

***Minimally Invasive
Direct Coronary
Artery Bypass
(MIDCAB) with the
Aid of Tissue
Stabilisers***

September 2001

MSAC reference 11

Assessment report

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The Medical Services Advisory Committee is an independent committee which has been established to provide advice to the Commonwealth Minister for Health and Ageing on the strength of evidence available on new and existing medical technologies and procedures in terms of their safety, effectiveness and cost-effectiveness. This advice will help to inform Government decisions about which medical services should attract funding under Medicare.

This report was prepared by the Medical Services Advisory Committee with the assistance of Ms Philippa Middleton and Dr Ann Scott from the Australian Safety and Efficacy Register of New Interventional Procedures – Surgical (ASERNIP-S). The report was endorsed by the Commonwealth Minister for Health and Ageing on 17 May 2002.

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MSAC recommendations do not necessarily reflect the views of all individuals who participated in the MSAC evaluation.

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Executive summary

The procedure

MIDCAB (minimally invasive direct coronary artery bypass) is a coronary artery bypass procedure done on a beating heart, through a minimal access incision.

Medical Services Advisory Committee – role and approach

The Medical Services Advisory Committee (MSAC) is a key element of a measure taken by the Commonwealth Government to strengthen the role of evidence in health financing decisions in Australia. MSAC advises the Commonwealth Minister for Health and Ageing on the evidence relating to the safety, effectiveness and cost-effectiveness of new and existing medical technologies and procedures, and under what circumstances public funding should be supported.

A rigorous assessment of the available evidence is thus the basis of decision making when funding is sought under Medicare. A team from the Australian Safety and Efficacy Register of New Interventional Procedures-Surgical (ASERNIP-S) was engaged to conduct a systematic review of literature on MIDCAB. A supporting committee with expertise in this area then evaluated the evidence and provided advice to the MSAC.

MSAC's assessment of MIDCAB

For the purposes of this review MIDCAB is defined as off-pump coronary artery bypass (OPCAB) grafting undertaken without undertaking a full median sternotomy. The evidence on the relative safety, effectiveness and cost-effectiveness of OPCAB using a full median sternotomy compared with conventional coronary artery bypass graft (CCABG) is described in a companion report titled, 'Off-Pump Coronary Artery Bypass (OPCAB) with the Aid of Tissue Stabilisers'.

Clinical need

Coronary artery disease is the leading cause of disease burden in Australia. Over 17,000 coronary bypass operations were done in Australia in 1998 and most were done as conventional procedures. The MIDCAB technique may be less invasive than conventional coronary artery bypass in terms of reduced morbidity and may also use less resources.

Safety

No differences in mortality rates could be detected between MIDCAB and CCABG groups and there was some limited evidence that MIDCAB may be associated with less perioperative and postoperative morbidity (less need for transfusion, lower rates of atrial fibrillation and myocardial injury, and reduced inflammatory response) than for CCABG. However, this evidence came from mostly small randomised controlled trials and non-randomised studies. There was insufficient evidence to establish whether MIDCAB reduced postoperative pain.

Effectiveness

No differences in patency rates could be detected between MIDCAB and CCABG groups. The MIDCAB procedure may be associated with shorter operating times and shorter hospital stays than for CCABG procedures. However, there may be more need for re-intervention in MIDCAB compared to CCABG.

Cost-effectiveness

There is insufficient evidence to determine whether MIDCAB procedures were less costly than CCABG procedures, although shorter operating times and shorter hospital stays are likely to make MIDCAB less costly than CCABG.

Recommendation

MSAC recommends that, on the strength of evidence pertaining to minimally invasive coronary artery bypass with the aid of tissue stabilisers, public funding should be supported where perfusion facilities are available for reasons of patient safety.

The Minister for Health and Ageing accepted this recommendation on 17 May 2002.

Introduction

The Medical Services Advisory Committee (MSAC) has reviewed the use of MIDCAB, which is a therapeutic technology for coronary artery disease. MSAC evaluates new and existing health technologies and procedures for which funding is sought under the Medicare Benefits Scheme in terms of their safety, effectiveness and cost-effectiveness, while taking into account other issues such as access and equity. MSAC adopts an evidence-based approach to its assessments, based on reviews of the scientific literature and other information sources, including clinical expertise.

MSAC's terms of reference and membership are at Appendix A. MSAC is a multidisciplinary expert body, comprising members drawn from such disciplines as diagnostic imaging, pathology, surgery, internal medicine and general practice, clinical epidemiology, health economics, consumer health and health administration.

This report summarises the assessment of current evidence for MIDCAB in treating coronary artery disease.

Background

Minimally invasive direct coronary artery bypass (MIDCAB)

The first coronary artery bypass grafting (CABG) procedures were done on the beating heart, but CABG then progressed to the use of temporary cardiopulmonary bypass (CPB) with a heart-lung machine or pump oxygenator. Stopping the heart temporarily allows the surgeon to operate on a motionless and relatively bloodless field. In the 1990s some surgeons returned to beating heart techniques. This is now usually done with some form of mechanical stabilisation to partially immobilise the beating heart, and sometimes minimal access incision is used instead of a full median sternotomy.

The MIDCAB procedure combines both aspects (beating heart and small incision) of minimally invasive CABG. Potential advantages of this minimally invasive approach, such as reduced morbidity and resource use, need to be balanced against the unknown long-term results and potential disadvantages or risks, such as graft failure.

The procedure

For the purposes of this review, MIDCAB has been defined as a coronary artery bypass procedure done on a beating heart, through a minimal access incision. MIDCAB was initially limited to single vessel revascularisation, usually of the left anterior descending artery (LAD). MIDCAB procedures may also be done in patients with multivessel disease, either as repair of all the lesions (complete revascularisation) or restricted to repair of the 'culprit' lesion(s) (incomplete or target revascularisation). The most common incision is a left anterior small thoracotomy (LAST) and the most common graft type is LIMA (left internal mammary artery) to LAD.

The main indications for MIDCAB are coronary artery disease limited to the LAD; a repeat procedure involving the LAD (eg for restenosis after catheter-based therapy); and in high-risk patients with a small probability of surviving a full sternotomy because of co-morbidities (Nauenberg et al 2000; Talwalkar et al 1998). Challenges or relative contraindications for the MIDCAB approach include: small or calcified target vessels; diffusely diseased or intramyocardial target vessels; small IMA (internal mammary artery); and difficult access to the LAD (Talwalkar et al 1998).

The two main features of MIDCAB (beating heart and minimal access incision) purportedly offer the following advantages over conventional CABG (CCABG):

- reduction of operating time and perioperative complications such as blood loss and harmful neurocognitive effects; and
- reduction of postoperative recovery time, hospital stay and cost.

Although minimal access surgery may be perceived as also being less painful, some of the surgical access methods used in MIDCAB may be more painful than sternotomy (Talwalkar et al 1998).

Intended purpose

The purpose of MIDCAB is to repair coronary artery lesions with long-lasting patent grafts and to thereby give symptomatic relief and improve survival. The procedure may also use fewer resources than CCABG.

Clinical need/burden of disease

Coronary heart disease is the largest single cause of death in Australia, claiming almost 28,000 lives in 1998. Australian deaths from coronary heart disease rank towards the middle of 18 countries (ninth lowest for males and tenth lowest for females) (Australian Institute of Health and Welfare 2001).

In 1997–98 there were an estimated 18,817 coronary heart disease events (mainly heart attacks) in Australia among people aged 35–69 years. However, there are no national figures for the number of Australians who have coronary heart disease (Australian Institute of Health and Welfare 2001).

Burden of disease

Coronary heart disease was the leading cause of disease burden in Australian in 1996, accounting for 12% of disease burden, 20% of premature mortality and 3% of years of equivalent 'healthy' life lost through disease, impairment and disability (Australian Institute of Health and Welfare 2001).

There were 17,448 coronary bypass graft operations done in 1998 in Australia, with an estimated mortality rate of 2.1%. The national average for coronary artery bypass graft surgery was 879 per million population in 1998, although this varied markedly between states (Australian Institute of Health and Welfare 2001). About 17% of coronary bypass operations are done off-pump (Wallace 2001), with the majority being done as off-pump coronary artery bypass (OPCAB) (full median sternotomy) rather than MIDCAB (minimal access incision).

The direct costs of coronary artery disease in Australia in 1993–94 were \$894 million, with the majority of costs related to hospital inpatients. This represents nearly 3% of total recurrent health expenditure in Australia.

Although there has been a decline in mortality following CABG surgery, age continues to be an independent predictor of increased mortality and morbidity after myocardial revascularisation (Boyd et al 1999).

Existing procedures

CCABG

CCABG is usually performed via a full median sternotomy, 20–25cm in length, with temporary CPB from a pump oxygenator. Target lesions are typically bypassed with the LIMA or saphenous vein grafts. Although CCABG is technically straightforward, and high survival rates and patency rates are achieved, there are some disadvantages.

The oxygenator is thought to have certain risks such as neutrophil and complement activation, pulmonary complications with reduced oxygen delivery, impaired haemostasis and cerebral microembolism. The operation is expensive, uses disposable appliances and patients require perioperative intensive care, typically stay in hospital five to ten days, and often have a lengthy recovery time (Talwalkar et al 1998). Dresden CABG is a form of on-pump CABG which is performed through a minimal access incision.

Port and robotic methods

Port and robotic CABG procedures cover a number of minimal access methods, usually performed on an arrested heart. Full endoscopic CPB is done through small thoracic ports using endoscopic visualisation and robotic assistance for construction of the anastomoses. Port-Access CABG is done through a left anterior minithoracotomy using a specific endovascular CPB system (Reichenspurner et al 1999).

OPCAB

OPCAB surgery is done via a full median sternotomy on a beating heart. Mechanical stabilisers (particularly the Octopus[®] suction device) are often used to immobilise the heart.

Catheter-based therapies

These consist of percutaneous transluminal coronary angioplasty (PTCA) and/or stenting.

Hybrid procedures

A composite procedure can be used in patients with multivessel disease, which usually consists of a LIMA to LAD graft done by MIDCAB, in conjunction with catheter-based therapy applied to the patient's other diseased arteries.

Comparator

The comparative procedure is conventional CABG with CPB on an asystolic (nonbeating) or beating heart. The comparator included on-pump CABG done via full median sternotomy and/or minimal access incisions (eg Dresden CABG), provided that the patient outcomes for the different incision types could be separated from any pooled data.

Marketing status of the device

Not applicable, except for the stabilising device.

The cardiac tissue stabilisers most commonly used in Australia at the current time are listed below.

- Suction stabilisers
 - Octopus[®] 2+ and Octopus[®] 3 (Medtronic Inc., USA) – these single use products are sold throughout Australia.
- Compression stabilisers
 - OPCAB Immobilizer[™] (Genzyme Surgical Products, USA) – this product combines reusable and single use components and is currently only sold in New South Wales and Victoria.
- Fully reusable stabilisers
 - Platypus Stabiliser (Wolfram Surgical Instruments, Australia) – this is a fully re-usable compression stabiliser. This product has taken over the market share previously occupied by the fully re-usable Axius[™] Mechanical Stabilizer System and the Ultima[™] OPCAB System (CardioThoracic Systems (CTS)-Guidant, USA), which were formerly known collectively as the CTS Stabilizer.

