Diagnostic Accuracy of Transesophageal Echocardiography, Helical Computed Tomography, and Magnetic Resonance Imaging for Suspected Thoracic Aortic Dissection

Systematic Review and Meta-analysis

Toshiya Shiga, MD, PhD; Zen'ichiro Wajima, MD, PhD; Christian C. Apfel, MD, PhD; Tetsuo Inoue, MD, PhD; Yoko Ohe, MD, PhD

Background: Patients with suspected thoracic aortic dissection require early and accurate diagnosis. Aortography has been replaced by less invasive imaging techniques including transesophageal echocardiography (TEE), helical computed tomography (CT), and magnetic resonance imaging (MRI); however, accuracies have varied from trial to trial, and which imaging technique should be applied to which risk population remains unclear. We systematically reviewed the diagnostic accuracy of these imaging techniques in patients with suspected thoracic aortic dissection.

Methods: Published English-language reports on the diagnosis of thoracic aortic dissection by TEE, helical CT, or MRI were identified from electronic databases. Sensitivity, specificity, and positive and negative likelihood ratios were pooled in a random-effects model.

Results: Sixteen studies involving a total of 1139 patients were selected. Pooled sensitivity (98%-100%) and specificity (95%-98%) were comparable between imaging techniques. The pooled positive likelihood ratio appeared to be higher for MRI (positive likelihood ratio, 25.3; 95% confidence interval, 11.1-57.1) than for TEE (14.1; 6.0-33.2) or helical CT (13.9; 4.2-46.0). If a patient had shown a 50% pretest probability of thoracic aortic dissection (high risk), he or she had a 93% to 96% posttest probability of thoracic aortic dissection following a positive result of each imaging test. If a patient had a 5% pretest probability of thoracic aortic dissection (low risk), he or she had a 0.1% to 0.3% posttest probability of thoracic aortic dissection following a negative result of each imaging test.

Conclusion: All 3 imaging techniques, ie, TEE, helical CT, and MRI, yield clinically equally reliable diagnostic values for confirming or ruling out thoracic aortic dissection.

Arch Intern Med. 2006;166:1350-1356

THE MORTALITY RATE ASSOciated with thoracic aortic dissection is high[1] and has recently been reported to rise by 1% to 1.4% per hour when a patient remains untreated, leading to a 68% mortality rate within 48 hours.[2,3] The mortality rate is highest in patients with type A dissection (involving the ascending aorta) and has been reported to be 58% without but still 26% with surgical treatment.[1] Conversely, the mortality rate for patients with type B dissection is lower, but more importantly, patients treated medically have an 11% lower mortality rate than those treated surgically, for which it is reported to be 31%.[1] Therefore, early and accurate diagnosis and decision making regarding surgical or conservative intervention are essential to reduce morbidity and mortality among patients with clinically suspected thoracic aortic dissection.

Beginning in the 1960s, aortography was used as a standard tool for assessing patients with clinically suspected thoracic aortic dissection. However, the technique is invasive, costly, potentially nephrotoxic owing to contrast materials and ionized radiation, and time consuming, sometimes causing diagnostic delays.[2] More importantly, the diagnostic accuracy of aortography is not as high as originally thought. According to a European cooperative study, sensitivity and specificity for the diagnosis of aortic dissection are 88% and 94%, respectively.[4]

Over the last 2 decades, aortography has been used less frequently, as noninvasive imaging techniques including transesophageal echocardiography (TEE), helical

Author Affiliations: Department of Anesthesiology, Toho University Ohashi Medical Center, Tokyo, Japan (Drs Shiga and Ohe); Department of Anesthesia, Nippon Medical School Chiba Hokusoh Hospital, Chiba, Japan (Drs Wajima and Inoue); and Department of Anesthesia and Preoperative Care, University of California at San Francisco (Dr Apfel).

computed tomography (CT), or magnetic resonance imaging (MRI) have emerged. Use of these imaging techniques tends to be based on availability at local hospitals, the degree of emergency, or whether they can be used in combination with another technique,[3] but cumulative data on the diagnostic accuracy of each of these techniques remain limited and have varied from trial to trial. In addition, which imaging technique should be applied to which risk population remains unclear. We, therefore, have systematically reviewed the diagnostic accuracy of each of these imaging techniques in patients with suspected thoracic aortic dissection.

METHODS

STUDY SELECTION AND QUALITY ASSESSMENT

We searched MEDLINE (January 1980 through August 2005) and the Cochrane Library (2005, issue 3) for reports of studies and trials related to the method used to diagnose thoracic aortic dissection. Only English-language articles were included. The initial search terms were "thoracic aortic dissection," "transesophageal echocardiography (TEE)," "helical CT" (or "spiral CT"), and "magnetic resonance imaging (MRI)." A manual search of references cited in published reports and reviews was also performed.

