RESEARCH

Meta-analysis of minimally invasive internal thoracic artery bypass versus percutaneous revascularisation for isolated lesions of the left anterior descending artery

Omer Aziz,[1] Christopher Rao,[1] Sukhmeet Singh Panesar,[1] Catherine Jones,[1] Stephen Morris,[2] Ara Darzi,[1] Thanos Athanasiou[1]

EDITORIAL by Taggart

[1]Department of Biosurgery and Surgical Technology, Imperial College London, St Mary's Hospital, London W2 1NY
[2]Tanaka Business School, Imperial College London
Correspondence to: T Athanasiou
tathan5253@aol.com

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ABSTRACT

Objective To compare outcomes between minimally invasive left internal thoracic artery bypass and percutaneous coronary artery stenting as primary interventions for isolated lesions of the left anterior descending artery.

Design Meta-analysis of randomised and non-randomised comparative peer reviewed publications.

Data sources Embase, Medline, Cochrane, Google Scholar, and Health Technology Assessment databases (1966-2005).

Review methods Studies comparing the two procedures as the primary intervention for isolated left anterior descending artery stenosis were identified and the following extracted: study design, population characteristics, severity of coronary artery disease, cardiovascular risk factors, and outcomes of interest.

Results 12 studies (1952 patients) reporting results from eight groups were included: one was a retrospective design, one prospective non-randomised, and six prospective randomised. Meta-analysis of randomised trials showed a higher rate of recurrence of angina (odds ratio 2.62, 95% confidence interval 1.32 to 5.21), incidence of major adverse coronary and cerebral events (2.86, 1.62 to 5.08), and need for repeat revascularisation (4.63, 2.52 to 8.51) with percutaneous stenting. No significant difference was found in myocardial infarction, stroke, or mortality at maximum follow-up between interventions.

Conclusions Minimally invasive left internal thoracic artery bypass for isolated lesions of the left anterior descending artery resulted in fewer complications in the mid-term compared with percutaneous transluminal coronary artery stenting.

INTRODUCTION

Much debate centres on what primary revascularisation strategy is best suited to patients with isolated lesions of the left anterior descending artery. We carried out a meta-analysis to compare outcomes from the best percutaneous intervention (transluminal coronary artery stenting) with the least invasive surgical intervention (minimally invasive direct coronary artery bypass with left internal thoracic artery).

METHODS

We carried out an electronic search on all studies published between 1966 and 2006 reporting on minimally invasive direct coronary artery bypass with left internal thoracic artery anastomosis compared with percutaneous transluminal coronary artery stenting (see bmj.com for search strategy).

Studies had to compare the two interventions for isolated lesions of the left anterior descending artery, include a patient group undergoing the procedure as a primary intervention, report on at least one outcome of interest, and contain a previously unreported patient group (for multiple studies reporting outcomes at different follow-up points, we extracted patient characteristics from the first study, with data for outcomes of interest at subsequent follow-up times extracted from the later studies).

We compared the two interventions for recurrence of angina, postoperative myocardial infarction (within 30 days of operation), myocardial infarction at maximum follow-up; stroke (including cerebrovascular event and transient ischaemic attacks), mortality (at maximum follow-up), need for repeat revascularisation at maximum follow-up, and major adverse coronary and cerebral events (a composite outcome including myocardial infarction, stroke, and death). In our study minimally invasive internal thoracic artery bypass refers to one of three types (see bmj.com).

Statistical analysis

For categorical variables we used the odds ratio as the summary statistic. To translate these results into benefits to clinical outcome we calculated the risk difference and number needed to treat to prevent one complication event. We used the Mantel-Haenszel method to combine the odds ratio for the outcomes of interest.

In this study we used a random effects model. In the primary analysis we considered only randomised trials. Heterogeneity was assessed using three strategies (see bmj.com).

