experiment-wise error rate, only two signs in this series of 86 consecutive trauma patients could be said to be associated with the positive diagnosis of aortic rupture: nasogastric tube deviation and depression of the left main-stem bronchus. Even with these two signs, however, there were both false negatives and false positives. Two false-negative and three false-positive cases of nasogastric tube deviation were seen. There were seven false-negative and four false-positive cases when examining depression of the left main-stem bronchus. In fact, false negatives and false positives occurred with each of the 16 radiographic signs analyzed (table 1).

Since our current analysis and that of previous authors have found individual radiographic signs to be nonspecific for the positive diagnosis of aortic rupture [14–21], and clinical reports advocate arteriography for all patients with blunt chest trauma [26, 27], we attempted to establish criteria for excluding aortic rupture on the basis of plain-film findings.

On the basis of our findings, we suggest this approach to the patient with blunt chest trauma. In critically injured patients, stabilization with central venous lines for fluid and drug administration, a nasogastric tube to decompress the stomach, an endotracheal tube if necessary for ventilatory assistance, and other tubes and lines as necessary are priorities when the patient reaches the emergency room. In patients

with blunt chest trauma and suspected aortic rupture, a chest film is obtained after nasogastric tube insertion and initial stabilization. If the nasogastric tube and trachea are not deviated and the aortic knob and contour are normal, aortic rupture is unlikely and further evaluation of the thoracic aorta is unnecessary. An overpenetrated chest film aids greatly in evaluating the aortic knob and contour as well as the other mediastinal signs. A second radiograph may be obtained with less penetration for detection of subtle pulmonary parenchymal abnormalities.

Patients with severe hypotension and chest films demonstrating nasogastric tube or tracheal deviation and abnormal mediastinal contours might be considered for immediate surgery without an arteriogram. The delay in obtaining an arteriogram may be too long if the patient is hemodynamically very unstable and does not have an obvious external site of massive blood loss or a grossly bloody peritoneal tap. It should be remembered, however, that even with three of the four, and even all four, signs positive, there will be some patients without aortic rupture. If possible, an aortogram should be obtained for confirmation. A normal aortic knob and contour and the absence of deviation of the nasogastric tube and trachea excluded aortic rupture in our experience, and thus consideration for aortography can be eliminated.

ACKNOWLEDGMENTS

We thank John Woods for statistical analysis; Methodist Hospital emergency room; our radiologic, surgical, and clinical colleagues who helped in this study; and Fran Shaul for secretarial assistance.

REFERENCES

1. Attar S, Ayella RJ, McLaughlin JS. The widened mediastinum in trauma. *Ann Thorac Surg* **1972**;13:435–449
2. Symbas PN, Tyras DH, Ware RE, Diorio DA. Traumatic rupture of the aorta. *Ann Surg* **1973**;178:6–12
3. Turney SZ, Attar S, Ayella RJ, Cowley RA, McLaughlin JS. Traumatic rupture of the aorta: a five-year experience. *J Thorac Cardiovasc Surg* **1976**;72:727–732
4. Marsh DG, Sturm JT. Traumatic aortic rupture: roentgenographic indications for aortography. *Ann Thorac Surg* **1976**;21:337–340
5. McHduft JB, Foster ED, Alley RD. Traumatic aortic rupture: an additional roentgenographic sign. *Ann Thorac Surg* **1977**;24:77–79
6. Tisnado J, Tsai FY, Als A, Roach JF. A new radiographic sign of acute traumatic rupture of the thoracic aorta: displacement of the nasogastric tube to the right. *Radiology* **1977**;125:603–608
7. Plume S, DeWeese JA. Traumatic rupture of the thoracic aorta. *Arch Surg* **1979**;114:240–243
8. Avery JE, Hall DP, Adams JE, Headrick JR, Nipp RE. Traumatic rupture of the thoracic aorta. *South Med J* **1979**;72:1238–1240
9. Simeone JF, Deren MM, Cagle F. The value of the left apical cap in the diagnosis of aortic rupture. *Radiology* **1981**;139:35–37
10. Phillips EH, Rogers WF, Gaspar MR. First rib fractures: incidence of vascular injury and indication for angiography. *Surgery* **1981**;89:42–47
11. Seltzer SE, D'Orsi C, Kirshner R, DeWeese IA. Traumatic aortic rupture: plain radiographic findings. *AJR* **1981**;137:1011–1014
12. Sturm JT, Olson FR, Cicero JJ. Chest roentgenographic findings in 26 patients with traumatic rupture of the thoracic aorta. *Ann Emerg Med* **1983**;12:598–600
13. Woodring JH, Loh FK, Kryscio RJ. Mediastinal hemorrhage: an evaluation of radiographic manifestations. *Radiology* **1984**; 151:15–21
14. Gerlock AJ, Muhletaler CA, Coulam CM, Hayes PT. Traumatic aortic aneurysm: validity of the esophageal tube displacement sign. *AJR* **1980**;135:713–718
15. Cole DC, Knopp R, Wales LR, Morishima MS. Nasogastric tube displacement to the right as a sign of acute traumatic rupture of the thoracic aorta. *Ann Emerg Med* **1981**;10:623–626
16. Fisher RG, Ward BE, Ben-Menachem Y, Maltox KL, Flynn TC. Arteriography and the fractured first rib: too much for too little? *AJR* **1982**;138:1059–1062
17. Livoni JP, Barcia TC. Fracture of the first and second rib: incidence of vascular injury relative to type of fracture. *Radiology* **1982**;145:31–33
18. Gundry SR, Williams S, Burney RE, MacKenzie JR, Cho KJ. Indications for aortography. Radiography after blunt chest trauma: a reassessment of the radiographic findings associated with traumatic rupture of the aorta. *Invest Radiol* **1983**;18:230–237
19. Barcia TC, Livoni JR. Indications for angiography in blunt thoracic trauma. *Radiology* **1983**;147:15–19
20. Sefczek DM, Sefczek RJ, Deeb ZL. Radiographic signs of acute traumatic rupture of the thoracic aorta. *AJR* **1983**;141:1259–1262
21. Marnocha KE, Maglinte DDT, Woods J, Goodman M, Peterson P. Mediastinal-width/chest-width ratio in blunt chest trauma: a reappraisal. *AJR* **1984**;142:275–277
22. Parmley LF, Mattingly TW, Manion WC, Jahnke EJ Jr. Nonpenetrating traumatic injury of the aorta. *Circulation* **1958**;17:1086–1101
23. Greendyke RM. Traumatic rupture of the aorta. *JAMA* **1966**;195:527–530
24. Bennett DE, Cherry JK. Natural history of traumatic aneurysms of the aorta. *Surgery* **1967**;61:516–623
25. Symbas PN, Tyres DH, Ware RE, et al. Rupture of the aorta: a diagnostic triad. *Ann Thorac Surg* **1973**;15:405–410
26. DeMeules JE, Cramer G, Perry JF. Rupture of the aorta and great vessels due to blunt thoracic trauma. *J Thorac Cardiovasc Surg* **1971**;61:438–442
27. Kirsh MM, Behrendt DM, Orringer BM, et al. The treatment of acute traumatic rupture of the aorta: a ten year experience. *Ann Surg* **1976**;184:303–316
28. Kirsh MM, Crane JD, Kahn DR, et al. Roentgenographic evaluation of traumatic rupture of the aorta. *Surg Gynecol Obstet* **1970**;131:900–904
29. Gundry SR, Williams S, Burney RE, Cho KJ, MacKenzie JR. Indications for aortography in blunt thoracic trauma: a reassessment. *J Trauma* **1982**;22:664–671