Current reimbursement arrangement

The Medicare Benefits Schedule for November 2000 lists fees for coronary artery bypass for ischaemic heart disease under Items 38497, 38500, and 38503 (Table 1). The number and type of graft conduits used in the operation determine the exact Item number that applies to a particular procedure. In addition, the administration of cardioplegia is covered under Item number 38588.

Currently, the Items do not distinguish between off-pump and on-pump coronary artery bypass surgery and, therefore, MIDCAB would be reimbursed under the Item numbers used for conventional coronary artery bypass at present.

Table 1 2000 Medical Benefits Schedule of Fees for coronary artery bypass surgery

Category	Item Number	Benefit
Coronary artery bypass	38497	\$1,594.10
	38500	\$1,712.75
	38503	\$1,859.70
Preservation of the arrested heart	38588	\$323.85

Approach to assessment

Review of literature

The medical literature was searched to identify relevant studies and reviews for the period between 1966 to 2001.

A single set of search strategies was developed for the MIDCAB review, alongside an OPCAB review also being conducted by MSAC. The MIDCAB and OPCAB studies were subsequently channelled to the appropriate review, but much of the background material was relevant to both.

Table 2 shows the search strategies for each database.

Table 2 Search strategies

Database	Search terms and dates
MEDLINE	NLM gateway 1966 to 2001 (last searched 4 October 2001) (midcab or (minimal* and invasiv*)) and coronary artery bypass Ovid MEDLINE 1966 to 2001 (last searched 4 October 2001) ((thoracot\$ or midcab\$ or (minimal\$ and invasiv\$)) and (cardi\$ or coronary or beating heart) PREMEDLINE (last searched 2 October 2001) offpump or off-pump; midcabg or midcab
HEALTHSTAR	1975 to June 2001 (last searched 4 October 2001) Coronary artery bypass (exploded) and (opcab or opcabg or offpump or off-pump or beating heart)
SCIENCE CITATION INDEX (Web of Science)	1995 to 2001 (last searched 4 October 2001) Midcab*; Coronary artery bypass and (opcab* or offpump or off-pump or beating heart)
CURRENT CONTENTS	2000 TO WEEK 40, 2001 (thoracot\$ or midcab\$) or (minimal\$ or invasiv\$) and (cardi\$ or coronary or beating heart): limit to yr=2000-2001 (minimal\$ and invasiv\$ and coronary artery bypass) or opcab: limit to yr=2000-2001
EMBASE	1980 to week 39 2001 (off-pump or opcab or opcabg or beating heart) and (coronary artery bypass surgery (as a subject term))
OTHER DATABASES	
National Research Register (UK)	2001 Issue 3 midcab\$; heart and surgery; cabg
Clinical Trials Database (US)	(last searched 4 October 2001) Heart (disease category)
NHS HTA (National Health Service Health Technology Assessments) (UK)	(last searched 4 October 2001) midcab\$
NHS CRD (National Health Service Centre for Reviews and Dissemination) (UK)	(last searched 4 October 2001) midcab\$
Cochrane Library	2001 Issue 3 (coronary artery bypass or cabg) and ("beating heart" or offpump or off-pump or "off pump" or (minimal* and invasiv*) or midcab* or opcab*)
SEARCHING OF ELECTRONIC JOURNALS	
Annals of Thoracic Surgery	2001 May 71(5) to 2001 October 72(4)
Heart Lung and Circulation	2000 May 9(1) to 2001 May 10(1)
Journal of the American College of Cardiology	2001 Jan 37(1) to 2001 October 38(4)
PEARLING	The references of all retrieved articles were checked for other relevant citations

Criteria for selecting studies

Participants

Adult (at least 18 years of age) human patients undergoing treatment of single or multiple vessel coronary artery disease. Paediatric or pregnant patients were not included because of the bias that may be introduced by the additional complicating factors associated with these subsets of patients. Animal studies were not included.

Intervention/comparisons

New intervention: MIDCAB

The new intervention, MIDCAB, refers to coronary artery bypass surgery performed on a beating heart without the aid of cardiopulmonary bypass, using a minimally invasive incision. For the purposes of this review, a minimally invasive incision was defined as any incision smaller than a full median sternotomy.

The MIDCAB procedure must have been performed with the use of a mechanical stabiliser. Studies were not excluded if more than one category of mechanical stabiliser (eg compression versus suction) was used. This was considered appropriate because the degree of positioning and heart displacement that can be achieved during MIDCAB is more limited by the restricted surgical access than by the category of mechanical stabiliser used. Thus, any inherent limitation within each stabiliser category was not considered to be a significant confounding factor on MIDCAB patient outcomes.

Procedures that were performed with adjunctive heart support or perfusion-assist devices were included only if the data for these patients could be separated from the outcomes of those who did not receive intra-operative haemodynamic assistance. Data derived from patients undergoing a hybrid procedure such as MIDCAB with PTCA, or in conjunction with any other cardiac procedure, such as mitral valve repair, were excluded. This avoids the difficulty of separating the confounding effects on MIDCAB outcomes contributed by the additional procedure(s).

Procedures performed with any degree of robotic assistance were beyond the scope of this review and were not included.

Comparative intervention: conventional CABG

The comparative procedure is CABG with CPB on an asystolic (non-beating) or beating heart. Comparative studies of on-pump and off-pump CABG that reported full median sternotomy and minimal access incisions were considered appropriate for inclusion, provided that patient outcomes for the different incision types could be separated from any pooled data.

Outcomes

The included papers had to contain information on at least one of the following outcomes of the new or comparative intervention. These could include but were not limited to the following:

- Perioperative and postoperative mortality of patients (short and long-term).

- Perioperative and postoperative morbidity of patients which may include:
 - arrhythmias;
 - myocardial injury;
 - cardiac function;
 - neuropsychological and neurological outcomes;
 - wound infection; and
 - haemorrhage.

- Perioperative and early postoperative factors for patients which may include:
 - operating time;
 - use of blood products;
 - rates of conversion from MIDCAB to CPB; and
 - discomfort and/or pain.

- Evaluation of graft patency which may include:
 - angiography;
 - transit-time graft flow; and
 - electrocardiography.

- Convalescence of patients which may include:
 - convalescence period;
 - wound healing time; and
 - length of hospital stay.

Cost-effectiveness

Any study that reported an evaluation of the costs incurred in using MIDCAB with a mechanical stabiliser was included.

Types of studies

Randomised controlled trials and/or non-randomised comparative studies were included. In order to gain a comprehensive overview of the specific safety issues relating to MIDCAB, additional safety outcome data were collected from case series and case reports. Where appropriate, additional relevant material in the form of letters, conference material, commentary, editorials and abstracts were included as background information.

Language restriction

Searches were conducted without language restriction.

Methods of the review

Articles were retrieved when they were judged to possibly meet the selection criteria. Retrieved articles were checked against the selection criteria. Eligible studies were then assessed for quality and data extracted into standard data extraction sheets. Where outcomes from randomised controlled trials (RCTs) could be sensibly combined (outcomes measured in comparable ways and no apparent heterogeneity), relative risks with 95% confidence intervals were calculated (using RevMan 4.1, Update Software). Relative risks and confidence intervals were to be calculated for some of the outcomes in individual RCTs where it was thought that this would aid in the interpretation of results. The confidence intervals represent the range within which the 'true' value of an effect size is expected to lie, with a given degree of certainty, eg 95%.

A detailed description of each included study is given in Appendix E. The results from each study are given by outcome in Appendix C and D: Tables 5 to 12.

The following conventions were used in the text and the tables:

- † $p \leq 0.05$; ‡ $p \leq 0.01$; § $p \leq 0.001$; *no statistically significant difference between comparisons ($p > 0.05$)
- standard deviation []; interquartile range () ; variance measure not specified { }

Included studies were given a study identifier in the form [first author; date of most recent paper] eg Gu 1998. This was done so that if there was more than one paper relating to a particular study, these could be listed together in the list of references to included studies. The individual papers have also been listed in the general references at the end of this report.

Description and methodological quality of included studies

The evidence presented in the selected studies was assessed and classified using the dimensions of evidence defined by the National Health and Medical Research Council (NHMRC 2000).

These dimensions (Table 3) consider important aspects of the evidence supporting a particular intervention and include three main domains: strength of the evidence; size of the effect; and relevance of the evidence. The first domain is derived directly from the literature identified as informing a particular intervention. The last two require expert clinical input as part of its determination.

Table 3 Evidence dimensions

Type of evidence	Definition
Strength of the evidence	
Level	The study design used, as an indicator of the degree to which bias has been eliminated by design.*
Quality	The methods used by investigators to minimise bias within a study design.
Statistical precision	The <i>p</i> -value or, alternatively, the precision of the estimate of the effect. It reflects the degree of certainty about the existence of a true effect.
Size of effect	The distance of the study estimate from the "null" value and the inclusion of only clinically important effects in the confidence interval.
Relevance of evidence	The usefulness of the evidence in clinical practice, particularly the appropriateness of the outcome measures used.

*See Table 4

The three sub-domains (level, quality and statistical precision) are collectively a measure of the strength of the evidence. The designations of the levels of evidence are shown in Table 4.

Table 4 Designations of levels of evidence*

Level of evidence	Study design
I	Evidence obtained from a systematic review of all relevant randomised controlled trials
II	Evidence obtained from at least one properly-designed randomised controlled trial
III-1	Evidence obtained from well-designed pseudorandomised controlled trials (alternate allocation or some other method)
III-2	Evidence obtained from comparative studies (including systematic reviews of such studies) with concurrent controls and allocation not randomised, cohort studies, case-control studies, or interrupted time series with a control group
III-3	Evidence obtained from comparative studies with historical control, two or more single arm studies, or interrupted time series without a parallel control group
IV	Evidence obtained from case series, either post-test or pre-test/post-test

*Modified from (NHMRC, 1999).

Randomised controlled trials

Randomised controlled trials (level II evidence) were assessed with regard to:

- adequacy of concealment of the initial allocation to groups;
- losses of patients to follow-up; and
- any other feature of the trial design or execution which may have introduced bias.

Gu 1998 compared inflammatory responses in 31 MIDCAB and 31 CCABG patients. The patients were randomly assigned to the two groups, but no details were given about the method of allocation to these groups. Patient characteristics were similar between the two groups. Length of follow-up was for the perioperative period only and there were no losses to follow-up. However, the inflammatory response markers were only measured in a subgroup of 20 (32%) patients (10 each for MIDCAB and CCABG). These patients were stated to have no signs of severe heart failure or other organ dysfunction and no history of a bleeding diathesis, and so were likely to represent a healthier cohort than the rest of the patients.

Gulielmos 1999 and Gulielmos 2000

Results have been extracted separately for each paper, although they may be duplicate reports of the same RCT. However, there are some different outcomes and different numbers of patients reported in the two papers. The latter could be due to (unreported) losses to follow-up in Gulielmos 1999. Neither report stated losses to follow-up and the length of follow-up was three months.

