HEART

Editorial

Imaging the thoracic aorta in the injured patient

In this issue, Absalom and colleagues (from Bury St Edmunds and Papworth) report on the diagnosis and successful surgical repair of aortic disruption in two teenagers with multiple injuries, rescued from the same car.¹ The resuscitation of these patients, the diagnosis and treatment of their many injuries, and their discharge home, one and three weeks after their accident, reveals an exemplary standard of care by the staff of both hospitals.

It is their belief that the availability of transoesophageal echocardiography, and expertise in its use in the district general hospital, was a key factor in the early and correct diagnosis in these cases. While there can be no doubt that transoesophageal echocardiography provided an expeditious and the least invasive method of diagnosis in these cases, is there evidence to support its more general availability?

There have been several studies of the role of transoesophageal echocardiography in the assessment of injured patients. Five studies²⁻⁶ report a total of 25 cases of proven thoracic aortic injury among 296 patients investigated (table). Summarising the data, both sensitivity (88%) and specificity (91%) are high for the combined series, but are they high enough? In the simplest terms, one in 10 cases diagnosed as a disruption would be a false positive, and about one in 10 cases would be missed on the basis of the pooled data. But sensitivity and specificity, although often quoted in studies of this type, have serious deficiencies in describing the efficacy of diagnostic tests.⁷ Studies merit more detailed and critical evaluation if they are to guide us towards the wider availability and use of transoesophageal echocardiography for trauma presenting in the district general hospital, as suggested by Absalom and colleagues.

Sensitivity and specificity, in statistical terms, are independent of prevalence. Sensitivity is the proportion of true positives that are correctly identified by the test; specificity is the proportion of true negatives that are correctly identified.⁷ This would apply if we could assume uniformity of diagnostic skill, that all investigators are on the plateau phase of the learning curve, and that the level of diagnostic suspicion does not influence the interpretation of the image. While one should be able to make such a claim for an established laboratory assay, it is unlikely to hold true

for transoesophageal echocardiography in the acutely ill patient, probably performed out of hours, in the accident department of a district general hospital. I think for that reason the terms are suspect in this context.

It is also worth remembering that where there is a degree of uncertainty, there is an element of choice about where we set our criteria. It is clear from a detailed reading of the cited articles that there were quite a number of such debatable cases. We can decide where we place our decision threshold—that is, whether the uncertain case is counted in or out.⁸ The decisions may be arbitrary for the purpose of a contingency table, and in fact this provides an opportunity to adjust the results to suit the mission statement, but it remains a worrying uncertainty when it is a real test and a real patient. If a test is to be used for screening a population with a low prevalence of a very dangerous condition, the decision threshold is set low so that sensitivity is high, close to 100%. There are more false positives but fewer missed cases. If, however, you are going to act on that test alone, you must set the decision threshold high, for fear of operating and finding a normal aorta after an unnecessary thoracotomy, as happened in one of the reported cases.⁶ The first approach works if we assume that aortography will be available as a confirmatory test, either as a policy or in any case where there remains doubt, or there is time to be more certain. The generally high sensitivity suggests that the test performs well if used in that way. Saletta *et al*'s study⁴ included three patients with negative results on transoesophageal echocardiography who subsequently had aortic disruption proven on aortography or at operation, and all three died. Their experience is out of line with the experience of others but should be noted.

