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Clinical Effect and Cost-Effectiveness of Screening for Asymptomatic Carotid Stenosis: A Markov Model

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WHAT THIS PAPER ADDS

Screening for carotid atherosclerosis is again up for debate and several guidelines even recommend selective screening in high risk populations. The present paper evaluates the cost-effectiveness of a screening strategy in a contemporary population based setting. The study indicates that the most important variable affecting cost-effectiveness of screening for carotid disease is the estimated stroke risk reduction effect of medical treatment initiated in the cohort with carotid stenosis detected at screening. Screening for asymptomatic carotid artery stenosis is highly likely to be cost-effective when assuming a minimum stroke risk reduction effect of 22% for best medical treatment.

Objective/Background: The cost-effectiveness of screening depends on the cost of screening, prevalence of asymptomatic carotid artery stenosis (ACAS), and the potential effect of medical intervention in reducing the risk of stroke. The aim of the study was to determine the threshold values for these parameters in order for screening for ACAS to be cost-effective.

Methods: The clinical effect and cost-effectiveness of ultrasound screening for ACAS with subsequent initiation of preventive therapy versus not screening was assessed in a Markov model with a lifetime perspective. Key parameters, including stroke risk, all cause mortality, and costs, were based on contemporary published data, population statistics, and data from an ongoing screening program in Uppsala county (population 300,000), Sweden. Prevalence of ACAS (2%) and the rate of best medical treatment (BMT; 40%) were based on data from a male Swedish population recently screened for ACAS. The required stroke risk reduction from BMT, incremental cost-efficiency ratio (ICER), absolute risk reduction for stroke (ARR), and number needed to screen (NNS) were calculated.

Results: Screening was cost-effective at an ICER of €5744 per incremental quality adjusted life year (QALY) gained. ARR was 135 per 100,000 screened, NNS was 741, and QALYs gained were 6700 per 100,000 invited. At a willingness to pay (WTP) threshold of €50,000 per QALY the minimum required stroke risk reduction from BMT was 22%. The assumed degree of stroke risk reduction was the most important determinant of cost-efficiency.

Conclusion: A moderate (22%) reduction in the risk of stroke was required for an ACAS screening strategy to be cost-effective at a WTP of €50,000/QALY. Targeting populations with a higher prevalence of ACAS could further improve cost-efficiency.

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INTRODUCTION

Asymptomatic carotid artery disease represents a significant risk factor for cardiovascular events, including stroke. Studies show that primary preventive treatment and risk factor adjustment may be beneficial.[1,2] Hence, the value of screening for carotid artery stenosis has been discussed.[1] While population screening for carotid disease is not recommended in current guidelines,[1,2] selective screening may be considered in patients with multiple vascular risk factors in order to optimise risk factor control and medical therapy, and reduce cardiovascular morbidity and mortality.[1] Factors affecting the efficacy of a screening strategy in an asymptomatic population include prevalence of disease in the target population, validity and reliability of the screening tool, and benefits and harms associated with preventive therapy.[3] The prevalence of significant (>50%) carotid

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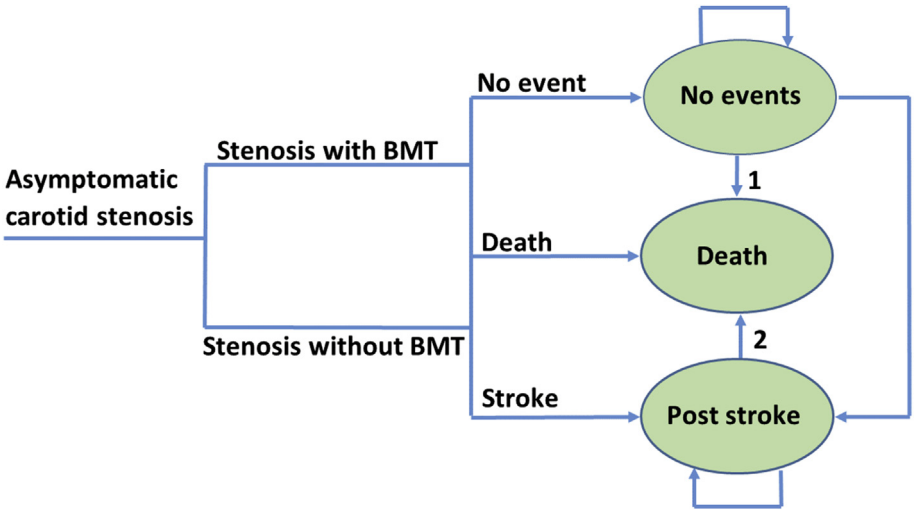