Gulielmos 1999: This RCT compared four different surgical techniques for single vessel coronary artery bypass – CCABG with median sternotomy, off-pump with median sternotomy (OPCAB), on-pump minithoracotomy (Dresden technique) and off-pump minithoracotomy (MIDCAB). Most of the main results (pain and post-traumatic stress disorder outcomes) were presented only by the two types of surgical access (ie on-pump and off-pump sternotomy versus on-pump and off-pump minithoracotomy) and so could not be used for this review. Where data could be used, the MIDCAB arm (n=9) was compared to the CCABG arm (n=10) and the Dresden CABG arm (n=8). The method of concealing the allocation to each of the four groups was not described.

Gulielmos 2000: This RCT described the same four arms as above, although there were four additional patients (11%) in this trial (one more each in the OPCAB and MIDCAB arms and two more in the minithoracotomy arms). Again the data for the main outcomes of the paper (inflammatory response) were presented only by the two types of surgical access (ie on-pump and off-pump sternotomy versus on-pump and off-pump minithoracotomy) and so could not be used for this review. Where data could be used, the MIDCAB arm (n=10) was compared to the CCABG arm (n=10) plus the Dresden CABG arm (n=10). No details of the method of concealing allocation to either the MIDCAB or CABG groups was given; the study report stated that 'One of the four techniques was prospectively chosen for each patient at random'.

POEM (Patency, Outcomes and Economics of MIDCAB) **2001** compared 165 MIDCAB patients with 145 CCABG patients. Only interim results were available for the POEM trial and so far these have only been published in the form of conference presentations or news reports. Thus, the study description and results are incomplete. No details of the method of concealing allocation to the two groups was given; the study was only described as being randomised to either MIDCAB or conventional CABG (Wood 2001). The trial was originally designed to have 200 patients in each arm, but results were only available for a total of 310 patients (Mack et al 1999). It was not clear whether there were recruitment problems or whether there were some post-randomisation exclusions. Only 56% of patients returned for angiographic follow-up at six months (62% of MIDCAB patients and 48% of CCABG patients). The POEM investigators intend to follow-up patients for one year and will also compare quality of life between MIDCAB and CCABG patients.

Non-randomised comparative studies (level III-2 and III-3)

Non-randomised comparative studies (level III-2 and III-3) were assessed with regard to:

- basis of patient selection;
- comparability of groups (eg age, risk profile);
- completeness of follow-up; and
- any other feature of the study design or execution which may have introduced bias.

Level III-2 studies

Diegeler 1999b prospectively compared 65 MIDCAB patients and 95 CCABG patients. The MIDCAB patients were compared to a computer matched control population undergoing CCABG, but no further details of the matching process were reported. The patient characteristics in the two groups were similar except for ejection fraction (more MIDCAB patients with better cardiac output) and obesity (less MIDCAB patients were obese). The mean number of grafts performed was 1.05 for MIDCAB and 2.21 for CCABG ($p < 0.05$). There was complete three-month follow-up for 96.8% (155/160) of patients. The number lost from each group was not given, although the paper reports that one patient from each group was dropped from the study due to prolonged postoperative recovery.

Kilger 2000 prospectively compared 29 MIDCAB patients, 31 CCABG patients and 27 OPCAB patients. The same inclusion and exclusion criteria were applied to all groups in order to compare the influence of the surgical technique only on markers of myocardial injury. One MIDCAB patient and one CCABG patient were subsequently excluded because of myocardial infarction (MI) in the postoperative period. MIDCAB and CCABG patients were similar with respect to age, gender mix and single/double vessel disease mix, but other characteristics such as risk profiles were not reported.

Level III-3 studies

Allen 1997 compared 23 MIDCAB redo patients with 12 single vessel redo CCABG patients. Each group consisted of consecutive patients, but the CCABG patients were operated on from one to 12 years before the MIDCAB patients. Age, gender mix and risk scores (Parsonnet and Cleveland Clinical Scores) were similar for the two groups.

Byrne 2001 was a retrospective comparison of 13 MIDCAB and 33 CCABG redo patients (and four Heartport patients, not included in this review). All patients received a left lateral thoracotomy. None of the 50 consecutive patients in the study were excluded, but the method of allocating patients to each of the three groups is not described. Patient characteristics were not described separately for the groups, so it was not clear how comparable the groups were.

Connolly 2000 was a retrospective review of MIDCAB (125 patients) and CCABG redo (348 patients). The MIDCAB patients were operated on more recently than the CCABG group and also had a higher risk profile. The mean number of grafts was 1.29 {0.7} for the MIDCAB group and 2.9 {1.1} for the CCABG group, ($p < 0.0001$). There were a number of arithmetical discrepancies in the paper.

D'Amato 2000 was a retrospective comparison of 96 MIDCAB patients and 42 single CCABG patients. There were no significant differences in patient characteristics between the two groups. Choice of MIDCAB or CCABG was made by individual surgeon and patient preferences. There were no losses to follow-up.

Diegeler 1998b compared leukocyte changes in 10 MIDCAB, 10 CCABG and 10 OPCAB patients. Only the MIDCAB and CCABG arms were used in this review. It was not stated how patients were allocated to each procedure. There were six MIDCAB patients with single vessel disease and four with double vessel disease, and all the CCABG patients had double or triple vessel disease. It was also not stated whether this was a prospective comparison, although it may have been. There were no losses to follow-up.

Diegeler 2000 also compared 10 MIDCAB, 10 CCABG and 10 OPCAB patients, but this study addressed humoral immune responses. Again, only the MIDCAB and CCABG arms were used in this review. The only information given about allocation to treatments is that 'patients were separated into three groups'. Six MIDCAB patients had single vessel disease, three had double vessel disease and one had triple vessel disease, while all ten OPCAB patients had triple vessel disease. It is also not stated whether this was a prospective comparison, although it may have been. There were no losses to follow-up.

Lazzara 1999 compared 16 MIDCAB patients with 10 CCABG patients. No high-risk patients were included, but the paper gave no definition of high-risk and no details about how patients were selected. The MIDCAB patients underwent single vessel grafting and the CCABG patients underwent multivessel grafting. A grading system was used to report patency, and this precluded comparison with patency rates in other studies.

Lichtenberg 2000 compared 15 MIDCAB patients with 15 CCABG patients. The only patient characteristics reported were age and weight, and these were similar for the two groups. The number of grafts was significantly different, mean 1.0 [0] for the MIDCAB group and mean 2.7 [0.7] for the CCABG group. No details were given about how the patients were selected for the study.

Ott 1999 compared MIDCAB, OPCAB and fast-track CCABG (a protocol which aimed to have patients on-pump for only a short time, as well as other measures to hasten recovery). This review used the results of the MIDCAB arm (29 patients) and the CCABG arm (104 patients). The total study consisted of a retrospective review of 158 consecutive patients undergoing isolated myocardial revascularisation. These patients were divided into three groups, but the basis of this division was not reported. Patient characteristics were generally similar between groups, although the MIDCAB patients were significantly younger and had more patients with diabetes than the CCABG patients. The MIDCAB patients had significantly fewer grafts (mean 1.0 [0.2]) than the CCABG patients (mean 3.6 [1.0]).

Reichenspurner 1999 was a retrospective economic comparison of five MIDCAB patients and 60 CCABG patients. Few details of the method of analysis were given and the MIDCAB figures were based on very few patients. Other outcomes were based on 121 MIDCAB and 475 CCABG patients. However, no variance measures were presented for outcomes relevant to resource utilisation, such as operating time and length of hospital stay, and thus, it was difficult to determine if the reported differences were likely to be important.

Struber 1999 was a comparison of cytokine responses in 12 consecutive MIDCAB patients and 12 consecutive CCABG patients. The study may have been prospective although this is not stated and so the level of evidence has been rated as III-3. The MIDCAB patients had single vessel disease and the CCABG patients had triple vessel disease. No other patient characteristics except for gender mix and age (which were broadly similar) were given. Length of follow-up and losses to follow-up were not stated, but are likely have been perioperative, and none, respectively.

Tevaearai 1999 compared a total of 25 MIDCAB procedures over four consecutive time periods. The only patient characteristics provided were age and gender mix, and the numbers are probably too small to detect differences in outcomes. This study report also included a table of results for a comparison of 14 MIDCAB and 81 CCABG patients (and 12 OPCAB patients, not included in this review) but no further details were provided.

Case series (level IV) and case studies

The case series and case studies were included mostly to provide additional safety information and so have not been assessed for methodological quality on an individual basis. Most of the 23 included case series were relatively small (median number of patients 23, range 4–271) and so the median percentages should be interpreted with caution, especially in the general absence of confidence intervals. There may also be double-counting of results. For instance, the two Diegeler studies (Diegeler 1998a; Diegeler 1999) are likely to have overlapping data. In addition, many of the small case series dealt with special surgical techniques and/or particular groups of patients and thus may not be generalisable to all MIDCAB procedures.

First-time versus redo MIDCAB

Miyaji 1999 retrospectively reviewed 95 first-time MIDCAB patients with 25 redo MIDCAB patients. Patient characteristics were not described separately for the groups, so it was not clear how comparable the groups were. Variance measures for operating time and hospital stay were reported as standard errors, but appeared to be standard deviations.

Stabiliser versus no stabiliser comparison

Calafiore 1998 compared stabiliser use in the last 168 patients in the study, with no mechanical stabilisers used in the earlier 93 patients. Patient characteristics were similar for both groups, except that there were significantly less urgent operations done in the stabiliser group. Nine more patients underwent MIDCAB, but were converted to a median sternotomy and were excluded from the study.

Douville 1999 was a retrospective comparison of stabiliser use (28 patients) and no stabiliser use (11 patients) in consecutive patients. The no stabiliser group consisted of the earlier patients. Patient characteristics were not described separately for the groups, so it was not clear how comparable the groups were. There were no losses to follow-up.

Maslow 1999 was a retrospective hospital record review of stabiliser use (40 patients) and no stabiliser use (20 patients) in MIDCAB. The no stabiliser group had significantly more comorbid patients and patients who were given pre-ischaemic conditioning than did the stabiliser group, but other patient characteristics were similar.

Possati 1998 was a retrospective comparison of stabiliser use (21 patients) and no stabiliser use (56 patients) in consecutive patients. No details were given about how the two groups were constituted (eg by time). Patient characteristics were not described separately for the groups, so it was not clear how comparable the groups were. Five patients were converted to a median sternotomy with beating heart (OPCAB); and were not included in this study.

Subramanian 1997 included a comparison of stabiliser use in the last 52 patients, with no mechanical stabilisers used in the earlier 114 patients. Patient characteristics were not described separately for the groups, so it was not clear how comparable the groups were. There were 12 conversions to CPB and sternotomy, but the results from these patients were not included in the study report.

Expert advice

A supporting committee with expertise in cardiothoracic surgery was established to evaluate the evidence and provide advice to MSAC from a clinical perspective. In selecting members for supporting committees, MSAC's practice is to approach the appropriate medical colleges, specialist societies and associations, and consumer bodies for nominees. Membership of the supporting committee is provided at Appendix B.

Results of assessment

The main comparison was MIDCAB versus CCABG (Comparison 1), with safety and effectiveness outcomes extracted from four RCTs and 14 non-randomised studies. Cost data were extracted from one study.

Safety and effectiveness outcomes were also extracted from 23 case series of MIDCAB.

The following subsidiary comparisons were also made:

- MIDCAB over time (one study) (Comparison 2);
- First-time versus redo MIDCAB (one study) (Comparison 3); and
- Use of mechanical stabilisers versus no stabilisers in MIDCAB (five studies) (Comparison 4).