Reports were independently selected and reviewed by 2 investigators (T.S. and Z.W.). The systematic review process for selection of eligible studies is shown in **Figure 1**. Reported studies were selected if they met the following criteria: (1) the study was prospective; (2) at least 1 imaging technique was used; (3) absolute numbers of true-positive, false-negative, true-negative, and false-positive results were available or could be derived from the published data; and (4) the reference standard for diagnosing thoracic aortic dissection was clearly indicated. We excluded retrospective studies, studies with insufficient data, and studies that did not focus on thoracic aortic dissection but rather focused on thoracic aortic disease in general.

Studies were graded for quality according to the modification of a priori criteria, as described by Romagnuolo et al[5]: (1) blinding; (2) consecutive recruitment of patients; and (3) single (vs composite) reference standards.

DATA EXTRACTION

We defined the presence of aortic dissection as the presence of 2 vascular lumens separated by an intimal flap within the aorta, as in most studies included in the review. We defined surgical, autopsy, or angiographic findings as the reference standard for thoracic aortic dissection, as in most studies included in the review. Extracted from the reports were the number of patients, mean age, general patient characteristics, diagnostic criteria for aortic dissection, the reference standard, onset and types of dissection, system-specific settings, and absolute numbers of true-positive, false-positive, true-negative, and false-negative results.

DATA SYNTHESIS

We calculated pooled estimates of sensitivity, specificity, positive and negative likelihood ratios, and the natural logarithm of the diagnostic odds ratio by the DerSimonian-Laird random-effects model.[6] Rates were pooled after logit transformation, weighting study rates by the inverse ratio of their variance plus the between-study variance for that measure, and then retransformed back into standard proportions with 95% confidence intervals (CIs). Homogeneity of the effect size across trials was tested by χ^2 statistics. Heterogeneity was defined as $P<.10$.

The diagnostic performance of each test was also assessed by means of summary receiver operating characteristic (ROC) curves according to the method described by Moses et al.[7] In construction of summary ROC curves, the true-positive rate was plotted against the false-positive rate for each study. To avoid calculation problems by having 0 values, 0.5 was added to each cell of the respective contingency table. The summary ROC model is described by the following equation: $D=a+bS$. The summary ROC curve analysis is based on regression analysis of logistic regression–transformed data, which plots the difference between the logistic regression of the true-positive rate (TPR) and that of the false-positive rate (FPR) ($D=\text{logit TPR}-\text{logit FPR}$) on the y-axis and their sum ($S=\text{logit TPR}+\text{logit FPR}$) on the x-axis. The y axis (D) is equivalent to the log diagnostic odds ratio, and the x-axis (S) is a measure of how the test characteristics vary with the test threshold. The regression coefficient b examines the extent to which the log odds ratio is dependent on the threshold values chosen. The linear regression analysis was weighted by the inverse of the variance of D. The regression line was back-transformed to the ROC space.

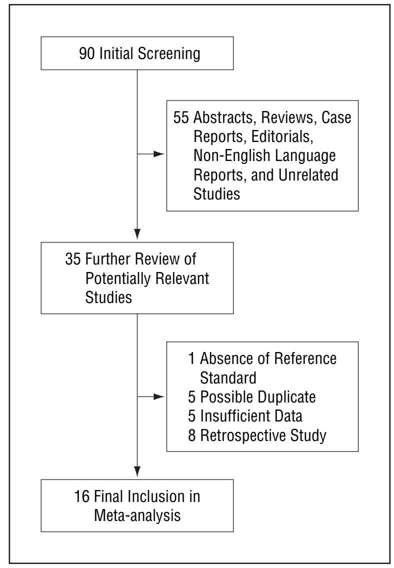

Figure 1. Meta-analysis flowchart.

To assess the potential for publication bias, a funnel plot was constructed in which the log of relative risks was plotted against the associated number of patients. In addition, correlation between the standardized log of relative risks and the associated number of patients was determined by the Kendall rank correlation coefficient.[8] The correlation between sample size and relative risk would be strong if not many small studies with null results were published. A significant correlation between sample size and relative risk would not exist in the absence of publication bias. Statistical significance was defined for treatment effects as $P<.05$, and heterogeneity and publication bias were assumed when $P<.10$. Analyses were performed with Microsoft Excel (Microsoft Corporation, Redmond, Wash), Meta-DiSc Version 1.2 for Windows (Hospital Ramón y Cajal, Madrid, Spain), and Number Cruncher Statistical System 2004 (NCSS Statistical Systems, Kaysville, Utah).

