The mediastinum—Is it wide?

C E Gleeson, R L Spedding, L A Harding, M Caplan

Abstract

Objective—To determine if the 8 cm upper limit for mediastinal width applies in the trauma setting of today. To define the upper limit of normal mediastinal width for supine chest films.

Methods—A retrospective review of chest computed tomography scans was conducted to determine the width and position of the mediastinum within the supine chest. Radiographs were performed using a model that enabled the degree of mediastinal magnification to be ascertained in a variety of clinical settings.

Results—The mean mediastinal width is 6.31 cm. With standard radiographical techniques this mediastinum is magnified to 8.93–10.07 cm. With minor adaptations in radiographical technique this can be reduced to 7.31–7.92 cm.

Conclusion—The 8 cm upper limit for normal mediastinal width, set in the 1970s does not apply in the modern trauma room. Changes in the position of the x ray cassette, and lengthening of the distance between the patient and the x ray source will significantly reduce magnification. A new range of upper limits is defined for the radiographical techniques possible in different trauma settings.

(Emerg Med J 2001;18:183-185)

Keywords: mediastinum; radiography

Evaluation of mediastinal width on a supine chest film is now a standard part of the initial assessment of the trauma patient.¹⁻³ In some cases of mediastinal widening, it is clear that the mechanism of injury and the condition of the patient should lead to further investigation. This may include contrast computed tomography (CT), transoesophageal echocardiography and definitive arch aortography.⁴⁻⁶ Interpretation is a diagnostic challenge when the mediastinum appears wide, the patient is well and the mechanism of injury is unlikely to have caused a traumatic rupture of the thoracic aorta.

Studies in the 1970s suggested an upper limit for mediastinal width of 8 cm–8.8 cm.^{7,8} Since then trauma management has changed and therefore radiographic techniques have had to adapt.

It is our intention to discover whether these historical upper limits still apply and if not, to define new upper limits.

Methods

To ascertain the width of the normal mediastinum and its position within the supine chest, we conducted an 18 month retrospective review of chest CT scans of white adults. Scans

Figure 1 CT scan of the chest at the level of the aortic arch.

where pathology distorted the mediastinum were excluded. The remaining scans were then examined at the level of the maximum diameter of the aortic arch to determine:

- (1) The composition and transverse diameter of the mediastinum at this level.
- (2) The maximum width of the aortic arch.
- (3) The distance from the anterior surface of the aortic arch to the skin of the posterior chest wall. (The position to which the aortic arch gravitates in the supine chest).

The images were obtained on an Elscint Twin II Helical scanner and stored on optical disk. The measurements were taken directly from the screen using an electronic cursor (fig 1). Two perpendicular lines from the edges of the object enabled measurement to be confirmed at two points. At the completion of the series, accuracy was confirmed by re-measuring every fifth scan.

Having obtained these figures, we were able to look at magnification in various simulated clinical settings.

Magnification is dependent on the:

- (1) Focus to film distance (FFD). The distance from the x ray source (focus) to the x ray film (fig 2).
- (2) Object to film distance (OFD). The distance between the object—that is, the mediastinum—and the x ray film (fig 2).

As FFD is increased, the x ray beams become more parallel and magnification is minimised. If OFD is increased, divergence of the x ray beams produces greater magnification of the object—that is, the mediastinum.

Using wood, sponge and a commercially available x ray measuring tool, we assembled a model. This enabled us to change the components of the OFD. The following factors were studied:

- (1) Equipment variables—the depth of the long spinal board, the depth of the mattress and the distance to the trolley's x ray tray.
- (2) Patient variables—mediastinal depth and patient weight. Volunteers with weights varying from 50–90 kg lay supine on a long

**Accident and
Emergency,
Warrington Hospital
NHS Trust,
Warrington**

Correspondence to:
Dr Gleeson,
25 The Village Gate,
Dalkey, Co Dublin, Ireland

Accepted for publication
19 June 2000

Figure 2 How changing the FFD and OFD influences magnification.

Table 1 Components of the mediastinum

Aorta and:	
SVC	197
SVC and brachiocephalic	63
SVC and brachiocephalic and innominate	5
Brachiocephalic	10
Three or more vessels	7
Total	282

spine board. The resultant compression of the mattress, beneath the board, was measured to accurately calculate the effect on OFD.

Once the above were quantified radiographs were taken using FFDs of 100, 140, and 180 cm.

We then looked at the effect these variables had on the magnification of a range of mediastinal widths. The geometry was then verified against the verified formula for magnification.⁹ Magnification = FFD/FFD-OFD.

