Systematic review and meta-analysis of plethysmography in the diagnosis of deep vein thrombosis

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Background

Plethysmography techniques (impedance, strain-gauge, air and plethysmography) have been evaluated by numerous studies over recent decades. We aimed to systematically review the literature to determine the diagnostic accuracy of these techniques in patients presenting with suspected deep vein thrombosis (DVT).

Methods

We sought to identify all diagnostic cohort studies of patients with suspected DVT that compared the results of plethysmography to a reference standard of venography or ultrasound. We searched the following electronic databases (1969-2004): Medline, EMBASE, CINAHL, Web of Science, Cochrane Database of Systematic Reviews, Cochrane Controlled Trials Register, Database of Reviews of Effectiveness, and the ACP Journal Club. The bibliographies of all retrieved articles were scanned for potentially relevant articles that were not identified by the original search.

Titles and abstracts were screened by two independent reviewers (FS and SG). Full copies of all selected articles were retrieved and reviewed by the same two reviewers. We included studies published in English, French, Spanish or Italian, but excluded studies published in other languages. Two independent reviewers (AW and TL) then extracted data and assessed study quality against validated criteria.

Screening the original search returned 2,443 studies. Of these, 993 were potentially suitable studies to be included in the meta-analysis, and 4 additional studies were identified from the bibliographies of selected articles. A total of 70 articles reported a total of 80 cohorts of patients: 66 with clinically suspected DVT, 12 asymptomatic cohorts, and 2 mixed cohorts. Only the symptomatic cohorts are reported here:

- Impedance plethysmography: 42 cohorts
- Strain-gauge plethysmography: 10 cohorts
- Air plethysmography: 4 cohorts

Statistical Analysis

Pooled estimates of sensitivity (proximal and distal DVT) and specificity were calculated using a random effects model. Meta-regression was used in order to explore the influence of study level covariates on diagnostic performance. All analyses were undertaken using MetaDisC statistical software.

Results

Impedance plethysmography has both been investigated by a substantial number of studies. However, the results of individual studies show considerable heterogeneity. This is demonstrated graphically on the ROC plane. The true positive rate (sensitivity) is plotted against the false positive rate (1 - specificity) for each study. A study of a perfect test would be plotted in the top left hand corner. Heterogeneity is demonstrated by the degree of scatter of the points.

Meta-regression was limited by poor reporting in the studies. We identified only one study-level covariate that predicted diagnostic performance for impedance plethysmography: the proportion of men in the cohort. Studies with more than the median proportion of men (43%) had better sensitivity (78%) and poorer specificity (85%). Studies with fewer men had poorer sensitivity (69%) and better specificity (83%). However, these analyses were still subject to significant heterogeneity (p<0.001).

Meta-regression did not identify any covariate that predicted diagnostic performance in studies of strain-gauge plethysmography.

Conclusions

Impedance plethysmography has a sensitivity of 88% for proximal DVT, a sensitivity of 28% for distal DVT, and a specificity of 90%.

Strain gauge plethysmography has a sensitivity of 90% for proximal DVT, a sensitivity of 56% for distal DVT, and a specificity of 81%.

Air plethysmography appears to have superior diagnostic performance, but has only been evaluated in a few studies.

There was substantial heterogeneity among the results of all the analyses that could not be explained by reported, study-level covariates. The most likely explanations for heterogeneity are unreported differences in the study populations and the operation of the plethysmography. Plethysmography techniques add useful information to the diagnostic assessment of patients with suspected DVT, but are unlikely to be considered to have adequate sensitivity or specificity to allow treatment decisions without additional diagnostic information.

Acknowledgements

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<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Specificity</th>
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<tbody>
<tr>
<td>Impedance plethysmography</td>
<td>0.88 (0.86 to 0.90)</td>
</tr>
<tr>
<td>Strain-gauge plethysmography</td>
<td>0.90 (0.89 to 0.91)</td>
</tr>
<tr>
<td>Air plethysmography</td>
<td>0.93 (0.91 to 0.95)</td>
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</tbody>
</table>

95% confidence interval in parentheses

P-value = Chi-square test for heterogeneity

Likelihood ratios for all DVT

<table>
<thead>
<tr>
<th>Likelihood Ratio</th>
<th>Positive test</th>
<th>Negative test</th>
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<tbody>
<tr>
<td>Impedance plethysmography</td>
<td>6.1 (4.8 to 7.9)</td>
<td>0.27 (0.23 to 0.32)</td>
</tr>
<tr>
<td>Strain gauge plethysmography</td>
<td>4.2 (3.3 to 5.3)</td>
<td>0.19 (0.16 to 0.27)</td>
</tr>
<tr>
<td>Air plethysmography</td>
<td>7.6 (5.7 to 11.7)</td>
<td>0.21 (0.11 to 0.45)</td>
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95% confidence interval in parentheses

P-value = Chi-square test for heterogeneity