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Accuracy of electrocardiography in diagnosis of left ventricular hypertrophy in arterial hypertension: systematic review

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ABSTRACT

Objective To review the accuracy of electrocardiography in screening for left ventricular hypertrophy in patients with hypertension.

Design Systematic review of studies of test accuracy of six electrocardiographic indexes: the Sokolow-Lyon index, Cornell voltage index, Cornell product index, Gubner index, and Romhilt-Estes scores with thresholds for a positive test of ≥4 points or ≥5 points.

Data sources Electronic databases ((Pre-)Medline, Embase), reference lists of relevant studies and previous reviews, and experts.

Study selection Two reviewers scrutinised abstracts and examined potentially eligible studies. Studies comparing the electrocardiographic index with echocardiography in hypertensive patients and reporting sufficient data were included.

Data extraction Data on study populations, echocardiographic criteria, and methodological quality of studies were extracted.

Data synthesis Negative likelihood ratios, which indicate to what extent the posterior odds of left ventricular hypertrophy is reduced by a negative test, were calculated.

Results 21 studies and data on 5608 patients were analysed. The median prevalence of left ventricular hypertrophy was 33% (interquartile range 23-41%) in primary care settings (10 studies) and 65% (37-81%) in secondary care settings (11 studies). The median negative likelihood ratio was similar across electrocardiographic indexes, ranging from 0.85 (range 0.34-1.03) for the Romhilt-Estes score (with threshold ≥4 points) to 0.91 (0.70-1.01) for the Gubner index. Using the Romhilt-Estes score in primary care, a negative electrocardiogram result would reduce the typical pre-test probability from 33% to 31%. In secondary care the typical pre-test probability of 65% would be reduced to 63%.

Conclusion Electrocardiographic criteria should not be used to rule out left ventricular hypertrophy in patients with hypertension.

INTRODUCTION

Left ventricular hypertrophy is an important risk factor in patients with hypertension, leading to a fivefold to 10-fold increase in cardiovascular risk.[1-5] Decisions about treatment should be based on assessments of hypertensive target organ damage and overall cardiovascular risk. The appropriate diagnostic work-up of suspected left ventricular hypertrophy in patients with hypertension is less clear, however. More than 30 electrocardiographic indexes for the diagnosis of left ventricular hypertrophy have been described. Many of the proposed indexes have remained anecdotal, but others are commonly used.[6-10] Debate about their comparative diagnostic value continues.[11-13] We did a systematic review to clarify the accuracy of different electrocardiographic indexes.