Results

In the 18 month study period, 343 chest CT scans were reviewed. Altogether 282 (82%) were suitable for inclusion in the study. The other 61 scans were excluded because of pathology in the chest or the abdomen distorting the mediastinum. Data were analysed on a SPSS package.

At the level of the aortic knuckle, the mediastinum contained the aorta and the other great vessels (table 1). In all cases, the superior vena cava (SVC) contributed to the mediastinal width. The biggest contribution was when the SVC lay beside the aorta.

The values for the mediastinal and aortic diameters were normally distributed. The

average aortic diameter was 4.6 cm (SD 0.95). However, the mean mediastinal width was 6.31 cm (SD 0.97).

The anterior surface of the aorta was situated at a mean of 15.89 cm (SD 1.69) from the skin of the posterior chest wall. The average chest diameter was 21.06 cm (SD 2.47).

The average long spinal board depth was 4.5 cm. The distance between the spinal board and the x ray cassette tray beneath six types of commercially available trolley varied between 7.1–12.9 cm.

Table 2 shows how the average 6.31 cm mediastinum is magnified. In the 1970s supine chest radiographs were exposed with 100 cm FFD and the x ray cassette directly beneath the patient. This resulted in the mean mediastinum being magnified to 7.5 cm. Using the same FFD of 100 cm, with the longer OFD commonly used in the modern trauma setting, the average mediastinum is magnified to 9.48 cm.

However, by lengthening the FFD to 140 cm this can be improved to 8.29 cm. Further improvement can be achieved by placing the x ray cassette beneath the spinal board—that is, shortening the OFD. The resultant mediastinal image is narrowed to 7.38 cm.

Table 3 shows the upper ranges of mediastinal widths. This range of new upper limits is dependent upon the FFD and the differing positions for the x ray cassettes. Using the standard used today of 100 cm FFD and long OFD, the new upper limit for normal mediastinal width in 95% of the population is 12.4 cm. By improving radiographic technique, with a 140 cm FFD and the x ray cassette under the

Table 2 Magnification of the average mediastinum (6.31 cm) in various clinical settings

FFD (cm)	x ray cassette placement			
	Beneath patient	Beneath spinal board	Beneath shallow trolley	Beneath deep trolley
100	7.5 (7.17–7.89)*	7.95 (7.56–8.33)	8.7 (8.26–9.21)	9.48 (8.93–10.07)
140	7.12 (6.9–7.36)	7.38 (7.31–7.92)	7.86 (7.6–8.15)	8.29 (7.99–8.61)
180	6.92 (6.76–7.10)	7.45 (7.25–7.65)	7.45 (7.25–7.65)	7.75 (7.54–7.96)

*Range relates to chest depth.

Table 3 Magnification of the mediastinum 1 and 2 SD above the mean*

FFD (cm)	x ray cassette placement			
	Beneath patient	Beneath spinal board	Beneath shallow trolley	Beneath deep trolley
100	8.67,9.83	9.18,10.40	10.05,11.39	10.94,12.40
140	8.22,9.32	8.54,9.68	9.08,10.29	9.56,10.84
180	8.0,9.07	8.67,9.32	8.60,9.75	8.94,10.14

*Mediastinum located at the average AP depth within the chest.

spinal board the upper limit is a more reasonable 9.68 cm.

Discussion

The supine chest film is used as a screening tool to detect thoracic aortic rupture (TAR). Many authors have discussed the usefulness of plain film findings.¹⁰⁻¹² None is perfect. In his review, Woodring found that 7.3% of great vessel damage does not result in mediastinal widening.⁶ Other authors have suggested various techniques for improving plain chest radiological interpretation including M/C ratio or a combination of signs.^{13 14} Most include mediastinal width as one of the cardinal signs of TAR. In everyday practice, mediastinal widening is still the most commonly sought after sign. Clinicians will be familiar with the scenario of the chest radiograph revealing an abnormally wide mediastinum. This may be an unexpected finding in a patient who is haemodynamically stable and has not sustained an injury associated with TAR.

The landmark work of Marsh and Sturm, set the upper limit of normal at 8–8.8 cm.^{7 8} At that time trauma management did not routinely include spinal immobilisation. The patient would have been lifted and the x ray cassette placed directly next to the skin, indeed the patient was often sat upright to have their chest radiograph. The FFD varied widely. Since the introduction of ATLS, the patient is now pre-packaged on a long spinal board and placed on a modern trauma trolley, which includes a thick mattress. Radiographic techniques have had to adapt.

The gold standard chest radiograph devised for an erect patient has an FFD of 180 cm.⁹ In the supine trauma patient, this FFD can be rarely obtained, as the focus of the x ray machine cannot be raised high enough above the supine patient. A ceiling suspended system can achieve longer FFDs than a mobile machine, but not the recommended 180 cm.