Sensitivity and specificity answer the question from one direction only; if the condition exists, can the test detect or exclude it?⁸ In practice, we have the results of a test and need to know the extent to which we can rely on it. The indices that help us in that respect are positive and negative predictive values. These are dependent on prevalence and the first thing I note from the table is that the prevalence of aortic disruption ranges from 5% to 26% in these studies (although the differences do not reach significance, $\chi^2 = 0.13$). The likely explanation is that case mix of the

Role of transoesophageal echocardiography (TOE) in diagnosing aortic disruption in trauma patients

Reference	TOEs performed	Cases found	Prevalence	True positive	False positive	True negative	False negative	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Karalis <i>et al</i> ²	20	1	5%	1	4	15	0	100%	79%	20%	100%
Brooks <i>et al</i> ³	58	3	5%	3	2	53	0	100%	96%	60%	100%
Saletta <i>et al</i> ⁴	114	8	7%	5	17	89	3	63%	84%	23%	97%
Smith <i>et al</i> ⁵	93	10	11%	10	1	82	0	100%	99%	91%	100%
Sparks <i>et al</i> ⁶	11	3	26%	3	0	8	0	100%	100%	100%	100%
Total	296	25		22	24	247	3	88%	91%	48%	99%

denominator varies between the studies. In the smallest series⁶ the 11 patients were estimated to be only 25% of the cases with severe blunt chest trauma admitted during the time frame of the study. In the two largest studies^{4,5} transoesophageal echocardiography was used in prospectively designed protocols, which presumably recruited not only more patients, but enrolled a group with a lower pretest probability of aortic injury. In one series, a wide mediastinum was the entry criterion (> 8 cm at the level of the aortic knuckle), but evidently on the basis of a supine film because that detail is not specified.⁴ In the other, clinical suspicion on the basis of the nature of the injury was enough to be included.⁵

The patient with multiple trauma suspected to have aortic disruption because of a wide mediastinum, or for any other reason, is a very difficult problem. It is a much feared condition and the very mention of it may cause the attending doctors to be unable to focus on anything else until the matter is resolved.⁹ Under these circumstances a test that reliably excludes aortic rupture, so that we can get on with the care of the other aspects of management, is a godsend. If the negative predictive value is high, then we can be confident that we are missing very few cases.⁷ Transoesophageal echocardiography had 100% negative predictive value in four of the five series. That seems to be its strength. If available, it can be performed at the bedside and is the least disruptive of the possible diagnostic tests. I use the word disruptive consciously. One anxiety is that it may precipitate rupture but that was not recorded in any of the studies and the safety record of transoesophageal echocardiography is excellent.^{10,11}

The alternative that has been suggested is computed tomography.^{12,13} The limitation that I anticipate is that computed tomography may confirm the haematoma but leave us unsure about the integrity of the aorta itself.⁹ Computed tomography is an excellent investigation for aortic dissection that propagates along the aorta and will be seen on one cut after another,^{14,15} but aortic transection is a transverse lesion, with little length. In Raptopoulos *et al.*'s study,¹³ in which eight of the 127 patients who underwent computed tomography were diagnosed as having aortic disruption, the positive predictive value was 21% (eight cases in 39 positive scans). None of the 88 cases in whom computed tomography was negative had transection so the negative predictive value in that study was 100%.

I have one lingering doubt about the enthusiasm for transoesophageal echocardiography in trauma patients. We know that most cases die at the roadside, before ever reaching hospital. We also know that there are some long term survivors. I have had two patients with a small, completely stable, calcified bulge in the aorta, and a story of a

terrible crash 20 and 25 years earlier. After several years of monitoring both remain unoperated. It is at least possible that some of the flaps and intimal tears described in the papers on transoesophageal echocardiography were not destined to rupture. Even if surgery might have been advised, it would have been better to have been deferred if there were other major injuries. We rarely dare to do that, but the less sensitive tests may have left them undiscovered. On the other hand, over the years we may have compromised survival more by rushing patients with multiple injuries to cardiac centres for aortograms that turn out to be negative, than the lives saved by the operations performed in those that were diagnosed. If transoesophageal echocardiography provides a reliably negative test, on site, which allows the trauma team to look after the whole patient rather than feel obliged to concentrate on the aorta, then transoesophageal echocardiography will be a lifesaver. The ability of transoesophageal echocardiography to diagnose aortic disruption when present is supported by the high sensitivity in the literature and by Absalom and colleague's report.

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