RESULTS

The electronic search resulted in 90 hits. Sixteen studies[9-24] representing a total of 1139 patients met the inclusion criteria (**Table 1** and **Table 2**). Pooled estimates of sensitivity, specificity, positive and negative likelihood ratios, and the natural logarithm of the diagnostic odds ratio as well as the regression model equation for each test are listed in **Table 3**. The positive likelihood ra-

Table 1. Details of Studies Included in the Meta-analysis

Source	Patients, No.	Age, y*	Subjects	Diagnostic Criteria for AD†	Reference Standard	Onset of Dissection	Prevalence of AD, %	System-Specific Settings
TEE Studies								
Pepi et al,[11] 2000	58	61 (32-78)	Clinically suspected AD	(1) And (2)	Intraoperative findings and CT, MRI, and aortogram	NS	51.7	Biplane or multiplane
Nishino et al,[13] 1996	15	62 ± 11	History of chest or back pain	(1) And a smooth surface of the lesion, and a crescent-shaped thrombus	Surgery and histologram	Acute (1), chronic (16)	46.7	Biplane
Sommer et al,[12] 1996	49	22-71	Symptomatic patients with clinically suspected AD	(1) And crescentic wall thickening with central displacement of intimal calcification or compression of the aortic lumen	Surgery, autopsy, and angiography	Acute (18), subacute (12), chronic (3)	67.3	Multiplane
Evangelista et al,[14] 1996	132	55 (18-79)	Patients with clinically suspected AD	(1) And (2)	Surgical findings, necropsy, and MRI	NS	49.2	Biplane or multiplane
Keren et al,[15] 1996	112	61 ± 17	Suspected acute AD	(1)	CT, MRI, aortograms, intraoperative inspection, and autopsy	Acute (112)	43.8	Biplane or multiplane
Laissy et al,[18] 1995	31	59 (40-85)	Suspected AD	(1) And (2)	Angiography and surgical findings	NS	40.0	Biplane
Chirillo et al,[19] 1994	70	18-79	Suspected AD	A consistent linear echo indicative of a dissection flap seen in the aortic lumen	Surgical findings	NS	57.1	Single
Nienaber et al,[20] 1993	70	NS	Clinically suspected AD	(1) And (2)	Angiography, intraoperative inspection, and autopsy	Acute (35), subacute (27)	62.9	NS
Simon et al,[21] 1992	32	26-81	Suspected AD	(1)	Surgical findings	Acute (21), chronic (7)	87.5	Single and biplane
Ballal et al,[22] 1991	61	57	Dyspnea, chest pain, back pain, and other atypical symptoms	(1)	Aortography, surgery, or autopsy	Acute (18), chronic (16)	55.7	Single and biplane
Helical CT Studies								
Yoshida et al,[9] 2003	45	57	Suspected acute AD or IMH	(3)	Surgery	Acute (45)	78.9	Nonionic contrast media used
Sommer et al,[12] 1996	49	22-71	Symptomatic patients with clinically suspected AD	(4)	Surgery, autopsy, and angiography	Acute (18), subacute (12), chronic (3)	67.3	Contrast material used
Zeman et al,[17] 1995	23	33-92	Suspected aortic dissection	The presence of dissection and the intimal flap	Surgery or other imaging tests	Acute (4), subacute (1), chronic (2)	36.8	Contrast material used

(continued)

tio was highest for MRI, suggesting a possibly superior discriminative power for confirming thoracic aortic dissection. Helical CT had the lowest negative likelihood ratio, suggesting that it might be best for ruling out thoracic aortic dissection. The highest diagnostic odds ratio suggests that of the 3 imaging techniques, MRI might be superior in overall diagnostic performance. The summary ROC curve for each test is shown in **Figure 2**. Diagnostic accuracy did not vary with the test threshold for TEE ($P=.45$), helical CT ($P=.53$), or MRI ($P=.53$). This suggests that the odds ratio is independent of the threshold values chosen.

The posttest probabilities following positive and negative test results are depicted with a possible range of pretest probabilities in **Figure 3**. According to Sarasin and colleagues,[3] in terms of diagnostic probability, patients with a pretest probability of 50% for aortic dissection should be considered high-

Table 1. Details of Studies Included in the Meta-analysis (cont)