Other limitations include the height of the trolley and, with a mobile system, the reach of the radiographer.

When placing a x ray cassette directly beneath the supine patient, the OFD consists entirely of the intra-thoracic distance from the mediastinum to the posterior chest wall. This component has been quantified for the first time in this study. The ranges in table 2 illustrate the contribution of this anatomical variable to magnification.

The introduction of the spinal board, the thick mattress and the x ray tray beneath the trolley has lengthened the distance between the x ray cassette and the mediastinum. This longer OFD has increased magnification of all the constituents of the thorax.

The result of all these changes means that for many patients the upper limit of Marsh and Sturm does not apply. To assist AED clinicians, practical options include:

- (1) Using the new upper limit based on traditional radiographic techniques—short

FFD and long OFD (table 3). This results in a greatly magnified mediastinum with limited clinical usefulness.

- (2) Modifying technique to maximise FFD and minimise the non-anatomical component of the OFD. This results in a more useful upper limit (tables 2 and 3).

We realise, as have other authors that TAR can occur within these upper limits and that these figures should not replace clinical suspicion.⁶ But by simple adaptations in radiographic technique, more useful information can be gained from the standard trauma chest radiograph.

In conclusion, using current radiographic techniques, the 8–8.8 cm upper limit for normal mediastinal width does not apply. This study provides clinicians with a range of upper limits applicable to the trauma setting of today. To minimise magnification, we recommend that the x ray plate is placed close to the patient. Ideally this should be directly under the spinal board. The FFD should be the maximum achievable in each AED.

We would like to thank student radiographers Andy England and Nathan de Beer for help with the model, Jackie Johnson (Senior 1 radiographer), the Warrington library staff, the Medical Illustration Department at the Royal Liverpool Hospital and Ann Martin (Senior 1 radiographer) Royal Victoria Hospital Belfast for her help with the pilot study.

Funding: this study was provided with funding by the R&D budget, Warrington Hospital NHS Trust.

Conflicts of interest: none.

Contributors

C E Gleeson collected the data, wrote the paper, and acts as guarantor. R L Spedding had the original idea, wrote the paper and supervised the project. L A Harding supervised radiographic techniques and contributed to writing the paper. M Caplan gave radiology advice and advised on the final draft of the paper.

- 1 Sandor F. Incidence and significance of traumatic mediastinal haematoma. *Thorax* 1967;22:43–62.
- 2 Wyman AC. Roentgenologic diagnosis of traumatic rupture of the thoracic aorta. *Arch Surg* 1953;66:656–63.
- 3 American College of Surgeons Committee on Trauma. *Advanced trauma life support for doctors*. Chicago: American College of Surgeons, 1980.
- 4 Gavatt ML, Menke PG, Fabian T, et al. Blunt traumatic aortic rupture: detection with helical CT of the chest. *Radiology* 1995;197:125–33.
- 5 Salleria S, Lederman E, Fein S, et al. Transoesophageal echocardiography for the initial evaluation of the widened mediastinum in trauma patients. *J Trauma* 1995;39:137–42.
- 6 Woodring JH. The normal mediastinum in blunt traumatic rupture of the thoracic aorta and brachiocephalic arteries. *J Emerg Med* 1990;8:467–76.
- 7 Marsh DG, Sturm JT. Traumatic aortic rupture. roentgenographic indications for angiography. *Ann Thorac Surg* 1976;21:337–40.
- 8 Sturm JT, Marsh DG, Kenton CB. Ruptured thoracic aorta: evolving radiological concepts. *Surgery* 1979;85:363–7.
- 9 Clarke KC. *Positioning in radiography*. Vol 1. 10th ed. London: Heinemann, 1979.
- 10 Sefczek SE, Sefczek RJ, Deeb ZL. Radiographic signs of acute traumatic rupture of the thoracic aorta. *AJR* 1983;141:1259–62.
- 11 Mirvis SE, Bidwell JK, Buddemeyer EU, et al. Value of chest radiography in excluding traumatic aortic rupture. *Radiology* 1987;163:487–93.
- 12 Kram HB, Wohlmuth DA, Appel PL, et al. Clinical and radiographic indications for aortography in blunt chest trauma. *J Vasc Surg* 1987;6:168–76.
- 13 Seltzer SE, D'Orsi C, Kirshner R, et al. Traumatic aortic rupture: plain radiographic findings. *AJR* 1981;137:1011–14.
- 14 Marnocha KE, Maglinte DDT, Woods J, et al. Mediastinal-width/chest-width ratio in blunt chest trauma: a reappraisal. *AJR* 1984;142:275–7.