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RESULTS

Twelve studies were included, totalling 1952 patients; 67% underwent transluminal stenting and 33% underwent minimally invasive internal thoracic artery bypass.[w1-w15] Two groups each published three studies using the same patient group but were included because they reported outcomes at different follow-up periods in each of these studies.[w2-w7] This paper reports on the results of eight groups over the 12 studies. The study designs were prospective randomised in six groups,[w1-w7 w13-w15] retrospective in one,[w11] and prospective non-randomised in one (see bmj.com for the trials' characteristics).[w9] Figures 1 and 2 show the results from meta-analysis of the randomised trials.

Outcomes of interest

Recurrence of angina

Four groups reported on the recurrence of angina. All were randomised trials with at least 12 months' follow-up.[w1-w7 w13] Meta-analysis of these showed a significantly higher incidence of recurrence at maximum follow-up with transluminal stenting (29%) compared with minimally invasive internal thoracic artery bypass (14%): odds ratio 2.62 (95% confidence interval 1.32 to 5.21); risk difference 15% (4% to 25%); NNT=7.

Postoperative myocardial infarction

Seven groups reported on postoperative myocardial infarction during the 30 days after intervention.[w2-w7 w9 w11 w13-w15] Meta-analysis of the five randomised studies[w2-w7 w13-w15] showed no significant difference in the incidence of postoperative myocardial infarction between transluminal stenting (3.7%) and minimally invasive internal thoracic artery bypass (2.7%): odds ratio 1.30 (0.51 to 3.32). For pooled studies, no significant difference was found between the groups (1.3% with transluminal stenting *v* 1.7% with minimally invasive internal thoracic artery bypass: 0.91, 0.38 to 2.19). Subgroup analysis of studies with at least 12 months' follow-up[w2-w7 w9 w11 w13 w15] also showed no significant difference between the groups (1.1% with transluminal stenting *v* 1.5% with minimally invasive internal thoracic artery bypass; 0.91, 0.29 to 2.79).