Source	Patients, No.	Age, y*	Subjects	Diagnostic Criteria for AD†	Reference Standard	Onset of Dissection	Prevalence of AD, %	System-Specific Settings
MRI Studies								
Silverman et al,[10] 2000	78	NS	History of possible aortic dissection or aneurysm	Intimal flap involved	Operative findings	NS	65.4	Phase-contrast cine-MRI
Sommer et al,[12] 1996	49	22-71	Symptomatic patients with clinically suspected AD	(1)	Surgery, autopsy, and angiography	Acute (18), subacute (12), chronic (3)	67.3	ECG-triggered, T1-weighted, spin-echo
Panting et al,[16] 1995	50	67 (56-79)	Suspected AD	(5)	Surgical findings and postmortem examination	Acute (50)	54.0	T1-weighted or fast spin-echo
Laissy et al,[18] 1995	31	59 (40-85)	Suspected acute AD	(5) And (6)	Angiography and surgical findings	NS	40.0	Cardiac-gated, spin-echo
Nienaber et al,[20] 1993	105	NS	Clinically suspected AD	(5)	Angiography, intraoperative inspection, and autopsy	Acute (35), subacute (27)	56.2	ECG-gated, spin-echo, and cine-MRI
Fruehwald et al,[23] 1989	25	49 (9-76)	Suspected AD	(5) And (7)	Angiography, CT, and echocardiography	NS	36.0	Cine-MRI
Kersting-Sommerhoff et al,[24] 1988	54	54 (16-90)	Suspected or known AD	(5) And (7)	Surgical findings, angiography, and CT	Acute (9), chronic (6)	42.6	Electrocardiographic gating

Abbreviations: AD, aortic dissection; CT, computed tomography; ECG, electrocardiography; IMH, intramural hematoma; MRI, magnetic resonance imaging; NS, not specified; TEE, transesophageal echocardiography.

*Ages may be reported as mean (range), mean ± SD, or range only.

†The following are the codes used for diagnostic criteria: (1) the presence of 2 vascular lumens separated by an intimal flap; (2) if there was complete thrombosis of the false lumen, a central displacement of intimal calcification was considered to be AD; (3) well-defined partition (ie, intimal flap) between the true and false lumina within the aorta; (4) the presence of intimal flap in at least one part of the thoracic aorta that separated 2 pefused lumina; (5) the intimal flap was identified as a linear band of intermediate signal intensity within the aorta when 2 lumina were present; (6) when a thrombosed false lumen was present, indirect signs were suggestive of dissection; and (7) the presence of slow flow within a thrombosed false channel.

Table 2. Further Details of Studies Included in the Meta-analysis

	Quality of Study			Detection of Aortic Dissection					
Source	Blinding	Consecutive Recruitment	Single Standard	TP	FN	TN	FP	Sensitivity (95% CI), %	Specificity (95% CI), %
TEE Studies									
Pepi et al,[11] 2000	NS	Y	N	30	0	28	0	100 (88-100)	100 (88-100)
Nishino et al,[13] 1996	NS	NS	N	6	1	6	2	86 (42-100)	75 (35-97)
Sommer et al,[12] 1996	Y	Y	N	33	0	15	1	100 (89-100)	94 (70-100)
Evangelista et al,[14] 1996	NS	Y	N	64	1	67	0	99 (92-100)	100 (95-100)
Keren et al,[15] 1996	NS	Y	N	48	1	60	3	98 (89-100)	95 (87-99)
Laissy et al,[18] 1995	Y	Y	N	12	2	16	1	86 (57-98)	94 (71-100)
Chirillo et al,[19] 1994	Y	Y	Y	39	1	29	1	98 (87-100)	97 (83-100)
Nienaber et al,[20] 1993	Y	Y	N	43	1	20	6	98 (88-100)	77 (56-91)
Simon et al,[21] 1992	NS	NS	Y	28	0	4	0	100 (88-100)	100 (40-100)
Ballal et al,[22] 1991	Y	NS	N	33	1	27	0	97 (85-100)	100 (87-100)
Helical CT Studies									
Yoshida et al,[9] 2003	NS	Y	Y	45	0	12	0	100 (92-100)	100 (74-100)
Sommer et al,[12] 1996	Y	Y	N	33	0	16	0	100 (89-100)	100 (79-100)
Zeman et al,[17] 1995	NS	NS	N	7	0	12	1	100 (59-100)	92 (64-100)
MRI Studies									
Silverman et al,[10] 2000	Y	N	Y	51	0	27	0	100 (93-100)	100 (87-100)
Sommer et al,[12] 1996	Y	Y	N	33	0	15	1	100 (.89-100)	94 (70-100)
Panting et al,[16] 1995	NS	Y	N	26	1	23	0	96 (81-100)	100 (85-100)
Laissy et al,[18] 1995	Y	Y	N	13	1	16	1	93 (66-100)	94 (71-100)
Nienaber et al,[20] 1993	Y	Y	N	58	1	45	1	98 (91-100)	98 (89-100)
Fruehwald et al,[23] 1989	Y	NS	N	9	0	16	0	100 (66-100)	100 (79-100)
Kersting-Sommerhoff et al,[24] 1988	N	NS	N	21	2	31	0	91 (72-99)	100 (89-100)

Abbreviations: CI, confidence interval; FN, false negative; FP, false positive; N, no; NS, not specified; TN, true negative; TP, true positive; Y, yes.

