Duplex ultrasound and magnetic resonance angiography compared with digital subtraction angiography in carotid artery stenosis: a systematic review

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CRD summary
This review found that magnetic resonance angiography (MRA) has a better discriminatory power than duplex ultrasound (DUS) for diagnosing 70-99% stenosis and is sensitive and specific compared with digital subtraction angiography (reference standard). It is difficult to evaluate the conclusions because of lack of detail about the included studies and analysis, and because comparisons of MRA and DUS were indirect.

Authors' objectives
To compare published data on the diagnostic value of duplex ultrasonography (DUS), magnetic resonance angiography (MRA) and conventional digital subtraction angiography (DSA) for the diagnosis of carotid artery stenosis.

Searching
PubMed was searched from January 1994 to December 2001 for articles in English; the keywords were specified. The reference lists of articles were checked and experts in the field were consulted for additional studies.

Study selection
Study designs of evaluations included in the review
The study designs eligible for inclusion were not specified. Studies of less than 15 patients were excluded.

Specific interventions included in the review
Studies of DUS, MRA, or contrast-enhanced MRA used alone, or in combination, to estimate the severity of carotid artery stenosis were eligible for inclusion. Studies where 100% occlusion was the main cut-off were excluded if there was no information on the non-occlusion group, as the review was concerned with treatment decisions based on the ability to distinguish severe occlusion (70 to 99%) from 100% occlusion.

Reference standard test against which the new test was compared
Only studies where DSA was used as the reference standard were eligible for inclusion.

Participants included in the review
Patients with carotid artery stenosis were eligible for inclusion.

Outcomes assessed in the review
Studies reporting absolute numbers for true positives, false negatives, true negatives and false positives (or where the figures could be derived from the data presented) for at least one cut-off criterion for the degree of stenosis based on DSA were eligible for inclusion.

How were decisions on the relevance of primary studies made?
The authors did not state how the papers were selected for the review, or how many reviewers performed the selection.

Assessment of study quality
Studies were assessed for the following: whether consecutive patients were included in the cohort; whether the thresholds were defined in advance; whether verification bias was present; and whether review bias was present. Two reviewers independently assessed the studies. Any discrepancies were discussed and resolved by consensus.

Data extraction
Two reviewers extracted the data independently. Any discrepancies were discussed and resolved by consensus. The numbers of true positives, false negatives, true negatives and false positives were extracted for the following categories of stenosis: 0 to 29%, 30 to 49%, 50 to 69%, 70 to 99%, and 100% (though the data were not reported separately in the paper for subgroups under 70%). The sensitivity and specificity were extracted or calculated from the data. Cut-off values determined according to the European Carotid Surgery Trial were converted to the corresponding North American Symptomatic Carotid Endarterectomy Trial criteria. The parameter that the authors considered optimal for determining the degree of stenosis was chosen. Where possible, single peak velocity values referring to a degree of stenosis of 70% were extracted. Other data extracted included the proportion of carotid arteries that were symptomatic, the type of DUS and/or MR machine, and the MRA technique used.

**Methods of synthesis**

**How were the studies combined?**

Pooled estimates of the sensitivity, specificity and diagnostic odds ratio were calculated. The studies were pooled using a random-effects model. The inverse of the variance was used for weighting. Fixed-effect and random-effects model were constructed, although only the data from the random-effects model were reported. To adjust for the heterogeneity in positivity criteria, a summary receiver operating characteristic (ROC) curve analysis was performed for each test. A summary ROC curve analysis was also performed to compare MRA and DUS.

**How were differences between studies investigated?**

A regression analysis was used to investigate differences between the studies. Multivariate summary ROC curves were developed using stepwise forward-regression for each diagnostic test. Patient, study quality and diagnostic test related variables, which met pre-specified criteria for explanatory value in a prior bivariate analysis, were used. Significant variables from the multivariate analysis for each individual test were then included as covariates in the ROC analysis comparing MRA and DUS. In addition, to assess the effect of individual studies, a sensitivity analysis was conducted in which the analysis was repeated, excluding one study each time.

**Results of the review**

Sixty-two studies of 85 separate study populations were included: 21 series on MRA and 64 series on DUS. Further details of the study designs were not provided.

Diagnosis of 70 to 99% versus less than 70% stenosis.

The diagnostic accuracy of the two tests were similar for severe stenosis: 4.1 (95% confidence interval, CI: 3.5, 4.8) for MRA and 4.0 (95% CI: 3.5, 4.5) for DUS. The data on sensitivity and specificity indicated better discriminatory power for MRA: the pooled sensitivity was 95% (95% CI: 92, 97) for MRA and 86% (95% CI: 84, 89) for DUS; the pooled specificities were 90% (95% CI: 86, 93) and 87% (95% CI: 84, 90), respectively.

When possible confounding variables were taken into consideration in the regression analysis, MRA was significantly better than DUS at discriminating 70 to 99% stenosis than less than 70% stenosis: the regression coefficient was 1.6 (95% CI: 0.37, 2.77, p=0.01). The sensitivity analysis showed that no individual study unduly influenced the results.

Diagnosis of less than 100% versus 100% stenosis.

The diagnostic accuracy of the two tests for occlusion was similar for distinguishing occlusion from severe stenosis: 6.5 (95% CI: 5.7, 7.4) for MRA and 6.5 (95% CI: 5.9, 7.0) for DUS. The pooled sensitivity was 98% (95% CI: 94, 100) for MRA and 96% (95% CI: 94, 98) for DUS; the pooled specificities of both MRA and DUS were 100% (95% CI: 99, 100).

When possible confounding variables were taken into consideration in the regression analysis, there was no difference between MRA and DUS in diagnostic performance: the regression coefficient was 0.73 (95% CI: -2.06, 3.51, P=0.51). The sensitivity analysis showed that no individual study unduly influenced the results.

**Authors' conclusions**
The results suggested that, compared with DUS, MRA has a better discriminatory power in diagnosing 70 to 99% stenosis. In addition, it is a sensitive and specific test compared with DSA in the evaluation of carotid artery stenosis. Both DUS and MRA are very accurate in detecting occlusion.

CRD commentary
The review question was clearly specified. The extent of the searches was very limited and, since the searches were restricted to publications in English, it is likely that studies were missed. The data extraction and quality assessment processes were carried out in duplicate, which helps to reduce error and bias, although it was unclear whether a similar approach was taken when selecting the studies. A quality assessment was carried out and the impact of quality on the findings was considered.

No details of the individual studies were provided. It was therefore not possible to assess clinical heterogeneity, or whether appropriate predictor variables were considered in the analysis. It was also unclear how many studies and participants were included in any of the analyses. Between-study differences were considered in the regression analysis and sensitivity analysis, but the extent of statistical heterogeneity in any of the analyses was unclear.

The authors' conclusions follow from the evidence presented. However, owing to the lack of detail on the included studies and some aspects of the analysis, it was not possible to determine the strength of these findings. In addition, caution is required as the comparison of MRA and DUS was entirely modeled and not based on direct comparisons.

Implications of the review for practice and research
Practice: The authors stated that associated costs and cost-effectiveness also need to be considered when deciding whether noninvasive tests can replace DSA in clinical practice.

Research: The authors did not state any implications for further research.

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