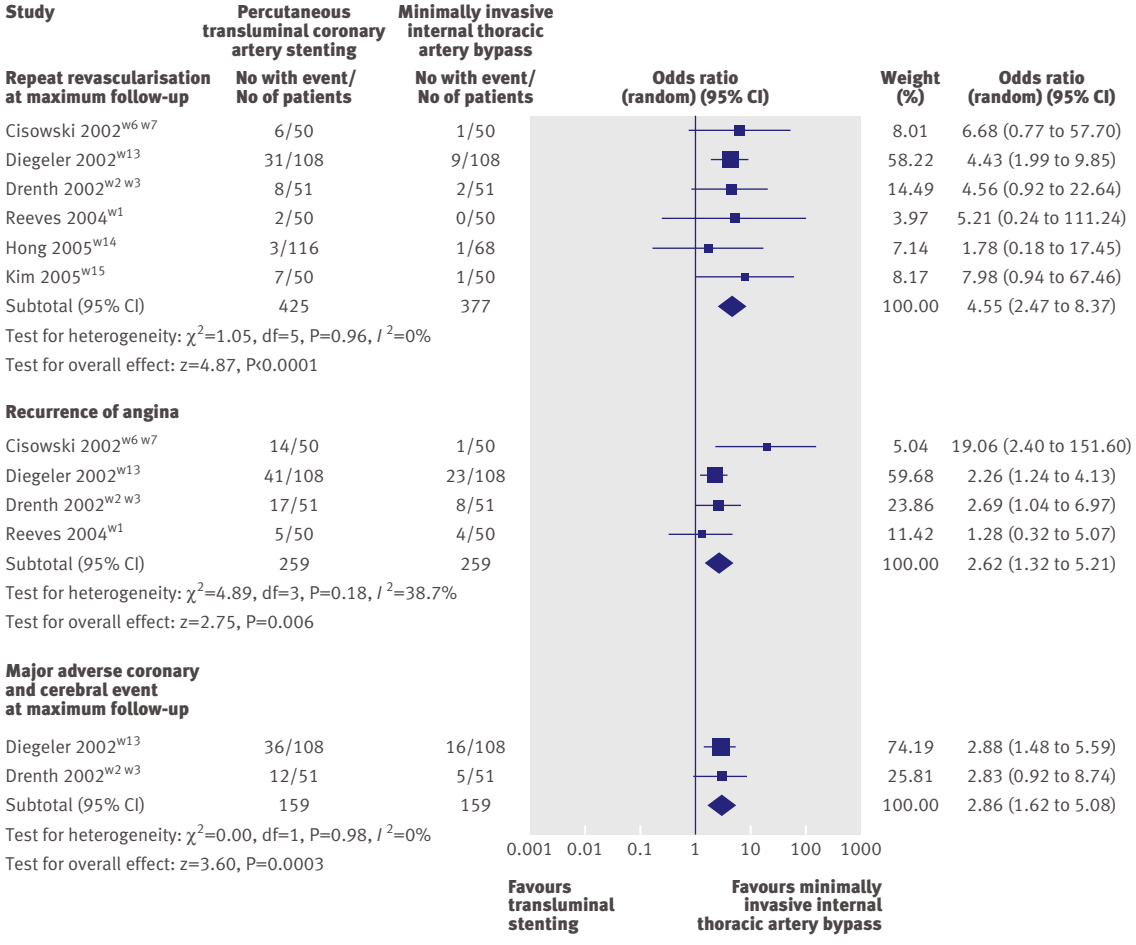

Fig 1 | Forest plot showing results from meta-analysis of randomised trials reporting need for repeat revascularisation at maximum follow-up, recurrence of angina, and major adverse coronary and cerebral event after minimally invasive thoracic artery bypass compared with transluminal stenting