Table 3. Results of Meta-analysis*

Imaging Technique	Studies Included, No.	Sensitivity	Specificity	Likelihood Ratio†		Diagnostic Odds Ratio	Moses et al[7] Model (Weighted)‡		
				Positive	Negative		*a*	*b*	*P* Value
TEE	10	98 (95-99)	95 (92-97)§	14.1 (6.0-33.2)§	0.04 (0.02-0.08)	6.1 (5.0-7.2)	6.2	−0.35	.45
Helical CT	3	100 (96-100)§	98 (87-99)	13.9 (4.2-46.0)	0.02 (0.01-0.11)	6.5 (4.4-8.7)	3.9	3.2	.53
MRI	7	98 (95-99)	98 (95-100)	25.3 (11.1-57.1)	0.05 (0.03-0.10)	6.8 (5.5-8.0)	6.8	0.25	.53

Abbreviations: CI, confidence interval; CT, computed tomography; MRI, magnetic resonance imaging; TEE, transesophageal echocardiography.

*Unless otherwise indicated, data are reported with 95% confidence intervals. The DerSimoninan-Laird random-effects model[6] was used throughout.

†Likelihood ratios greater than 10 and less than 0.1 are considered strong evidence for confirming or ruling out a diagnosis, respectively, under most circumstances.

‡See "Methods" section for term definitions.

§Significant heterogeneity ($P<.10$) was found.

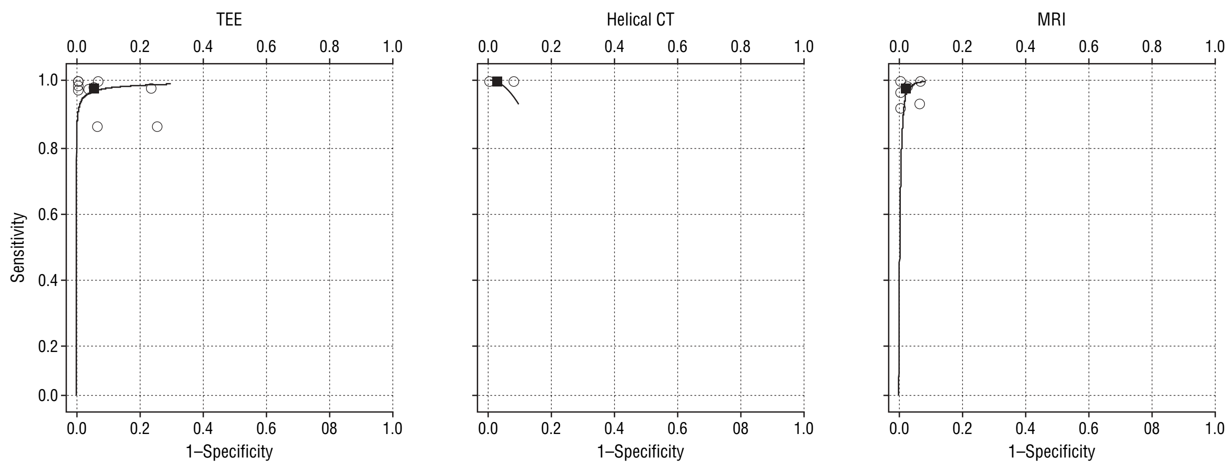

Figure 2. Summary receiver operating characteristic (ROC) curve analysis of transesophageal echocardiography (TEE), computed tomography (CT), and magnetic resonance imaging (MRI). The weighted summary ROC curve is expressed by a solid line. Individual study estimates of sensitivity and (1−specificity) are shown by open circles. Solid squares indicate pooled point estimates of sensitivity and specificity.

risk patients, and patients with a 5% pretest probability should be considered low-risk patients. High-risk patients were defined as patients with typical clinical findings of aortic dissection (eg, tearing chest pain in the back, hypotension, and disparity in pulses). Low-risk patients were defined as patients with severe and acute chest pain and no other suggestive vascular or neurologic findings. In our results, if a patient had a 50% pretest probability of thoracic aortic dissection, he or she had a 96%, 93%, or 93% posttest probability of thoracic aortic dissection following a positive result for MRI, TEE, or helical CT, respectively. In contrast, if a patient had a 5% pretest probability of thoracic aortic dissection (low-risk population), he or she had a 0.1%, 0.2%, or 0.3% posttest probability of thoracic aortic dissection following a negative result for helical CT, TEE, or MRI, respectively.