Excluded studies

A large number of studies (n=222) were excluded, mainly because mechanical stabilisers were not used, or because separate results were not provided for MIDCAB and OPCAB procedures (see Appendix F).

Comparison 1: MIDCAB versus CCABG

There were insufficient data for a meaningful meta-analysis to be carried out on any of the outcomes in the four included RCTs. However, relative risks were calculated for some of the outcomes in the POEM trial in order to show precision and aid interpretation of the results. Without further information, none of the RCTs could currently be categorised as being of high quality.

Safety

Randomised studies

Four RCTs: Gu 1998; Gulielmos 1999; Gulielmos 2000; POEM 2001; See Appendix C: Table 5.1.

Mortality

There were no perioperative deaths in the three smaller RCTs (Gu 1998, Gulielmos 1999 and Gulielmos 2000) and there was one perioperative death in the CCABG group in the POEM 2001 trial. At six months follow-up in the POEM trial, there was no discernible difference in mortality between the MIDCAB group (four deaths - 2.4%) and the CCABG group (two deaths - 1.5%). The relative risk for postoperative mortality at six months for MIDCAB compared to CCABG was 1.76 (95% confidence interval (CI) 0.33–9.46).

Complications

Other perioperative and postoperative outcomes were sparsely reported. The Gulielmos RCTs reported no discernible difference in overall complication rates (no serious complications for either the MIDCAB, CCABG or Dresden CABG groups).

Myocardial infarction

There was no discernible difference between MIDCAB and CCABG in the POEM trial for perioperative or postoperative MI (six month follow-up). The relative risk for perioperative MI with MIDCAB compared to CCABG was 0.22 (95% CI 0.05–1.02). The relative risk for postoperative MI was 2.64 (95% CI 0.11–64.27).

Stroke

There was no discernible difference between MIDCAB and CCABG for perioperative stroke (measured as neurologic events) or cerebrovascular accidents at six months follow-up in the POEM trial. The relative risk of perioperative stroke for MIDCAB compared to CCABG was 0.50 (95% CI 0.15–1.68).

Blood loss/need for transfusion

There was greater blood loss ($p < 0.001$) for CCABG compared to MIDCAB, in one RCT (Gu 1998). Significantly more CCABG patients than MIDCAB patients required transfusion in two RCTs (Gu 1998 and POEM 2001).

Atrial fibrillation

There were fewer instances of perioperative atrial fibrillation in the MIDCAB group (23 cases - 13.9%) than the CCABG group (33 cases - 22.8%) in one RCT (POEM 2001); relative risk 0.61 (95% CI 0.15–0.99).

Inflammatory response

Leukocyte, plasma elastase and C3a (complement activation) levels were all elevated in the CCABG group compared to the MIDCAB group ($p < 0.05$) in one RCT (Gu 1998), although no difference in platelet levels was detected.

Non-randomised comparative studies

Fourteen studies: Allen 1997; Byrne 2001; Connolly 2000; D'Amato 2000; Diegeler 1998; Diegeler 2000; Diegeler 1999; Kilger 2000; Lazzara 1999; Lichtenberg 2000; Ott 1999; Reichenspurner 1999; Struber 1999; Tevæarai 1999; See Appendix C: Table 5.2.

Mortality

Six studies reported perioperative mortality, with five studies showing no discernible difference in death rates between MIDCAB and CCABG. One study (Connolly 2000) showed significantly fewer deaths in MIDCAB patients compared to CCABG patients.

Perioperative MI and stroke

No differences could be detected between MIDCAB and CCABG groups for perioperative MI (two studies: Allen 1997 and Ott 1999) or for stroke (three studies: Allen 1997, Lazzara 1999 and Ott 1999). In Kilger 2000, one MIDCAB patient and one CCABG patient suffered MI postoperatively and were subsequently excluded from the study.

Renal failure

Two studies reported renal failure, with one showing significantly less renal failure with MIDCAB compared to CCABG (Connolly 2000) and one study unable to detect a difference between the MIDCAB and CCABG groups (Diegeler 1999).

Need for transfusion and reoperation for bleeding

There was a significantly greater requirement for transfusion in the CCABG group compared to MIDCAB in two studies (Allen 1997 and Diegeler 1999) but no discernibly different rate of reoperation for bleeding in one study (Allen 1997). Another study (Diegeler 2000) showed no discernible difference in transfusion requirements between MIDCAB and CCABG.

Atrial fibrillation

Three studies reported in-hospital atrial fibrillation, with Allen 1997 and D'Amato 2000 showing a significantly lower rate of atrial fibrillation in the MIDCAB group compared to the CCABG group, and Ott 1999 showing no discernible difference. D'Amato 2000 also showed a significantly lower rate of new onset atrial fibrillation six weeks postoperatively in the MIDCAB group compared with the CCABG group.

Sepsis

Two studies reported sepsis, with a significantly lower rate of sepsis in the MIDCAB group compared with the CCABG group in Connolly 2000 and no discernible difference between the two groups in Ott 1999.

Myocardial injury

In Kilger 2000, there was no discernible difference in myoglobin levels (maximal activity 12 hours postoperatively) between the MIDCAB and the CCABG groups. However, the specific markers of myocardial injury, such as creatine kinase mass MB (CK-MB) and troponin I (cTnI) were significantly higher after CCABG than after MIDCAB, both for peak levels and throughout the measurement period.

Inflammatory response

Struber 1999 measured cytokine levels before MIDCAB or CCABG procedures; immediately after surgery; and two, eight and 24 hours postoperatively. Intergroup comparisons showed elevated levels in the CCABG group compared with the MIDCAB group for all measurements: interleukin-6; interleukin-8; soluble tumour necrosis factor (TNF) receptors 1 and 2; complement activation C3a; and C1 esterase inhibitor. Diegeler 2000 showed broadly similar results, finding elevated cytokine levels in CCABG patients compared to MIDCAB patients. There were some significant differences between the MIDCAB and CCABG groups at several time periods for complement activation C5a, TNF receptors, and interleukins 6, 8 and 10. In Diegeler 1998, both MIDCAB and CCABG patients followed the same patterns for leukocyte and lymphocyte subsets. Leukocyte subsets peaked after surgery and remained slightly elevated at postoperative day (POD) 6 for both groups, and while lymphocyte subsets peaked after surgery, they had returned to preoperative levels by POD 6 for both groups.

Pain

Pain was reported in two studies. In Diegeler 1999, the MIDCAB group had significantly worse pain (measured with a visual analogue scale (VAS)) than the CCABG group on POD 1, but this had reversed by POD 7, with the CCABG group then having significantly worse pain than the MIDCAB group. In Lichtenberg 2000, pain on forced inspiration was significantly worse for the MIDCAB group on POD 3, but by POD 5 there was no discernible difference between the MIDCAB and CCABG groups.

Case series

Twenty-three studies; See Appendix C: Table 5.3.

Mortality

The median perioperative mortality rate across 18 case series was 0% (range 0–7.7%). The median postoperative mortality rate across six case series was 0.2% (range 0–10%), with the longest follow-up being two years.

Complications

The median rate of major unspecified complications across six case series was 0% (range 0–4.5%).

Myocardial infarction

The median rate of perioperative myocardial infarction across 11 case series was 0%, (range 0–5%).

Stroke

The median rate of perioperative stroke across five case series was 0% (range 0–0.9%).

Renal failure

The median rate of renal failure across five case series was 0.9% (range 0–5%).

Reoperations for bleeding

The median number of reoperations for bleeding was 0% (range 0– 3.9%) across six case series.

Atrial fibrillation

The median rate of in-hospital atrial fibrillation across four case series was 6.1% (range 0– 43%). Postoperative atrial fibrillation was only reported in one case series (10.3%).

Myocardial injury

Four case series reported postoperative CK-MB levels (ranging from no rise to a median peak of 16 IU/L). One case series reported a rise to more than 0.2 ng/mL of troponin T (TnT) in 17.4% (4/23) of patients and another reported 20% of patients (2/10) to have postoperative troponin I (cTnI) levels greater than 0.35 ng/mL (these TnT and cTnI levels are considered to be the threshold for normal levels).

Inflammatory response

No case series reported any measures of inflammatory response.

Pain

In four case series, the percentage of patients continuing to experience pain varied from 0% to 13.6% (over a follow-up ranging from six days after surgery to two years).

Wound infections/complications

Five case series reported no postoperative wound infections or complications, but a sixth case series reported a rate of 9.1%.

Case studies: complications

The following rare complications were described in case reports of patients undergoing MIDCAB procedures: delayed cardiac tamponade (Hirose 1999); rupture of the right ventricle (Ono 1998); 'steal syndrome' from a large lateral branch arising from the IMA (Pagni 2001); and avulsion of grafts (McMahon 1997, Radermecker 2001 and Ricci 2000).

Effectiveness

Randomised studies

Four RCTs: Gu 1998; Gulielmos 1999; Gulielmos 2000; POEM 2001; See Appendix D: Table 9.1.

Patency

There were no discernible differences in MIDCAB and CCABG patency rates in three RCTs (Gulielmos 1999, Gulielmos 2000 and POEM 2001). In the POEM trial, patency was measured six months postoperatively by angiography and was defined as less than 75% stenosis at the LIMA-LAD anastomosis and/or thrombolysis in myocardial infarction (TIMI) 3 flow. Angiographic follow-up was only available for 56% of patients, many refusing to return for an angiogram (Wood 2001). The relative risk of patency (ie the 'risk' of a patient being successfully patent as defined above) was 0.99 (95% CI 0.91 to 1.07) for MIDCAB compared to CCABG.

In the Gulielmos trials, 100% patency at three months angiographic follow-up was reported for all patients (from the MIDCAB, CCABG and Dresden CABG groups), but the study reports do not define how patency was measured.

Re-intervention rate

In the POEM trial, five patients (3%) from the MIDCAB group underwent 'clinically driven' revascularisation within six months, compared to one (0.7%) of the patients in the CCABG group.

Conversions to CPB and full sternotomy

One of the MIDCAB patients in the POEM trial and none of the MIDCAB patients in the two Gulielmos trials were converted to CPB and full sternotomy.

Operating time

Mean operating time was shorter for MIDCAB than CCABG in two RCTs (Gu 1998, $p < 0.05$ and POEM 2001, $p < 0.0001$) but longer in another RCT (Gulielmos 2000, $p < 0.001$). In Gulielmos 2000, the operating time for the Dresden CABG group was also significantly longer than for the CCABG group ($p < 0.001$).

Hospital stay

Hospital stay was significantly shorter for the MIDCAB than the CCABG group in two RCTs (Gu 1998, $p < 0.001$; POEM 2001, $p < 0.001$).

Ventilation time

Ventilation time was significantly shorter for the MIDCAB group than the CCABG group in two RCTs (Gu 1998, $p < 0.001$; POEM 2001, $p = 0.0002$), but no difference was detected in one other RCT (Gulielmos 2000). The Gulielmos 2000 trial also showed no discernible difference in ventilation time for the Dresden CABG group.

LAD occlusion time

Only Gulielmos 2000 reported LAD occlusion time: 19.8 minutes, standard deviation (SD) 5.27.