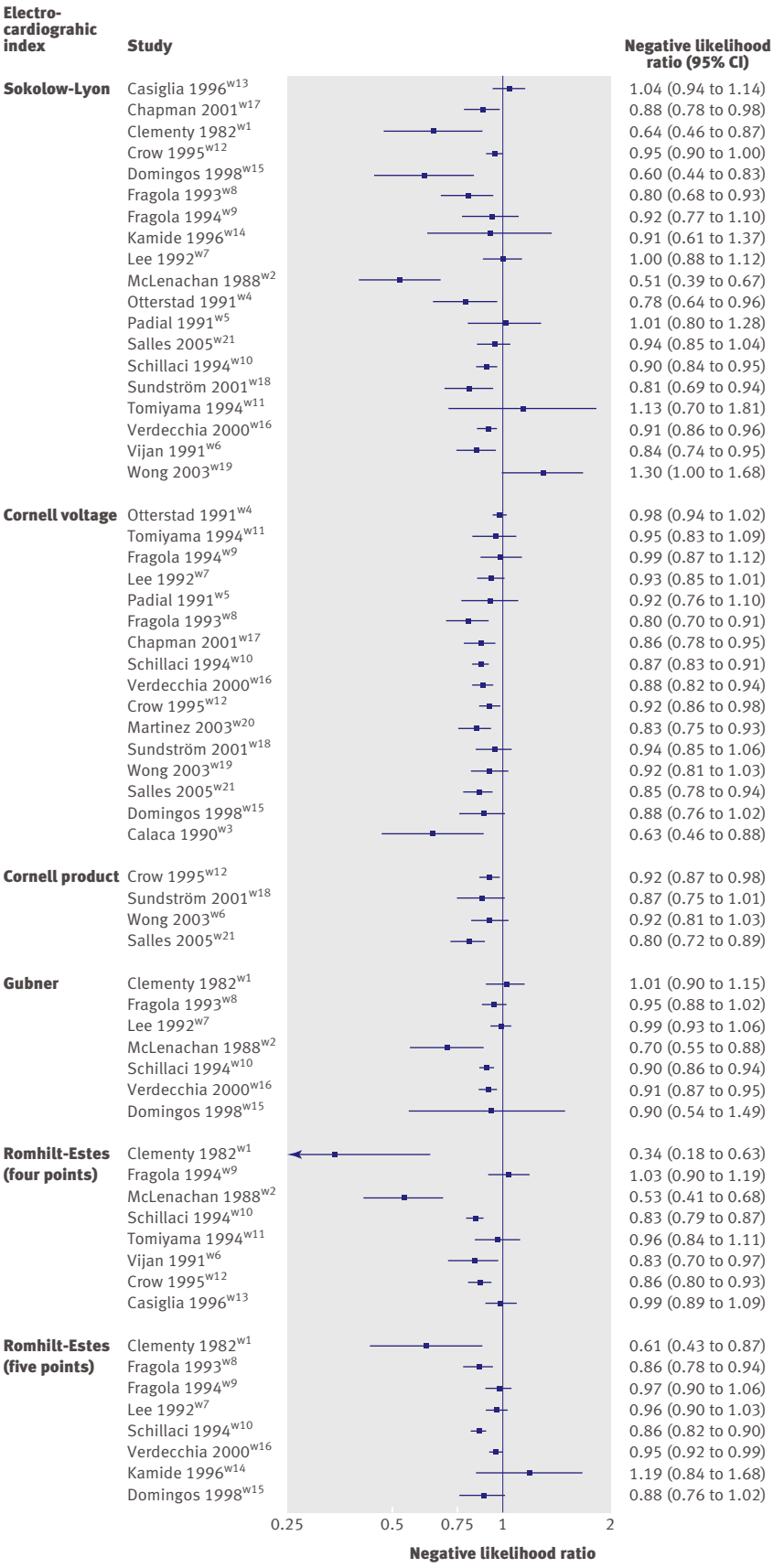

Fig 1 | Forest plots of negative likelihood ratio from test accuracy studies of six electrocardiographic indexes in diagnosis of left ventricular hypertrophy. Points represent estimates of likelihood ratio; lines represent 95% confidence intervals

METHODS

Identification of studies—We searched Medline from 1966 to December 2005 and Embase from 1980 to December 2005 to identify observational studies that evaluated the accuracy of electrocardiographic indexes for the diagnosis of left ventricular hypertrophy and established the presence or absence of left ventricular hypertrophy with echocardiography. We checked reference lists of relevant studies and contacted experts to complement electronic searches.

Study selection—We included studies in asymptomatic patients with primary arterial hypertension in any healthcare setting. Studies included patients taking antihypertensive treatment, those being evaluated for treatment, and patients in whom treatment was withdrawn shortly before evaluation. Two reviewers independently assessed the abstracts of all retrieved studies. We included all studies that assessed the electrocardiographic criteria in hypertensive adults against echocardiography.

Data extraction—We extracted data in duplicate, including the number and characteristics of patients, the healthcare setting, the prevalence of echocardiographically confirmed left ventricular hypertrophy, the electrocardiographic indexes evaluated, and the definition of the echocardiography threshold.

Assessment of study quality—We assessed the methodological quality of papers. We examined the methods of patient selection and data collection, completeness of descriptions of index and reference tests, completeness of blinding, and the likelihood of verification bias.[14-16] We ranked the quality of studies on the basis of the following criteria: description of setting; prospective data collection, with enrolment of consecutive patients and follow-up of all patients; and provision of details on echocardiography and blinding.

Statistical analysis—We calculated sensitivities, specificities, and likelihood ratios with their confidence intervals. As the electrocardiogram will mainly be used to rule out the diagnosis of left ventricular hypertrophy, we were particularly interested in the sensitivity and the likelihood ratio of a negative electrocardiogram result. The likelihood ratio of a negative test indicates how likely it is to find a negative result among people with left ventricular hypertrophy compared with those without.[17] We summarised results by plotting sensitivities and specificities in the receiver operating curve space and by calculating medians, ranges, and interquartile ranges.