Symmetry in the funnel plot was confirmed by a significant Kendall correlation coefficient of 0.11 ($P=.65$) for TEE, 1.0 ($P=.11$) for helical CT, and 0.14 ($P=.65$) for MRI, suggesting absence of publication bias.

COMMENT

In the present meta-analysis, we found that sensitivity and specificity were comparable between imaging techniques, and the diagnostic value of each imaging technique was acceptable for confirming or ruling out thoracic aortic dissection. In patients at high risk for thoracic aortic dissection (pretest probability of 50%), MRI yielded the highest values for confirming thoracic aortic dissection. In contrast, helical CT yielded the best values for ruling out thoracic aortic dissection in patients at low risk for thoracic aortic dissection (pretest probability of 5%). However, capabilities of the 3 imaging techniques were found to be equivalent for confirming or excluding thoracic aortic dissection. It is therefore difficult to determine from our results which imaging technique should be recommended after stratification of patients according to pretest probabilities.

TRANSESOPGHAGEAL ECHOCARDIOGRAPHY

Transesophageal echocardiography is often used in the primary care setting. Compared with MRI and helical CT, TEE is advantageous in emergency situations with time constraints and in patients with hemodynamic compromise. The amount of time needed for diagnosis may be shortest with TEE; this seems very important because the progress of complications is time dependent. Color-flow Doppler TEE is advantageous in confirming the presence of aortic valve insufficiency associated with aortic dissection. However, the distal part of the ascending aorta and the branches of the aortic arch cannot be adequately evaluated by TEE.[25] Interference by the trachea and the left main stem bronchus produces a "blind zone" or "blind spot."[2] Generally, TEE examination tends to be somewhat observer and experience dependent, and false-positive or false-negative findings can arise easily when data are interpreted by unskilled or single observers.[26] In patients with esophageal varices, TEE is contraindicated.

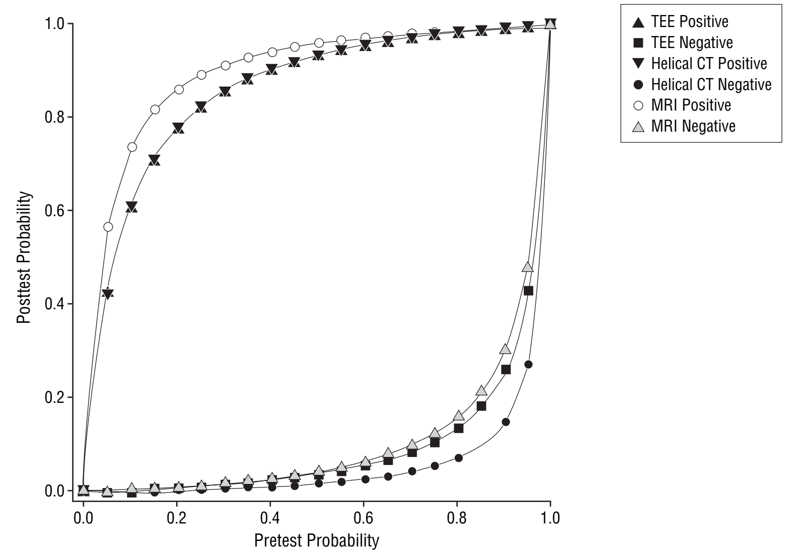

Figure 3. Posttest probability according to pretest probability. Posttest probability was calculated as follows: Posttest probability=[pretest odds × likelihood ratio]/[(1+pretest odds) × likelihood ratio]; where pretest odds=pretest probability/(1−pretest probability). CT indicates computed tomography; MRI, magnetic resonance imaging; and TEE, transesophageal echocardiography.

HELICAL CT

Currently, conventional CT is probably the most widely used imaging technique in the diagnosis of thoracic aortic dissection,[1] but it is reported to be associated with an insufficient sensitivity of 83% to 94% and a specificity of 87% to 100%.[2,12] The next generation of imaging technology, helical CT, offers many advantages over conventional CT: temporal resolution is improved; motion artifacts are minimal; scanning is more rapid; examination time is substantially shorter; and 3-dimensional renderings are possible. Our analysis showed that helical CT yielded a sensitivity of 100% and a specificity of 98% and, of the 3 techniques, the best value for ruling out thoracic aortic dissection when a patient is at low risk for thoracic aortic dissection (pretest probability of 5%). Of the 3 techniques, CT may be the least operator dependent. The disadvantages of helical CT include the need for contrast material or ionizing radiation. This may be a problem especially when the patient is in a state of acute or chronic renal compromise. Aortic valve insufficiency is difficult to evaluate with helical CT.