Non-randomised comparative studies

Fourteen studies: Allen 1997; Byrne 2001; Connolly 2000; D'Amato 2000; Diegeler 1998; Diegeler 2000; Diegeler 1999; Kilger 2000; Lazzara 1999; Lichtenberg 2000; Ott 1999; Reichenspurner 1999; Struber 1999; Tevaearai 1999; See Appendix D: Table 9.2.

Patency

Only two of the 14 studies reported on patency. Allen 1997 reported 80% patency in 10 MIDCAB patients, but did not give results for patency in the CCABG group. Using a grading system for patency, Lazzara 1999 was unable to detect a difference between the MIDCAB and CCABG groups.

Re-intervention rate

In Lazzara 1999, five MIDCAB patients (31%) required re-intervention, compared to none in the CCABG group. In Reichenspurner 1999, there were no discernible differences between the MIDCAB (1.7%; 2/121) and CCABG groups (2.1%; 10/475).

Conversions to CPB and full sternotomy

There were no conversions in Allen 1997 and Kilger 2000; one each in Byrne 2001 (7.7%) and Lazzara 1999 (6.3%); and three in Ott 1999 (10.3%).

Operating time

Operating time was significantly shorter for MIDCAB in five studies (Lichtenberg 2000, Ott 1999, Reichenspurner 1999, Struber 1999 and Tevaearai 1999) while three studies (Diegeler 1998, Diegeler 2000 and Kilger 2000) were unable to detect a difference in operating times between the MIDCAB and the CCABG groups.

Hospital stay

Hospital stay was significantly shorter for MIDCAB in four studies (Allen 1997, Connolly 2000, D'Amato 2000 and Tevaearai 1999) and probably also in Reichenspurner 1999, although a measure of variance and statistical significance level were not provided in the latter study. There was no discernible difference in length of hospital stay between the MIDCAB and CCABG groups in Diegeler 1998, Diegeler 2000 or Ott 1999, but the CCABG patients in this latter study were under a fast-track protocol, specifically designed to hasten recovery time.

Ventilation time

Ventilation time was significantly shorter for the MIDCAB group than the CCABG group in two studies (D'Amato 2000 and Lichtenberg 2000) but no differences were detected in Diegeler 1998, Diegeler 1999 or Diegeler 2000.

Quality of life

In Diegeler 1999, no differences were detected in quality of life measures seven days after surgery, except for activity, where MIDCAB patients scored better than CCABG patients. At three months follow-up, the MIDCAB patients scored significantly better than the CCABG group for mobility and pain.

LAD occlusion time

The LAD occlusion time was a mean of 17 minutes (SD 8) in Struber 1999 and a mean of 23.2 minutes (unspecified variance measure 3.7) in Tevaearai 1999.

Case series

Twenty-three case series; See Appendix D: Table 9.3.

Patency

The median patency rate was 96.7% (range 70–100%) across 12 case series.

Re-intervention rate

The median re-intervention (early plus late) was 6.1% (range 0–50%) across seven case series.

Conversions to CPB and full sternotomy

The median conversion rate was 0% (range 0–14.7%) across 11 case series.

Operating time

The median value for mean operating time was 139.9 minutes (range 68.2–276.0) across nine case series.

Hospital stay

The median value for mean hospital stay was 6 days (range 3.2–8.3) across 11 case series.

Ventilation time

The median value for mean ventilation time was 6.5 hours (range 4.6–14.9) across five case series.

Mean number of grafts

The median number of grafts per patient was 1.2 (range 1.05–1.70) across six case series.

Comparison 2: MIDCAB over time

One non-randomised comparative study: Tevaearai 1999.

Safety

See Appendix C: Table 6.

No differences in major complications and reoperation rates over four six-month time periods could be detected in Tevaearai 1999.

Effectiveness

See Appendix D: Table 10.

The last two time periods in Tevaearai 1999 showed a significant reduction in both operating time and length of hospital stay, compared with the first time period. For length of Intensive Care Unit (ICU) stay, the last time period showed a significant reduction compared with the first time period. There were two conversions to CABG, both in the first year of the study (the first two time periods). There were no discernible differences in LAD occlusion times over the four time periods.

Comparison 3: MIDCAB redos versus first time MIDCAB

One non-randomised comparative study; Mijayi 1999.

Safety

See Appendix C: Table 7

There was no discernible difference in either mortality or major complications between the redo and the first-time MIDCAB groups in Mijayi 1999.

Effectiveness

See Appendix D: Table 11

Similarly, no differences in effectiveness (operating time or hospital stay) could be detected. All 12 redo patients (100%) showed patent grafts; patency was not reported for the first-time MIDCAB group.

Comparison 4: MIDCAB stabiliser versus no stabiliser

Five non-randomised comparative studies: Calafiore 1998; Douville 1999; Maslow 1999; Possati 1998; Subramanian 1997.

Safety

See Appendix C: Table 8.

There were no discernible differences in perioperative mortality between the stabiliser and no stabiliser group in three studies (Calafiore 1998, Douville 1999 and Maslow 1999) or in postoperative mortality at 19 months follow-up (Calafiore 1998). Nor were there any discernible difference in any rates of complications reported in two of the studies (Calafiore 1998 and Maslow 1999). Subramanian 1997 did not report any safety outcomes and Possati 1998 did not report safety outcomes separately for the two groups.

Effectiveness

See Appendix D: Table 12.

Patency was significantly better for the stabiliser group in three of the four studies reporting this outcome (Calafiore 1998, Douville 1999 and Possati 1998) but not in a fourth study (Subramanian 1997) where there was no detectable difference. Patients in the stabiliser group had a significantly longer operating time and hospital stay than the patients in the no stabiliser group in one study (Calafiore 1998) but there was no discernible difference between the two groups for hospital stay in another study (Maslow 1999).

Conversion rates to CPB with full sternotomy were not discernibly different between the stabiliser and no stabiliser groups in two studies (Calafiore 1998 and Maslow 1999), but there were significantly less conversions for the stabiliser group in Douville 1999. In Calafiore 1998, the reasons for conversion in the stabiliser group were: LAD not visible (n=3); small-sized LAD (n=1); and calcified LAD (n=1). In the no stabiliser group, the reasons for conversion were: LAD not visible (n=3); and calcified LAD (n=1).

Reintervention rates were significantly different in Calafiore 1998, but not in Maslow 1999. In Calafiore 1998, three patients in the stabiliser group had reintervention for graft failure (all surgical redos). In the no stabiliser group, nine patients had reintervention for graft failure (seven surgical redos and three PTCAs). In Maslow 1999, three patients in the stabiliser group returned to the operating room for graft repair and one returned for PTCA for graft failure. The same figures applied for the no stabiliser group. Two patients from the stabiliser group and one patient from the no stabiliser group also returned to the operating theatre for CABG with CPB – these patients were counted in the conversions described above.

What are the economic considerations?

See Appendix D: Table 9.2.

Only one study (Reichenspurner 1999) comparing MIDCAB and CCABG costs was included. This retrospective comparison found the intraoperative and postoperative costs of MIDCAB to be lower than CCABG, particularly for operating room materials. Staff costs were very similar for the two groups. The overall analysis costed MIDCAB at US\$14,050 and CCABG at US\$16,230. In this study, MIDCAB patients stayed in hospital for a minimum of five days, according to German hospital guidelines. Thus, a shorter stay for MIDCAB patients might reduce MIDCAB costs even further in other settings.

Discussion

Safety overview

There appeared to be little difference between MIDCAB and CCABG mortality rates. The MIDCAB case series also reported very low mortality rates. Although patchy, the safety data were relatively consistent for both the RCTs and the non-randomised comparative studies. For most complications, there was no discernible difference between MIDCAB and CCABG but almost none of the studies are likely to be powerful enough to detect differences. However, there was limited evidence of less need for transfusion, lower rates of atrial fibrillation and less indication of myocardial injury and inflammatory response in MIDCAB groups compared to CCABG groups. There is also some very limited and non-randomised evidence that pain from the MIDCAB procedure is worse shortly after surgery, but that this reduced to at least the same level as in the CCABG procedure by about a week after surgery.

Patency

There also appeared to be little overall difference between MIDCAB and CCABG patency rates. However, it was not possible to give a robust estimate of a typical patency success rate for MIDCAB. Both the Guliemos RCTs were small and the patency results from each of the RCTs are likely to be duplicated. Just over half (56%) of the patients in the POEM trial have returned for six month angiographic follow-up, with some imbalance between the proportion of MIDCAB and CCABG patients. If there was some systematic reason for not returning for follow-up, then the POEM results for patency may be biased. The principal investigator, Mehran, is quoted as saying that many patients refused to come back, speculating that they were feeling too well to return for angiography (Wood, 2001), although no evidence was presented to support this view.

Only two of the non-randomised comparative studies measured patency. The median patency rate in the case series (13 studies) was 98.9%. In a registry study of 35 international centres using CTS stabilisers for MIDCAB (excluded because some hybrid procedures were done in conjunction with MIDCAB), the patency rate was 94% (78 out of 83 patients showed patent grafts). This subset represented patients who had angiograms a mean of 2.2 days after surgery. The use of a mechanical stabiliser did appear to achieve better patency results than not using a mechanical stabiliser for MIDCAB.

The variation in methods of measuring patency (eg occlusion versus degree of stenosis) made accurate estimation and comparison difficult, and the different periods of follow-up (immediately after surgery to 12 months) also made estimation difficult. Many studies reported clinical patency (no requirement for further revascularisation) rather than angiographic patency (Mehran 2001a).

However, the findings here of little difference between MIDCAB and CCABG are consistent with the IMAGE study findings of 98.8% early patency (no occlusion) or 91% widely patent (less than 50% stenosis) for CCABG LIMA to LAD grafts (Berger et al 1999), a study which can be regarded as a benchmark for MIDCAB patency. Long-term (10 year) patency of CCABG grafts is estimated to be 90% (Loop et al 1986; Cameron et al 1996).

Although only short-term results for patency rates were generally available, some authors (eg Calafiore et al 1997) maintain that if MIDCAB grafts are to fail, then this will happen early (within days after surgery). This is in contrast to PTCA, where failures can be spread over many months. Some early patency abnormalities may even disappear in subsequent weeks or months. Calafiore noted that six graft or anastomotic malfunctions had resolved a mean of 94 days (SD 56) after surgery, and speculated that this may have been due to small clots or haematomas which can disappear (Calafiore et al 1998a). However, the long-term patency rates for MIDCAB are still unclear.

MIDCAB 'failures'

A MIDCAB failure can be defined as either an early conversion to CPB and sternotomy, an early conversion to sternotomy while still remaining off-pump, an early or late surgical redo or PTCA, a later PTCA, or surgical redo to repair other branches. This would give a failure rate of 17% in the Calafiore study (discussion by Gundry in Calafiore et al 1998a). It is likely that failures (especially conversions) were under-reported.

There may be a trend towards higher re-intervention rates for MIDCAB than for CCABG, although the data were insufficient and inconsistent. Generally, re-intervention rates included surgical revision of graft stenoses or occlusions, but some studies included redos for bleeding and conversions to sternotomy. In the POEM study (POEM 2001), 'clinically driven' revascularisation was not discernibly different between MIDCAB (5/165) and CCABG (1/145). However, the investigators did not define 'clinically driven' and did not say if other types of revascularisations took place.