Figure 1. Markov model structure. (1) Death from unrelated causes; (2) conditional life expectancy. Same structure for the screening cohort and no-screening cohort except different part of best medical treatment (BMT).

stenosis among 65 year old Swedish men is 2%, when evaluated with duplex ultrasound as the diagnostic tool.[4]

Previous studies have shown a small benefit for surgery versus best medical treatment (BMT) in terms of stroke reduction in patients with asymptomatic carotid artery disease.[5,6] However, BMT has improved significantly over the past few years, with the broad introduction of statins and effective antiplatelet therapy.[7] Recent data suggest that BMT should be the treatment of choice, questioning the role of surgery in asymptomatic patients.[8,9]

The possible clinical effectiveness and cost-efficiency of a screening program initiating BMT among non-medicated individuals with screening detected asymptomatic carotid artery stenosis (ACAS) has not been investigated in a modern population. The aim of the present study was to determine the threshold values for parameters affecting cost-effectiveness of ultrasound screening for ACAS, with a focus on the minimum required stroke risk reduction of contemporary BMT for screening to be cost-effective.

MATERIALS AND METHODS

A Markov cohort simulation was performed to investigate two hypothetical cohorts of 65 year old men assigned to either a strategy with one time ultrasound screening of carotid arteries or a strategy of no screening (where management of ACAS was based on incidental detection). The study setting was the Swedish healthcare system, with the exception of annual stroke risk rates and mortality rates, which were extrapolated from international cohorts. A carotid stenosis was defined as >50% stenosis according to the Jogestrand criteria (European Carotid Surgery Trial (ECST)).[10] Individuals with screen detected carotid artery stenosis were simulated to receive BMT. BMT included antihypertensive treatment, blood glucose control, lipid lowering therapy, and antiplatelet agents. It was assumed that real life compliance was the same in both cohorts. In the screening cohort all subjects received BMT, whereas in the cohort not participating in screening 40% were assumed to have BMT for other causes, as reported in a recent screening study.[4] The prevalence of carotid artery stenosis, as well as risk factors, was assumed to be equal in both groups. The potential effect of preventive treatment in terms of stroke risk reduction among patients with screen detected ACAS was simulated in the model, in order to assess the minimum required effect to reach cost-effectiveness for screening.

Model structure

A Markov state transition model (1 year cycles) was constructed to model disease progression and the effect of preventive therapy for the screening and non-screening strategies (Fig. 1). The model was made up of three exclusive health states: no events, post stroke, and death (represented by ovals in Fig. 1). Subjects were followed from the time of screening until death or reaching 100 years of age. At the end of the simulation accumulated costs and health outcome (quality adjusted life years [QALYs]) were summarised for each cohort. The screening cohort was subjected to screening costs and the cost of BMT for all individuals, whereas the no-screening cohort was subjected to a lower cost of BMT, as only a fraction of individuals with ACAS were receiving BMT. Cost of care for a stroke event was equal for both cohorts. Cost-effectiveness acceptability was defined as an incremental cost efficiency ratio (ICER) below £20,000–£30,000 (€23,000–36,000) per incremental QALY,[11] and a willingness to pay (WTP) threshold of €100,000/€50,000 per incremental QALY, as defined by the National Board of Health and Welfare in Sweden, was evaluated.[12] Parameters with inherent uncertainty based on the available literature were range tested in a deterministic sensitivity analysis. Probabilities were tested with a Monte Carlo analysis that was set to 1,000,000 simulations. The model was developed in the TreeAge Pro 2016 Healthcare software package (TreeAge Software, Williamston, MA, USA).

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