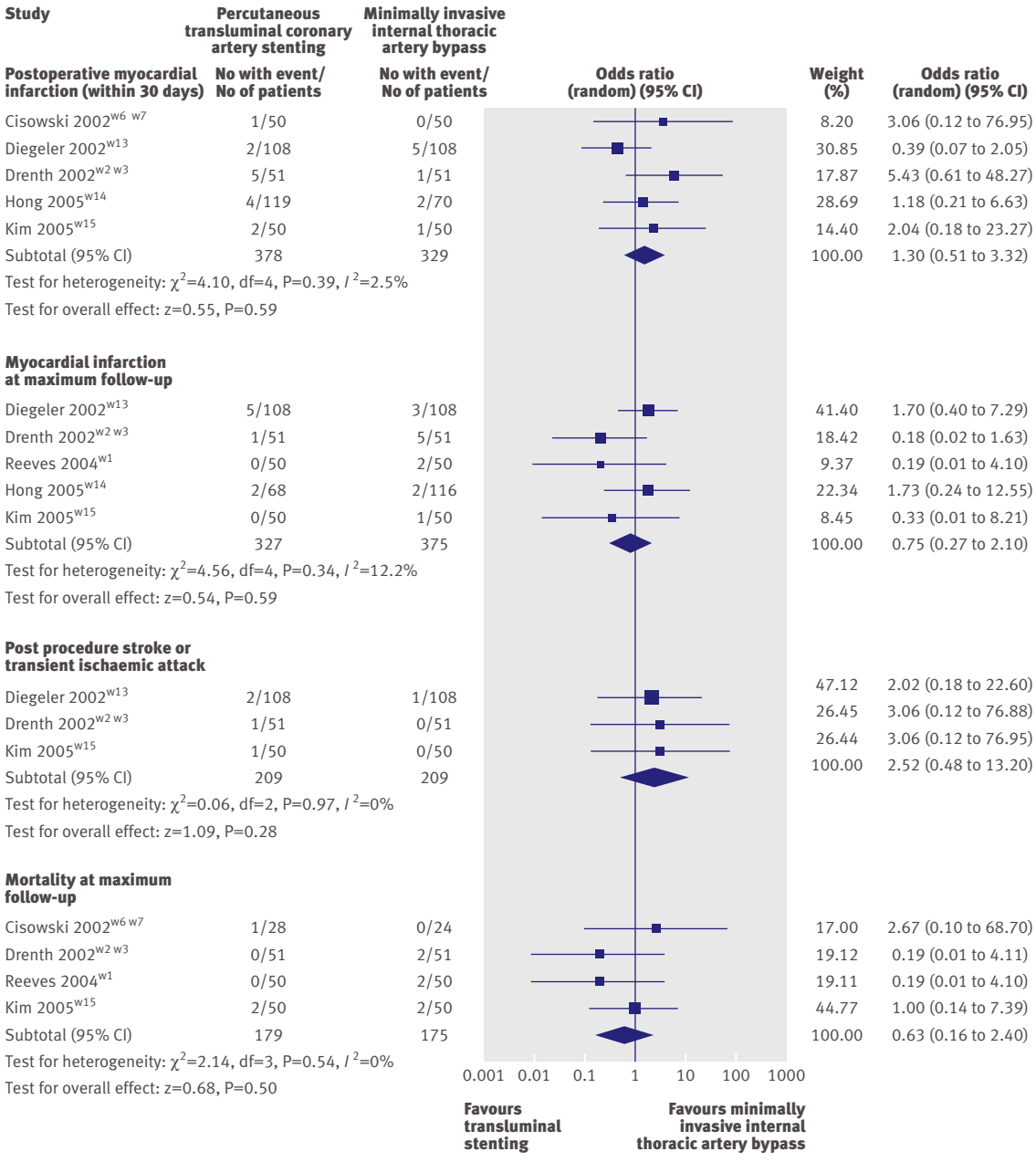

Fig 2 | Forest plot showing results from meta-analysis of randomised trials reporting postoperative myocardial infarction, myocardial infarction at maximum follow-up, mortality at maximum follow-up, and post-procedural stroke or transient ischaemic attack after minimally invasive thoracic artery bypass compared with transluminal stenting

Myocardial infarction at maximum follow-up

Seven groups reported on the incidence of myocardial infarction over the follow-up period, ranging from nine to 92 months.[w1-w4 w9 w11 w13-w15] Of these, five were randomised studies[w1-w4 w13-w15] and six contained groups with at least 12 months' follow-up.[w1-w4 w9 w11 w13 w15] Meta-analysis of the randomised trials showed no significant difference in the incidence of myocardial infarction between transluminal stenting (2.4%) and minimally invasive internal thoracic artery bypass (3.5%): odds ratio 0.75 (95% confidence interval 0.27 to 2.10). For pooled studies the respective incidence was 1.2% and 1.5%: 0.92 (0.36 to 2.34). When only studies with follow-up of at least one year were considered the respective incidence was 1.2% and 1.4%: 0.77 (0.25 to 2.36).

Stroke or transient ischaemic attack

Five groups reported on the incidence of stroke (including transient ischaemic attack).[w2-w4 w9 w11 w13 w15] of which three were prospective randomised trials.[w2-w4 w13 w15] All studies had a follow-up time greater than 12 months. Meta-analysis of the randomised trials showed no significant difference in the incidence of stroke between transluminal stenting (1.9%) and minimally invasive internal thoracic artery bypass (0.5%): odds ratio

WHAT IS ALREADY KNOWN ON THIS TOPIC

Surgical bypass may offer a more favourable long term outcome for multiple vessel coronary disease compared with percutaneous interventions

Debate centres on what primary revascularisation strategy is best for patients with isolated lesions of the left anterior descending artery

WHAT THIS STUDY ADDS

For isolated disease of the left anterior descending artery, minimally invasive left internal thoracic artery bypass results in fewer mid-term complications than transluminal stenting

2.52 (95% confidence interval 0.48 to 13.2). This was true for pooled studies (2% *v* 1.1%; 1.67, 0.67 to 4.19).