MAGNETIC RESONANCE IMAGING

Magnetic resonance imaging has been considered the most accurate technique for diagnosing thoracic aortic dissection.[2] Our meta-analysis confirmed that the overall diagnostic accuracy for detecting thoracic aortic dissection is excellent. Magnetic resonance imaging also yielded the best value for confirming thoracic aortic dissection when a patient is at high risk for this disorder (pretest probability of 50%). The results were homogeneous, irrespective of the type of MRI study, such as cine magnetic resonance angiography.[10] Despite the advantages, MRI is rarely used as the initial imaging technique[1] because of lack of availability, time delay, incompatibility with implanted metal devices, or monitoring difficulties during examination. Magnetic resonance imaging is not applicable for hemodynamically unstable patients.

STRENGTHS AND LIMITATIONS

Our analysis showed that the diagnostic odds ratio is independent of the test threshold chosen. This is likely because most studies defined aortic dissection as the presence of 2 vascular lumens separated by an intimal flap. Some studies included an additional criterion for aortic dissection: central displacement of intimal calcification was considered aortic dissection if thrombosis of the false lumen was present; however, this additional criterion did not affect the overall diagnostic performance of the 3 imaging techniques. With the exception of a few parameters in TEE and helical CT results, heterogeneity did not exist between studies.

Despite the strengths of our meta-analysis, our findings are limited by the following. First, our systematic review did not permit head-to-head comparisons of the 3 imaging techniques because only 3 studies[12,18,20] directly compared 2 or more imaging techniques in the same cohort. Second, there were several criteria included in the reference standard (eg, surgical findings and autopsy findings). This may be inevitable because a single reference standard would not be applicable in the same cohort; surgery is performed in some cases and not in others, and the same is true for autopsy, angiography, and other procedures. Third, some of our findings are limited by the low number of studies meeting our inclusion criteria, especially those of helical CT. This might explain why the summary ROC curve for spiral CT looks irregular. Finally, in addition to confirming or ruling out thoracic aortic dissection, there are other important factors that must be evaluated: the presence of branch vessel or coronary artery involvement, and the presence of aortic valve insufficiency. These factors strongly influence the type of surgical intervention. However, our meta-analysis could not determine the role of any of the 3 imaging techniques in this respect because few studies evaluated this.

Given the equally high performance of each test, what other information should a clinician use to choose the most appropriate test for a given patient? A clinician must take into account the availability of each imaging test because time delay increases the mortality rate in untreated patients.[3] A clinician also needs to recognize that there is wide disparity in levels of expertise and resources at local hospitals. A clinician should not hesitate to order another test when thoracic aortic dissection is still clinically strongly suspected but the initial diagnostic test is negative. This was clearly recommended in the report based on the International Registry of Acute Aortic Dissection[27]; however, delay must be avoided.

In conclusion, our systematic review suggests that all 3 imaging techniques, ie, TEE, helical CT, and MRI, yield equally reliable diagnostic values for confirming or ruling out thoracic aortic dissection.

Accepted for Publication: April 10, 2006.
Correspondence: Toshiya Shiga, MD, PhD, Department of Anesthesiology, Toho University Ohashi Medical Center, Ohashi 2-17-6, Meguro-ku, Tokyo 153-8515, Japan (QZX02115@nifty.com).
Financial Disclosure: None reported.