Conversion rates from MIDCAB to CABG with full sternotomy (ranging from 0% to 10.3%) are also difficult to interpret. These rates were likely to be underestimated by failing to include MIDCAB patients who required conversion in the MIDCAB results. Once the heart is initially exposed, need for a conversion may become apparent (eg anatomical concerns such as small or inaccessible IMA, intramyocardial placement of the LAD or calcification of the LAD). Such patients may then be classified as CCABG, despite MIDCAB being the originally intended treatment.

Operating time and hospital stay

MIDCAB procedures were generally associated with shorter operating times and shorter hospital stays than for CCABG procedures. However, the comparisons were often between single vessel MIDCAB and multi-vessel CCABG, which may inflate reductions in operating times for MIDCAB. Nonetheless, shorter hospital stays usually indicate quicker recovery and fewer complications, and may more truly reflect the less invasive nature of the MIDCAB procedure.

Stabilisers

The use of mechanical stabilisers clearly improved the patency rates without a discernible compromise in safety. This was broadly consistent with the conclusions of Stanbridge et al (1999) who reviewed four studies comparing stabiliser use and no stabiliser use in MIDCAB (three in common with this review). However, there was some very limited evidence that use of stabilisers may increase operating time and hospital stay.

All of the five studies in this review were non-randomised comparisons and, therefore, may be subject to bias. Degree of experience and expertise was likely to be a confounder, since the patients undergoing the MIDCAB procedures without mechanical stabilisers were generally the earlier patients, and improved patency rates may be expected over time. Unfortunately, patency rates were not reported in the only study (Tevearai et al 1999) which compared MIDCAB procedures over time. Other effectiveness outcomes such as operating time and hospital stay did show some improvement over time in this study.

Redo operations

Over 10% of all adult cardiac surgical procedures are likely to be reoperations and conventional reoperative CABG carries a high mortality rate ranging from 3% to 12% (D'Ancona et al 2001). Relief of symptoms and improvement in quality of life, as well as survival, are aims of redo CABG (Bergsland et al 1998b). Avoiding CPB is thought to reduce complications after redo CABG (D'Ancona et al 2001). Although three of the non-randomised studies in this review compared MIDCAB and CCABG in redo patients only, there was not sufficient information to confirm or refute this. Similarly, Mijayi 1999 could not detect any significant safety or effectiveness differences between first-time and redo MIDCAB procedures, although all 12 redo patients had patent grafts.

Other high risk factors

Apart from redo operations, some high risk models show advanced age, female gender, impaired left ventricular ejection fraction, urgent operation, left main disease and comorbidities such as diabetes, chronic obstructive pulmonary disease (COPD), renal failure, peripheral vascular disease (PVD) and cerebrovascular disease to be factors associated with high risk for morbidity and mortality after cardiac surgery (Boyd et al 1999; Boyd et al 2000). High-risk patients represent an increasing proportion of people presenting for coronary revascularisation (Bergsland et al 1998; D'Ancona et al 1999). CPB is thought to be particularly harmful to high-risk patients because of non-physiological blood flow, cardiac consequences of cardioplegia and manipulation of the aorta (Boyd et al 2000). There were insufficient data to be able to investigate whether the avoidance of CPB in MIDCAB produced better outcomes for high-risk patients. Some authors predict that MIDCAB will become a 'niche' procedure for high risk, usually older, patients with significant comorbidities, who are not candidates for CCABG and who will receive targeted (incomplete) revascularisation (Mack et al 1999).

Single versus multi-vessel repair; complete versus 'culprit' revascularisation

MIDCAB has generally been used to repair single vessel disease, but complete revascularisation through a single LIMA-LAD graft represents only a small fraction (perhaps less than 10%) of revascularisations (D'Amato et al 2000). MIDCAB procedures have thus been extended to a second group of patients with multi-vessel disease, some of whom may be considered too high risk for CPB and would typically be denied a redo CCABG (Allen et al 1997).

Although the POEM trial does not give selection criteria for patients and does not describe the location and nature of patients' lesions, some patients with multivessel disease were obviously included. The process of randomisation to either MIDCAB or CCABG should have ensured a relatively even distribution of single and multivessel disease between the two groups, but the MIDCAB group had significantly fewer grafts per patient than the CCABG group (mean of one graft per patient for MIDCAB and three for CCABG).

No patients from the CCABG group and eleven patients from the MIDCAB group underwent target vessel revascularisation, which presumably was incomplete revascularisation. Given the study design, this rate of incomplete revascularisation seems very low overall and unbalanced between the two groups.

In the non-randomised studies, selection bias may have been operating in a number of ways. In studies comparing MIDCAB patients showing isolated single LIMA-LAD disease, with CCABG patients showing multivessel disease, the CCABG group may be sicker and give the appearance that MIDCAB is safer and more effective. On the other hand, if the study is of redo or other high risk patients, selection bias may operate in the other direction, with MIDCAB appearing worse than CCABG since the MIDCAB patients may be sicker.

Myocardial injury and inflammatory response

Although myocardial injury and systemic inflammatory response are generally thought to be less apparent in off-pump than on-pump procedures, these may both be increased in multivessel disease and when more grafts are done (Cattozzo et al 2001; Andrew et al 1998) and may therefore be confounding factors in MIDCAB and CCABG comparisons. These observations have led to the speculation that anaesthesia rather than CPB induces inflammatory response, since MIDCAB patients also show some degree of neuropsychological impairment (Andrew et al 1998). However Kilger et al (2000) were unable to detect any differences between MIDCAB and CCABG in myocardial injury marker response between an overall analysis and a subgroup analysis by number of grafts.

While Diegeler et al (1998a; 2000) saw some differences in the timing of responses as measured by cytokine levels, they maintained that the type of operative approach (MIDCAB, CCABG or OPCAB) does not influence the immune or inflammatory response. However, some authors (eg Struber et al 1999 and Gu et al 1998) believe that MIDCAB does induce less inflammatory response than CCABG and therefore causes less trauma. Gu et al (1999) suggest that avoiding heparin and heparin reversal with protamine, as well as avoiding CPB, reduced the inflammatory response which in turn led to less postoperative morbidity for MIDCAB patients.

Learning curve

One small study of a total of 25 patients (Tevaeairai 1999) showed a reduction in operating time and hospital stay over time, but no discernible difference for other effectiveness and safety outcomes. This latter result is consistent with the CTS registry data (Holubkov et al 1998) where no trend (as measured by major event rates) was seen. While the reduction in operating time and hospital stay may indicate a learning curve effect, most studies indicate such effects generally only become apparent after the first 300 procedures (Katz 1998 cited in Nauenberg et al 2000).

Currently, there are no standards for training of cardiothoracic residents in off-pump coronary artery operations – the American Board of Thoracic Surgery requires a trainee to perform 35 cases of coronary revascularisation. Performance of at least 50 cases under supervision by a trained surgeon has been suggested for minimally invasive coronary revascularisation (Karamanoukian et al 2000).

Different incisions, conduits and target vessels

The LAD is considered to be the most important vessel to repair and the IMA is the best performing arterial graft (Biglioli et al 2000). However, there are instances where LIMA-LAD grafts are not possible - for instance adhesions are commonly found in patients undergoing reoperations and an H-graft may then be done (D'Ancona et al 2001). Many of the small case series report such variations of MIDCAB, but there is insufficient information to see whether these variations make any differences to outcomes.

Limitations of the review

A large number of studies were excluded, many because they made no mention at all of stabiliser use. Many of these studies (particularly the recent ones) may have indeed used mechanical stabilisers and so a more complete picture could have been obtained by systematically contacting the authors of the studies to determine this. However, the vast majority of such studies were case series and therefore comprise a lower level of evidence than randomised or non-randomised comparative studies.

MIDCAB/OPCAB comparison

CABG without CPB is possible in over 90% of unselected patients referred for surgical treatment of coronary artery disease, but median sternotomy is still far more common than use of small incisions (Bergsland et al 1998a; Mack et al 1998). Comparisons of the safety and effectiveness of MIDCAB compared to OPCAB revealed very few differences, although heterogeneity of the outcome measures makes these comparisons difficult. Five studies reported perioperative conversion rates which were generally higher following MIDCAB than OPCAB, with technical difficulty being the usual reason for conversion. Further details of MIDCAB and OPCAB comparisons are given in the review on OPCAB. Although there is much speculation in the literature as to the benefits and/or disadvantages of minimal incisions in MIDCAB, the relative contributions of beating heart surgery and small incisions to MIDCAB outcomes remain unclear, except perhaps for perioperative conversion rates.

Costs

A number of cost studies (eg Arom et al 1999; Magovern et al 1998; Nauenberg et al 2000; Subramanian et al 1997; Zenati et al 1997) were excluded since their analyses did not report costs separately for MIDCAB with and without mechanical stabilisers. However, they were consistent with Reichenspurner 1999 in reporting lower costs for MIDCAB than CCABG. In these studies, the cost reductions generally come from shorter operating times for MIDCAB (eg savings of nearly \$US3,000 CPB costs in Zenati et al 1997) and shorter hospital stays. The savings from shorter hospital stays (two to three days for MIDCAB patients) reported in some cost studies do not reflect the findings of other more general studies reporting these outcomes. For instance, such a short hospital stay for MIDCAB patients was achieved in only one of the comparative studies or case series included in this review (Allen 1997).

Conclusions

Safety

No differences in mortality rates could be detected between MIDCAB and CCABG groups and there was some limited evidence that MIDCAB may be associated with less perioperative and postoperative morbidity (less need for transfusion, lower rates of atrial fibrillation and myocardial injury, and reduced inflammatory response than for CCABG). However, this evidence came from mostly small RCTs and non-randomised studies. There was insufficient evidence to establish whether MIDCAB reduced postoperative pain.

Effectiveness

No differences in patency rates could be detected between MIDCAB and CCABG groups. The MIDCAB procedure may be associated with shorter operating times and shorter hospital stay than for CCABG procedures. However, there may be more need for re-intervention in MIDCAB compared to CCABG.

Cost-effectiveness

There is insufficient evidence to determine whether MIDCAB procedures were less costly than CCABG procedures, although shorter operating times and shorter hospital stays are likely to make MIDCAB less costly than CCABG.

Recommendation

MSAC recommends that, on the strength of evidence pertaining to minimally invasive coronary artery bypass with the aid of tissue stabilisers, public funding should be supported where perfusion facilities are available for reasons of patient safety.

The Minister for Health and Ageing accepted this recommendation on 17 May 2002.

Appendix A MSAC terms of reference and membership

MSAC's terms of reference are to:

- advise the Minister for Health and Ageing on the strength of evidence pertaining to new and emerging medical technologies and procedures in relation to their safety, effectiveness and cost-effectiveness and under what circumstances public funding should be supported;
- advise the Minister for Health and Ageing on which new medical technologies and procedures should be funded on an interim basis to allow data to be assembled to determine their safety, effectiveness and cost-effectiveness;
- advise the Minister for Health and Ageing on references related either to new and/or existing medical technologies and procedures; and
- undertake health technology assessment work referred by the Australian Health Ministers' Advisory Council (AHMAC), and report its findings to AHMAC.