Mortality at maximum follow-up

Five groups reported on mortality at maximum follow-up.[w1-w7 w11 w13 w15] Meta-analysis of the four randomised studies[w1-w7 w15] showed no significant difference in mortality at maximum follow-up between interventions (1.7% with transluminal stenting *v* 3.4% with minimally invasive internal thoracic artery bypass; odds ratio 0.63, 95% confidence interval 0.16 to 2.4). For pooled studies still no significant difference was found (2.9% *v* 3.4%; 0.83, 0.35 to 1.97).

Need for repeat revascularisation at maximum follow-up

Eight groups reported the need for repeat revascularisation (percutaneous or surgical bypass) over their maximum follow-up period.[w1-w7 w9 w11 w13-w15] Meta-analysis of the six randomised trials[w1-w7 w13-w15] produced a revascularisation rate of 13% for transluminal stenting compared with 4% for minimally invasive internal thoracic artery bypass (odds ratio 4.63, 95% confidence interval 2.52 to 8.51), significantly favouring surgery (risk difference 9%, 2% to 17%; NNT=11). For pooled studies this difference was still significant (14.3% *v* 4.4%; odds ratio 3.56, 2.35 to 5.41). Subgroup analysis of seven studies with at least 12 months' follow-up also showed significantly higher revascularisation rates after transluminal stenting (15.4% *v* 4.8%; 3.65, 2.39 to 5.59). [w1-w7 w9 w11 w13 w15]

Composite outcome for major adverse coronary and cerebral events

Three studies reported the incidence of the composite outcome for major adverse coronary and cerebral events at maximum follow-up.[w2-w4 w9 w13] Meta-analysis of the two randomised trials[w2-w4 w13] showed a significantly higher incidence of the outcome after transluminal stenting: 30% *v* 11%; odds ratio 2.86 (1.62 to 5.08); risk difference 19% (8% to 25%); NNT=5. For pooled studies the results still favoured surgical revascularisation (21.4% *v* 11.1%; odds ratio 2.62, 1.71 to 4.02).

Sensitivity analysis

See bmj.com for the results for sensitivity analysis using fixed and random effects models for postoperative myocardial infarction, need for repeat revascularisation, and mortality at maximum follow-up. The lowest heterogeneity for repeat revascularisation at maximum follow-up was identified when only randomised trials were considered, followed by studies with more than 70 patients in each group (see figures on bmj.com).

DISCUSSION

The findings from our meta-analysis suggest that minimally invasive direct coronary artery bypass produces a more definitive revascularisation in the mid-term for isolated lesions of the left anterior descending than does percutaneous transluminal coronary artery stenting, with a reduced rate of recurrence of angina, incidence of the composite outcome of major adverse coronary and cerebral events, and need for repeat revascularisation. One explanation may be that stenting has a greater potential to occlude septal branches and diagonals, affecting interventricular septal blood supply.

Several aspects of the included studies deserve consideration. Firstly, none matched patients for severity of lesions, which has implications for the success of stenting.[1] Patients with tortuous and diffuse lesions are at greater risk of periprocedural complications from stenting and may further benefit from minimally invasive internal thoracic artery bypass. Secondly, the effect of the learning curve for minimally invasive internal thoracic artery bypass must be clarified as it affects patency rates. Thirdly, advances in robotic minimally invasive surgery means that anastomosis can be carried out with less trauma.[2] Finally, newer technologies offer the potential to improve the outcome from transluminal stenting, although this may not translate to a reduction in total mortality.[3]

Our meta-analysis has several limitations. Firstly, the studies may have had different criteria for defining outcomes of interest. Secondly, treatment allocations and outcome assessments were not blinded. Thirdly, publication bias could have been present. Fourthly, the use of a composite outcome is not as robust as reporting its individual components. Finally, the studies varied in quality (see bmj.com).