RESULTS

Our search identified 1761 citations. We considered 142 as potentially eligible, and after scrutinising the full text articles we included 21 studies.[w1-w21]

Study characteristics

The 21 studies included a total of 5608 (range 30-947) patients. Ten studies were done in primary care and 11 in secondary care. The median prevalence of left ventricular hypertrophy was 33% (interquartile range 23-41%) in primary care settings and 65% (37-81%) in

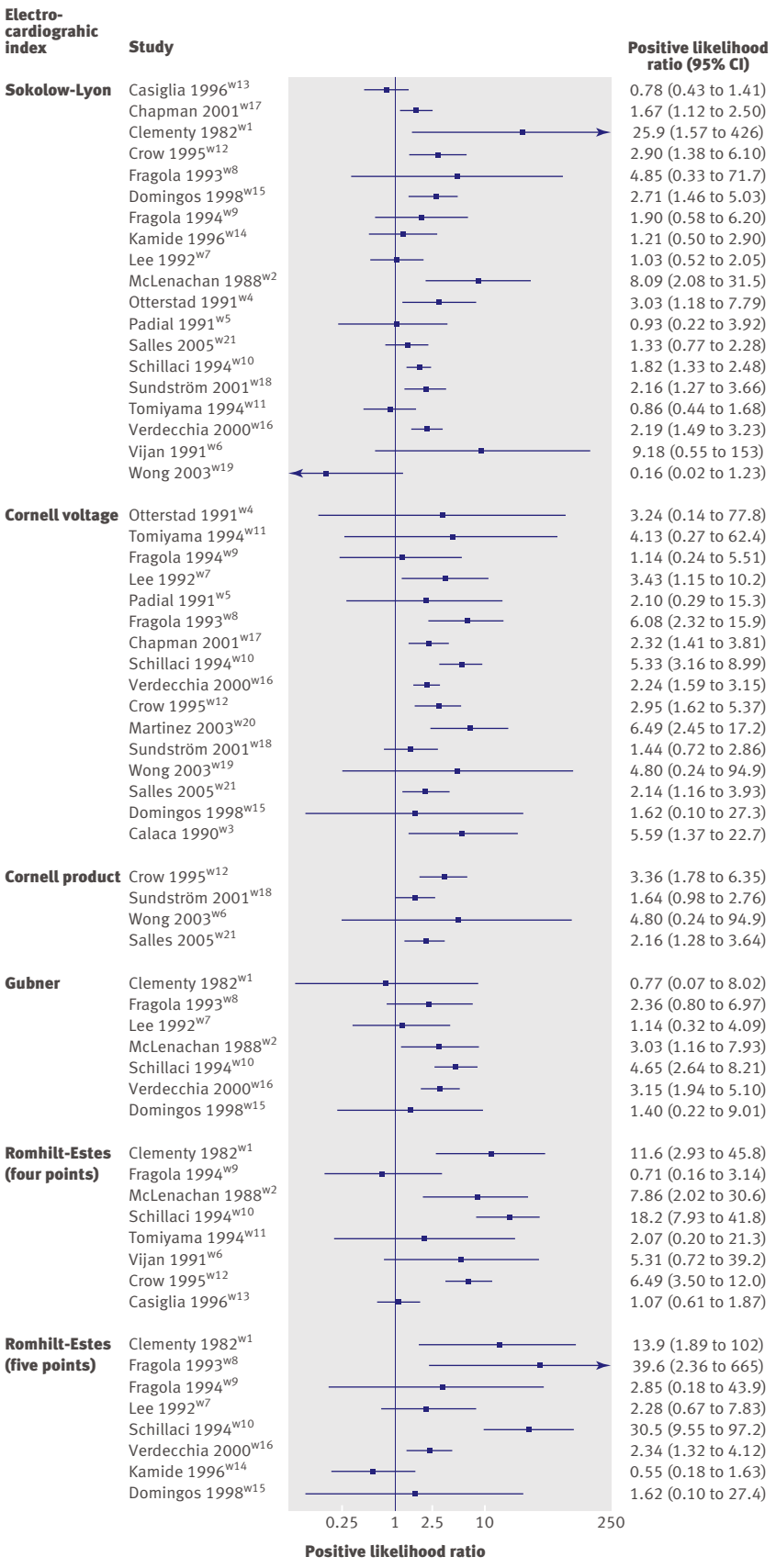

Fig 2 | Forest plots of positive likelihood ratio from test accuracy studies of six electrocardiographic indexes in diagnosis of left ventricular hypertrophy. Points represent estimates of likelihood ratio; lines represent 95% confidence intervals

secondary care. Three studies met all six methodological criteria and were ranked as high quality. Another 11 studies met four or five criteria and were ranked as intermediate quality, whereas seven studies met two or three quality criteria and were considered of low quality.