The membership of MSAC comprises a mix of clinical expertise covering pathology, nuclear medicine, surgery, specialist medicine and general practice, plus clinical epidemiology and clinical trials, health economics, consumers, and health administration and planning:

Member	Expertise or Affiliation
Dr Stephen Blamey (Chair)	general surgery
Professor Bruce Barraclough	general surgery
Professor Syd Bell	pathology
Dr Paul Craft	clinical epidemiology and oncology
Professor Ian Fraser	reproductive medicine
Associate Professor Jane Hall	health economics
Dr Terri Jackson	health economics
Ms Rebecca James	consumer health issues
Professor Brendon Kearney	health administration and planning
Mr Alan Keith	Assistant Secretary, Diagnostics and Technology Branch Commonwealth Department of Health and Ageing
Associate Professor Richard King	internal medicine
Dr Ray Kirk	health research
Dr Michael Kitchener	nuclear medicine
Mr Lou McCallum	consumer health issues
Emeritus Professor Peter Phelan	paediatrics
Dr Ewa Piejko	general practice
Dr David Robinson	plastic surgery
Professor John Simes	clinical epidemiology and clinical trials

Professor Richard Smallwood	Chief Medical Officer Commonwealth Department of Health and Ageing
Professor Bryant Stokes	neurological surgery, representing the Australian Health Ministers' Advisory Council
Associate Professor Ken Thomson	radiology
Dr Douglas Travis	urology

Appendix B Supporting committee

Supporting committee for MSAC reference 11 - Off-Pump Coronary Artery Bypass (OPCAB) and Minimally Invasive Direct Coronary Artery Bypass (MIDCAB)

Dr Stephen Blamey (Chair)

BSc, MBBS, FACS, FRACS
Surgeon
Monash Medical Centre, Melbourne

Chair of MSAC

Mr Peter Edwards

Chairman, Illawarra Stroke Unit Project and Deputy
Convenor, Wollongong Consumers' Health Advisory
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Nominated by the Consumers'
Health Forum of Australia

Dr Michael Gardner

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St Vincent's Hospital, Sydney

Nominated by the Cardiac Society
of Australia and New Zealand

Dr Mark A J Newman

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Nominated by the Royal
Australasian College of Surgeons

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Dr Ross Wallace

MBBS, DA, FANZCA, FFARCSI (Dublin)
Staff Specialist Anaesthetist
Royal Prince Alfred Hospital, Camperdown

Nominated by the National
Association of Medical Perfusionists
of Australia

Associate Professor Richard Walsh
MB, BS, FANZCA, FCARCSI (Ireland)
Adjunct Associate Professor, University of Sydney
Head, Cardiothoracic Anaesthesia & Medical Perfusion
Royal Prince Alfred Hospital, Sydney

Nominated by the Australian and
New Zealand College of
Anaesthetists

Table 5.1 Safety outcomes for MIDCAB versus conventional CABG (RCTs)

Perioperative outcomes	Gu 1998 (level II)		Gulielmos 1999 (level II)			Gulielmos 2000 (level II)			POEM 2001 (level II)	
	MIDCAB (n=31)	CCABG (n=31)	MIDCAB (n=9)	CCABG (n=10)	DRESDEN CABG (n=8)	MIDCAB (n=10)	CCABG (n=10)	DRESDEN CABG (n=10)	MIDCAB (n=165)	CCABG (n=145)
Mortality	0	0	0	0	0	0	0	0	0	1 (0.8%)*
Myocardial infarction									2 (1.3%)	8 (4.6%)*
Blood loss, mean total (mL)	312 {167}	788 {365}§								
Stroke									4 (1.2%)	7 (4.8%)*
Transfusion required	0 (0%)	11 (35.3%)§							7 (4.2%)	29 (20.0%) §
Reoperation for bleeding									2 (1.3%)	10 (6.9%)†
Atrial fibrillation									23 (13.9%)	33 (22.8%)†
Major complications (unspecified)			0	0	0	0	0	0		
Postoperative outcomes									Mean follow-up 6 months	
Mortality									4 (2.4%)	2 (1.5%)*
Myocardial infarction									1 (0.6%)	0*
CVA									2 (1.2%)	1 (0.7%)*
Inflammatory response ^a										
Leukocytes (10 ⁹ /L) ^b	4.8 [1.3] to 4.8 [1.3]	5.3 [1.6] to 12.8 [4.1]‡								
Plasma elastase (ng/mL) ^b	100 [79] to 61 [38]	107 [38] to 340 [237]‡								29 (20.0%)§
Platelets (10 ⁹ /L) ^b	195 [54] to 215 [120]	193 [63] to 258 [126]*								10 (6.9%)
Complement activation C3a (ng/mL) ^b	789 [190] to 725 [224]	1,654 [638] to 3,503 [348]‡								33 (22.8%)

^a inflammatory response was measured for a subset of only 20 patients (10 MIDCAB; 10 CCABG)

^b change from baseline to postop

†p≤0.05; ‡p≤0.01; §p≤0.001; *no statistically significant difference between comparisons (p>0.05)

Table 5.2 Safety outcomes for MIDCAB versus conventional CABG (non-randomised comparative studies)

Perioperative outcomes	Allen 1997 (level III-3)		Byrne 2001 (level III-3)		Connolly 2000 (level III-3)		D'Amato 2000 (level III-3)	
	MIDCAB (n=23)	CCABG (n=12)	MIDCAB (n=13)	CCABG (n=33)	MIDCAB (n=125)	CCABG (n=348)	MIDCAB (n=96)	CCABG (n=42)
Mortality	1 (4.3%)	2 (16.7%)*	0	2 (6.1%)*	2 (1.2%) ^a	32 (9.2%) [‡]	0	0
Myocardial infarction	1 (4.3%)	3 (25%)*						
Stroke	1 (4.3%)	1 (8.0%)*						
Renal failure					8 (6%) [‡]	61 (17%) ^{‡a}		
Transfusion required	1 (4.3%)	10 (83%) [§]						
Reoperation for bleeding	1 (4.3%)	3 (25%)*						
Atrial fibrillation (in-hospital)	0	7 (58) [§]					3 (3%)	12 (28%) [†]
Sepsis					1 (1%)	20 (6%) [†]		
Postoperative outcomes	Mean follow-up 12 [6] months	Mean follow-up 98 [9] months					Follow-up 6 weeks	
Mortality	1 (4.3%)	1 (8.3%)						
Atrial fibrillation -in the first 6 weeks after surgery							4 (4%)	12 (28%) [‡]

^afigures may be incorrect

[†]p≤0.05; [‡]p≤0.01; [§]p≤0.001; *no statistically significant difference between comparisons (p>0.05)

Table 5.2 (continued) Safety outcomes for MIDCAB versus conventional CABG (non-randomised comparative studies)

Perioperative outcomes	Diegeler 1998 (level III-3)		Diegeler 2000 (level III-3)	
	MIDCAB (n=10)	CCABG (n=10)	MIDCAB (n=10)	CCABG (n=10)
Blood loss , mean total (mL)	716 {214}	946 {913}	716 {24}	946 {913}
Transfusion required			1 (10%)	2 (20%)
Postoperative outcomes	Follow-up not stated		Follow-up not stated	
Inflammatory response				
Leukocyte subsets	Peaked after surgery, decreased but remained slightly elevated at POD 6	Peaked after surgery, decreased but remained slightly elevated at POD 6*		
Lymphocyte subsets	Peaked after surgery, decreased but returned to preop levels by POD 6	Peaked after surgery, decreased but returned to preop levels by POD 6*		
Complement activation			C5a levels at 4 hours and 24 hours postopt† C5a at all other time periods*	
TNF receptor p55 and p75			4 hours, 24 hours and 48 hours postopt†	
IL-6			24 hours†	
IL-8			4 hours, 24 hours and 48 hours postopt†	
IL-10			at reperfusion†	

†p≤0.05; ‡p≤0.01; §p≤0.001; *no statistically significant difference between comparisons (p>0.05)

Table 5.2 (continued) Safety outcomes for MIDCAB versus conventional CABG (non-randomised comparative studies)

Perioperative outcomes	Diegeler 1999 (level III-2)		Kilger 2000 (level III-2)		Lazzara 1999 (level III-3)		Lichtenberg 2000 (level III-3)	
	MIDCAB (n=65)	CCABG (n=95)	MIDCAB (n=29)	CCABG (n=31)	MIDCAB (n=16)	CCABG (n=10)	MIDCAB (n=15)	CCABG (n=15)
Mortality					0	0		
Myocardial infarction					0	0		
Blood loss, mean total (mL)	568 [114]	623 [136]*						
Stroke					0	0		
Renal failure	0	1 (1.1%)						
Transfusion required	1 (1.5%)	13 (13.7%)†						
Major complications (unspecified)					0	0		
Postoperative outcomes	Three months follow-up		Follow-up not stated		Follow-up not stated		Follow-up not stated	
Myocardial infarction			1 (3.6%)	1 (3.3%)*				
Myocardial injury								
Creatine-kinase MB mass (ng/mL) maximal			2.6 (1.5/6.5)	31(21/40) †				
Myoglobin (ng/mL) maximal			299 (260/363)	301 (217/391)*				
Troponin-T (ng/mL) maximal			0.5 (0.5/4.7)	11 (6/16) †				
Pain								
POD 1 (VAS)	6.3 {4-8.5}	5 {2.5-7.6}†						
POD 7 (VAS)	3.9 {2.2-5.2}	5.2 {2.9-7.7}†						
POD 3 (forced inspiration)							4.0 [1.2]	2.9 [0.7] †
POD 5 (forced inspiration)							2.1 [0.8]	1.9 [0.7]*
Pulmonary function							0	0

†p≤0.05; ‡p≤0.01; §p≤0.001; *no statistically significant difference between comparisons (p>0.05)

Table 5.2 (continued) Safety outcomes for MIDCAB versus conventional CABG (non-randomised comparative studies)

Perioperative outcomes	Ott 1999 (level III-3)		Reichenspurner 1999 (level III-3)		Struber 1999 (level III-3)		Tevearai 1999 (level III-3)	
	MIDCAB (n=29)	CCABG (n=104)	MIDCAB (n=121)	CCABG (n=475)	MIDCAB (n=12)	CCABG (n=12)	MIDCAB (n=14)	CCABG (n=81)
Mortality	1 (3.4%)	2 (1.9%)*						
Myocardial infarction	0	2 (2.1%)						
Cardiac ischaemia					0	0		
Blood loss, mean total (mL)					580 [280]	720 [350]		
Stroke	1 (3.4%)	2 (1.9%)						
Renal failure								
Atrial fibrillation (in- hospital)	3 (10.4%) [†]	9 (8.8%)*						
Sepsis	0	0						
Infection sternal leg	1 (3.4%) 0	0 2 (1.9%)						
Postoperative outcomes					Follow-up 24 hours			
Inflammatory response: Complement activation (ng/mL) C3a C1 esterase inhibitor Cytokines IL-6 IL-8 STN FR ^b					Intergroup comparison [§] Intergroup comparison [†]			
					Intergroup comparison [§] Intergroup comparison [‡] Intergroup comparison [§]			

^a quoted as 12.0% in the paper

^b soluble tumour necrosis factor receptor

[†]p≤0.05; [‡]p≤0.01; [§]p≤0.001; *no statistically significant difference between comparisons (p>0.05)