Our findings reinforce the need for a multidisciplinary approach in the management of patients with isolated lesions of the left anterior descending artery. A real need exists to evaluate the long term cost effectiveness and impact on patients' quality of life of minimally invasive internal thoracic artery bypass compared with transluminal stenting. To do this we propose the use of an evidence synthesis approach, which we have undertaken to compare the long term cost effectiveness and effect on quality of life of the two interventions for this patient group.[4]

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Competing interests: None declared.
Ethical approval: Not required.

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Cost effectiveness analysis of minimally invasive internal thoracic artery bypass versus percutaneous revascularisation for isolated lesions of the left anterior descending artery

Christopher Rao,[1] Omer Aziz,[1] Sukhmeet Singh Panesar,[1] Catherine Jones,[1] Stephen Morris,[2] Ara Darzi,[1] Thanos Athanasiou[1]

EDITORIAL by Taggart

[1]Department of Biosurgery and Surgical Technology, Imperial College London, St Mary's Hospital, London W2 1NY
[2]Tanaka Business School, Imperial College London
Correspondence to: T Athanasiou tathan5253@aol.com

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ABSTRACT

Objective To compare the cost effectiveness of percutaneous transluminal coronary artery stenting with minimally invasive internal thoracic artery bypass for isolated lesions of the left anterior descending artery.

Design Cost effectiveness analysis.

Data sources Embase, Medline, Cochrane, Google Scholar, and Health Technology Assessment databases (1966-2005), and reference sources for utility values and economical variables.

Methods Decision analytical modelling and Markov simulation were used to model medium and long term costs, quality of life, and cost effectiveness after either intervention using data from referenced sources. Probabilistic sensitivity and alternative analyses were used to investigate the effect of uncertainty about the value of model variables and model structure.

Results Stenting was the dominant strategy in the first two years, being both more effective and less costly than bypass surgery. In the third year bypass surgery still remained more expensive but became marginally more effective. As the incremental cost effectiveness was £1 108 130.40 (€1 682 146.00; $2 179 194) per quality adjusted life year (QALY), the additional effectiveness could not be said to justify the additional cost at this stage. By five years, however, the incremental cost effectiveness ratio of £28 042.95 per QALY began to compare favourably with other interventions. At 10 years the additional effectiveness of 0.132 QALYs (range −0.166 to 0.430) probably justified the additional cost of £829.02 (range £205.56 to £1452.48), with an incremental cost effectiveness of £6274.02 per QALY. Sensitivity and alternative analysis showed the results were sensitive to the time horizon and stent type.

Conclusions Minimally invasive left internal thoracic artery bypass may be a more cost effective medium and long term alternative to percutaneous transluminal coronary artery stenting.

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INTRODUCTION

A meta-analysis of randomised trials suggested that minimally invasive internal thoracic artery bypass for isolated lesions of the left anterior descending artery resulted in fewer complications in the mid-term than did transluminal stenting.[1] We compared the cost effectiveness of the two interventions and determined whether this translated into differences in quality of life.

METHODS

We calculated the incidences of clinical outcomes of interest from the meta-analysis weighted means data.[1] We used decision analysis and Markov simulation to model long term outcomes of interventions in the absence of empirical long term follow-up data.[2] We used quality adjusted life years (QALYs) and cost as measures of effect and the incremental cost effectiveness ratio to assess whether improved efficacy justified increased cost. To investigate the uncertainty of our results we used sensitivity and alternative analysis.

Model structure and variables

The model we used is on bmj.com. The base case analysis was for a 61 year old male cohort, the average age of patients in the included studies. We carried out the analysis for a 10 year time horizon, with one year Markov cycles. Costs and effects were discounted at 3.5%.

We converted the incidences of outcomes into transition probabilities[3] with the exception of perioperative death and cerebrovascular event, which we assumed to always occur within the first cycle. See bmj.com for sources of transition probabilities for baseline mortality, the likelihood of death after myocardial infarction and cerebrovascular event, confidence intervals for these values, and a table showing the variables used in the analysis.