Electrocardiographic indexes

The 21 articles reported on 12 different electrocardiographic criteria. We analysed in detail the six most commonly used indexes, including the Sokolow-Lyon voltage index,[6] the Cornell voltage and Cornell product indexes,[7,8] the Gubner index,[9] and the Romhilt-Estes score with thresholds for a positive test of ≥4 points or ≥5 points.[10]

Sensitivity, specificity, and likelihood ratios

For all indexes, most studies showed low sensitivity and high specificity (see bmj.com). The median sensitivity ranged from 10.5% (range 0-39%) for the Gubner index to 21% (4-52%) for the Sokolow-Lyon index. Median specificity ranged from 89% (53-100%) for the Sokolow-Lyon index to 99% (71-100%) for the Romhilt-Estes (five points) score.

Figures 1 and 2 show forest plots of the negative and positive likelihood ratios. The median negative likelihood ratio was similar across electrocardiographic indexes, ranging from 0.85 (range 0.34-1.03) for the Romhilt-Estes score (four points) to 0.91 (0.70-1.01) for the Gubner index. More variation existed in the positive likelihood ratio, which ranged from 1.90 (0.16-25.9) for the Sokolow-Lyon index to 5.90 (0.71-18.2) for the Romhilt-Estes score (four points). Using the median likelihood ratios from the Romhilt-Estes score (four points) in primary care, a negative electrocardiogram result would reduce the typical pre-test probability of 33% to 31%, whereas a positive electrocardiogram would increase it to 74%. In secondary care, the typical pre-test probability of 65% would be reduced to 63% or increased to 92%.

DISCUSSION

This systematic review of studies of the accuracy of diagnostic tests found that the accuracy of electrocardiographic indexes in the diagnosis of left ventricular hypertrophy is unsatisfactory. Irrespective of the index used, the electrocardiogram is a poor screening tool to exclude left ventricular hypertrophy in hypertensive patients. Of note, specificity was reasonably high in most studies, but because sensitivity was low the power to rule in left ventricular hypertrophy was also unsatisfactory.

Strengths and limitations

We did a comprehensive literature search, selected studies according to pre-defined criteria, and appraised the methodological quality of studies. We excluded diagnostic case-control studies, which are known to overestimate accuracy,[14,15] as well as studies that did not index ventricular mass for body surface area. We also excluded studies that evaluated patients with concomitant left anterior fascicular block and left bundle

WHAT IS ALREADY KNOWN ON THIS TOPIC

Left ventricular hypertrophy leads to a fivefold to 10-fold increase in cardiovascular risk in hypertensive patients

Several indexes calculated from standard 12 lead electrocardiograms are used in the diagnostic work-up of patients with hypertension

WHAT THIS STUDY ADDS

The accuracy of the more commonly used electrocardiographic criteria for ruling out left ventricular hypertrophy is unsatisfactory in both primary and secondary care.

Echocardiography is needed for a comprehensive assessment of cardiovascular risk in hypertensive patients

branch block, because these patients usually need further examinations and referral irrespective of left ventricular hypertrophy. We summarised the evidence by calculating medians, rather than combining data in meta-analysis. We believe that a formal meta-analysis would have added little in this situation. We felt that further exploration of potential sources of heterogeneity was not warranted. The published data did not allow direct comparisons of test accuracy between the different indexes. More importantly, we did not identify any randomised comparisons of diagnostic and treatment strategies and assessed clinical end points.

Implications for clinical practice

Electrocardiograms should not be done specifically to exclude left ventricular hypertrophy in patients with hypertension. Referral for specialist examinations is often based on high cardiovascular risk scores, but echocardiography may be more informative in hypertensive patients who, on the basis of age, sex, smoking history, and blood lipids, are at low or intermediate risk. In patients known to be at high risk, echocardiographic findings will often not affect clinical management, because interventions to reduce risk are already in place.

The evidence on the capacity of various antihypertensive agents to decrease left ventricular hypertrophy is limited. Preventing cardiovascular disease through modifications of other risk factors such as smoking cessation, lifestyle change, or lipid lowering treatment is the most promising approach.[18 19]

Future research

Further research is needed to identify cost effective diagnostic strategies in primary care settings. Such research could inform the development of algorithms to identify patients who should be referred for echocardiography. In the absence of accurate and inexpensive screening tests for left ventricular hypertrophy, research into new diagnostic technologies is also warranted. Further studies are needed to better define the pathophysiological mechanisms and outcomes in patients with echocardiographically confirmed left ventricular hypertrophy but negative electrocardiograms. Similarly, more data are needed on patients with positive electrocardiographic tests but negative echocardiography.

Conclusions

The power of some of the more commonly used electrocardiographic criteria to rule out the diagnosis of left ventricular hypertrophy in patients with hypertension is poor. Further research is needed to assess the cost effectiveness of different diagnostic and treatment strategies of left ventricular hypertrophy in primary care.

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