REFERENCES

1. Hagan PG, Nienaber CA, Isselbacher EM, et al. The International Registry of Acute Aortic Dissection (IRAD): new insights into an old disease. *JAMA*. 2000;283:897-903.
2. Erbel R, Alfonso F, Boileau C, et al. Diagnosis and management of aortic dissection. *Eur Heart J*. 2001;22:1642-1681.
3. Sarasin FP, Louis-Simonet M, Gaspoz JM, Junod AF. Detecting acute thoracic aortic dissection in the emergency department: time constraints and choice of the optimal diagnostic test. *Ann Emerg Med*. 1996;28:278-288.
4. Erbel R, Engberding R, Daniel W, Roelandt J, Visser C, Rennollet H. Echocardiography in diagnosis of aortic dissection. *Lancet*. 1989;1:457-461.
5. Romagnuolo J, Bardou M, Rahme E, Joseph L, Reinhold C, Barkun AN. Magnetic resonance cholangiopancreatography: a meta-analysis of test performance in suspected biliary disease. *Ann Intern Med*. 2003;139:547-557.
6. DerSimonian R, Laird N. Meta-analysis in clinical trials. *Control Clin Trials*. 1986;7:177-188.
7. Moses LE, Shapiro D, Littenberg B. Combining independent studies of a diagnostic test into a summary ROC curve: data-analytic approaches and some additional considerations. *Stat Med*. 1993; 12:1293-1316.
8. Begg CB, Mazumdar M. Operating characteristics of a rank correlation test for publication bias. *Biometrics*. 1994;50:1088-1101.
9. Yoshida S, Akiba H, Tamakawa M, et al. Thoracic involvement of type A aortic dissection and intramural hematoma: diagnostic accuracy–comparison of emergency helical CT and surgical findings. *Radiology*. 2003;228:430-435.
10. Silverman JM, Raissi S, Tyszka JM, Trento A, Herfkens RJ. Phase-contrast cine MR angiography detection of thoracic aortic dissection. *Int J Card Imaging*. 2000;16:461-470.
11. Pepi M, Campodonico J, Galli C, et al. Rapid diagnosis and management of thoracic aortic dissection and intramural haematoma: a prospective study of advantages of multiplane vs. biplane transoesophageal echocardiography. *Eur J Echocardiogr*. 2000;1:72-79.
12. Sommer T, Fehske W, Holzknecht N, et al. Aortic dissection: a comparative study of diagnosis with spiral CT, multiplanar transesophageal echocardiography, and MR imaging. *Radiology*. 1996; 199:347-352.
13. Nishino M, Tanouchi J, Tanaka K, et al. Transesophageal echocardiographic diagnosis of thoracic aortic dissection with the completely thrombosed false lumen: differentiation from true aortic aneurysm with mural thrombus. *J Am Soc Echocardiogr*. 1996;9:79-85.
14. Evangelista A, Garcia-del-Castillo H, Gonzalez-Alujas T, et al. Diagnosis of ascending aortic dissection by transesophageal echocardiography: utility of M-mode in recognizing artifacts. *J Am Coll Cardiol*. 1996;27:102-107.
15. Keren A, Kim CB, Hu BS, et al. Accuracy of biplane and multiplane transesophageal echocardiography in diagnosis of typical acute aortic dissection and intramural hematoma. *J Am Coll Cardiol*. 1996;28:627-636.
16. Panting JR, Norell MS, Baker C, Nicholson AA. Feasibility, accuracy and safety of magnetic resonance imaging in acute aortic dissection. *Clin Radiol*. 1995;50:455-458.
17. Zeman RK, Berman PM, Silverman PM, et al. Diagnosis of aortic dissection: value of helical CT with multiplanar reformation and three-dimensional rendering. *AJR Am J Roentgenol*. 1995;164:1375-1380.
18. Laissy JP, Blanc F, Soyer P, et al. Thoracic aortic dissection: diagnosis with transesophageal echocardiography versus MR imaging. *Radiology*. 1995;194:331-336.
19. Chirillo F, Cavallini C, Longhini C, et al. Comparative diagnostic value of transesophageal echocardiography and retrograde aortography in the evaluation of thoracic aortic dissection. *Am J Cardiol*. 1994;74:590-595.
20. Nienaber CA, von Kodolitsch Y, Nicolas V, et al. The diagnosis of thoracic aortic dissection by noninvasive imaging procedures. *N Engl J Med*. 1993; 328:1-9.
21. Simon P, Owen AN, Havel M, et al. Transesophageal echocardiography in the emergency surgical management of patients with aortic dissection. *J Thorac Cardiovasc Surg*. 1992;103:1113-1117.
22. Ballal RS, Nanda NC, Gatewood R, et al. Usefulness of transesophageal echocardiography in assessment of aortic dissection. *Circulation*. 1991; 84:1903-1914.
23. Fruehwald FX, Neuhold A, Fezoulidis J, et al. Cine-MR in dissection of the thoracic aorta. *Eur J Radiol*. 1989;9:37-41.
24. Kersting-Sommerhoff BA, Higgins CB, White RD, Sommerhoff CP, Lipton MJ. Aortic dissection: sensitivity and specificity of MR imaging. *Radiology*. 1988;166:651-655.
25. Borner N, Erbel R, Braun B, Henkel B, Meyer J, Rumpelt J. Diagnosis of aortic dissection by transesophageal echocardiography. *Am J Cardiol*. 1984; 54:1157-1158.
26. Shiga T, Wajima Z, Inoue T, Ogawa R. Survey of observer variation in transesophageal echocardiography: comparison of anesthesiology and cardiology literature. *J Cardiothorac Vasc Anesth*. 2003;17:430-442.
27. Moore AG, Eagle KA, Bruckman D, et al. Choice of computed tomography, transesophageal echocardiography, magnetic resonance imaging, and aortography in acute aortic dissection: International Registry of Acute Aortic Dissection (IRAD). *Am J Cardiol*. 2002;89:1235-1238.