Table 5.3 Safety outcomes for MIDCAB case series: Perioperative

	Mortality	MI	Mean blood loss (mL)	Stroke	Renal failure	Transfusion required	Reoperation for bleeding	AF (in-hospital)	Major complications (unspecified)
Azoury 2001 (n=21)	0	1 (5%)			1 (5%)		0		
Baumgartner 1999 (n=7)	0	0							
Boonstra 1997 (n=35)	0					0			
Coulson 1998a (n=8)	0								'minimal'
Coulson 1998c (n=4)									
Cremer 1997 (n=44)	2 (4.5%)	0	595 {365}			3 (6.8%)			
D'Ancona 2000 (n=67)	3 (4.5%)	2 (3%)		0	1 (1.5%)		0		3 (4.5%)
Diegeler 1998 (n=209)	1 (0.47%)	4 (1.9%)	234 [131]			8 (3.8%)			
Diegeler 1999 (n=130)	1 (0.4%)	6 (2.2%)		1 (0.4%)	1 (0.4%)				
Dullum 1999 (n=7)	0					1 (14%)		3 (43%)	
Flege 2000 (n=10)	0								0

†p≤0.05; ‡p≤0.01; §p≤0.001; *no statistically significant difference between comparisons (p>0.05)

AF – atrial fibrillation

Table 5.3 (continued) Safety outcomes for MIDCAB case series: Perioperative (continued)

	Mortality	MI	Mean blood loss (mL)	Stroke	Renal failure	Transfusion required	Reoperation for bleeding	AF (in-hospital)	Major complications (unspecified)
Kim 1999 (n=4)									0
Lazzara 1997 (n=10)	0	0							0
Lin 2000 (n=35)	1 (2.8%)	0		0			0		
Mack 1999 (n=103)	2 (1.94%)			1 (0.9%)	1 (0.9%)		4 (3.9%)	8 (7.7%)	
Magovern 2001 (n=22)	1 (4.5%)		622 {560}	0	0	8 (36%)	0		
Niinami 2001 (n=22)	0 (95% CI 0 to 15.4%)	0 (95% CI 0 to 15.4%)				0		1 (4.5%) 95% CI 0.1% to 22.8%	0
Oster 1998 (n=27)	0	0					1 (3.7%)		
Shiga 2000 (n=23)		0						0 malignant arrhythmia	
Watanabe 1999 (n=20)	0					0			0
Wolf 1999 (n=13)	1 (7.7%)								0

†p≤0.05; ‡p≤0.01; §p≤0.001; *no statistically significant difference between comparisons (p>0.05)

Table 5.4 Safety outcomes for MIDCAB case series: Postoperative

	Follow-up	Mortality	MI	Myocardial injury	AF	Pain	Pulmonary function	Wound infections/ complications	Sepsis
Azoury 2001 (n=21)	15 [13] months	1 (5%)			1 (5%)				
Boonstra 1997 (n=35)	Not stated			CK-MB 3.1 {1.9} U/L, range 1 to 8					
Cremer 1997 (n=44)	3 months					0 persisting		0	
D'Ancona 2000 (n=67)	6 weeks							0	1 (1.5%)
Diegeler 1999 (n=271)	6 months	1 (0.4%)			28 (10.3%)				
Lazzara 1997 (n=10)	Post-operative only	1 (10%)		2 (20%) cTnl >0.35 ng/mL					
Lin 2000 (n=35)	>2 years	0				1 (2.8%)		0	
Mack 1999 (n=103)	Up to 96 hours					5 (4.8%)			
Magovern 2001 (n=22)	6 months mean	0						0	
Ng 2000 (n=165)	2 weeks							15 (9.1%)	
Niinami 2001 (n=22)	1 month			CK-MB peak (IU/L) (median 7.2 (range 2 to 17))		On POD 6, 3 (13.6%) mild pain. Maximal pain was on POD 2		0	
Shiga 2000 (n=23)	24 hours			CK-MB peak (IU/L): Median 16 (IQR 6-33); <u>TnI</u> : Detectable: 21 (91.3%) >0.2 ng/mL: 4 (17.4%)					
Watanabe 1999 (n=20)	7.0 months mean {5.6}	0		No rise in CK-MB					

†p≤0.05; ‡p≤0.01; §p≤0.001; *no statistically significant difference between comparisons (p>0.05)

Table 6 Comparison 2 Safety outcomes: comparison of MIDCAB over time (non-randomised comparative studies)

Teveearai 1999 (level III-3)					
Perioperative outcomes	July to December 1997 (n=7)	January to June 1998 (n=4)	July to December 1998 (n=7)	January to March 1999 (n=7)	TOTAL (n=25)
Reoperation	1 (14.3%)*	0 (0%)*	1 (14.3%)*	1 (14.3%)*	3 (12%)
Major complications (pneumonia and arrhythmias)	5 (71.4%)*	2 (50%)*	2 (28.6%)*	1 (14.3%)*	10 (40%)

†p≤0.05; ‡p≤0.01; §p≤0.001; *no statistically significant difference between comparisons (p>0.05)

Table 7 Comparison 3 Safety outcomes for redo MIDCAB compared with first-time MIDCAB (non-randomised comparative studies)

Mijayi 1999 (level III-3)		
Perioperative outcomes	MIDCAB redos (n=25)	MIDCAB first-time (n=95)
Mortality	1 (4.0%)	2 (2.1%)*
Major complications	3 (12%)	11 (11.6%)*

†p≤0.05; ‡p≤0.01; §p≤0.001; *no statistically significant difference between comparisons (p>0.05)

Table 8 Comparison 4 Safety outcomes for MIDCAB (stabiliser versus no stabiliser): non-randomised comparative studies

Perioperative outcomes	Calafiore 1998 (level III-3)		Douville 1999 (level III-3)		Maslow 1999 (level III-3)		Possati 1998 (level III-3)		Subramanian 1997 (level III-3)	
	Stabiliser (n=168)	no stabiliser (n=93)	Stabiliser (n=28)	no stabiliser (n=11)	Stabiliser (n=40)	no stabiliser (n=20)	Stabiliser (n=21)	no stabiliser (n=56)	Stabiliser (n=52)	no stabiliser (n=117)
Mortality	1 (0.6%)	0*	0	1 (0.9%)	0	0*				
Myocardial infarction	0	0			0	0*				
Stroke			2 (1.7%)	0						
Transfusion required	2 (1.2%)	2 (2.1%)*								
Reoperation for bleeding	3 (1.8%)	3 (3.2%)*	1 (3.6%)	0						
Atrial fibrillation (in-hospital)			4 (14.3%)	1 (0.9%)	13 (2.5%)	4 (20%)*				
Postoperative outcomes	Follow-up 19 months		Follow-up 30 days		Follow-up not stated		Follow-up 18 months		Follow-up mean 9.2 {7.4} months	
Mortality	1 (0.7%)	1 (1.0%)								
Event-free survival	161 (95.8%)	84 (89.9%)†								
Atrial fibrillation	14 (8.3%)	9 (9.7%)*								
Pulmonary complications					1 (2.5%)	0*				

†p≤0.05; ‡p≤0.01; §p≤0.001; *no statistically significant difference between comparisons (p>0.05)

Table 9.1 Effectiveness outcomes for MIDCAB versus conventional CABG (RCTs)

Perioperative outcomes	Gu 1998 (level II)		Gulielmos 1999 (level II)			Gulielmos 2000 (level II)			POEM 2001 (level II)	
	MIDCAB (n=31)	CCABG (n=31)	MIDCAB (n=9)	CCABG (n=10)	DRESDEN CABG (n=8)	MIDCAB (n=10)	CCABG (n=10)	DRESDEN CABG (n=10)	MIDCAB (n=165)	CCABG (n=145)
Mean operating time (mins)	104 {28}	140 {28}†				130.6 [22.54]	93.5 [14.27] §	160.1 [17.2] §	168 {108}	240 {90}§
Mean ICU stay (days)									1.2 {1.7}	2.1 {3.3}§
Mean hospital stay (days)	4.4 {1.7}	7.7 {2.6}§							4.5 {4.3}	8.3 {11.8}§
Mean duration of ventilation (hours)	7.7 {4.1}	12.2 {3.4}§				4.9 [1.84]	4.7 [1.89]*	4.42 [2.11]*	3.2 {2.4}ª	12.0 {13.1}§
Conversion to CABG with CPB			0%	NA	NA	0%	NA	NA	1 (0.6%)	NA
Grafts/patient									1.0 {0.2}	3.3 {1.0}§
LAD occlusion time (mins)						19.8 [5.27]	NA	NA		
Postoperative outcomes			Follow-up 3 months			Follow-up 3 months			Follow-up 6 months	
Re-intervention rate									5 (3%)	1 (0.7%)*
Graft patency			9 (100%)	10 (100%)	8 (100%)	10 (100%)	10 (100%)	10 (100%)	96 (93.2%)	66 (94.3%)*ª

ª 24 in paper

ª data available for only 56% of patients (103 MIDCAB and 70 CCABG)

†p≤0.05; ‡p≤0.01; §p≤0.001; *no statistically significant difference between comparisons (p>0.05)

Table 9.2 Effectiveness outcomes for MIDCAB versus conventional CABG (non-randomised comparative studies)

Perioperative outcomes	Allen 1997 (level III-3)		Byrne 2001 (level III-3)		Connolly 2000 (level III-3)		D'Amato 2000 (level III-3)	
	MIDCAB (n=23)	CCABG (n=12)	MIDCAB (n=13)	CCABG (n=33)	MIDCAB (n=125)	CCABG (n=348)	MIDCAB (n=96)	CCABG (n=42)
Mean hospital stay (days)	3.0 (median) {2.4}	7.5 (median){5.0} ‡			6.3 {7.3}	13.4 {21.1}§	4.0 {1.2}	7.0 {5.1}†
Mean duration of ventilation (hours)							3.6 {8}	12.5 {6}§
Conversion to CABG with CPB	0	NA	1 (7.7%)	NA				
Postoperative outcomes	12 [6] months follow-up	98 [29] months follow-up						
Graft patency	8/10 (80%)							

†p≤0.05; ‡p≤0.01; §p≤0.001; *no statistically significant difference between comparisons (p>0.05)

Perioperative outcomes	Diegeler 1998 (level III-3)		Diegeler 2000 (level III-3)	
	MIDCAB (n=10)	CCABG (n=10)	MIDCAB (n=10)	CCABG (n=10)
Mean operating time (mins)	114.0 {19.8}	180.3 {64.8}	114.0 {61.3}	180.3 {64.8}
Mean ICU stay (days)	0.59 {0.41}	0.94 {0.31}	0.59 {0.41}	0.79 {0.28}
Mean hospital stay (days)	7.8 {1.7}	8.0 {0.8}	8.3 {2.21}	7.8 {0.79}
Mean duration of ventilation (hours)	8.1 {3.8}	10.8 {3.7}	8.1 {3.9}	10.8 {3.7}
Grafts/patient			1.0 [0]	3.5 {0.97}

†p≤0.05; ‡p≤0.01; §p≤0.001; *no statistically significant difference between comparisons (p>0.05)

Table 9.2 (continued) Effectiveness outcomes for MIDCAB versus conventional CABG (non-randomised comparative studies)

Perioperative outcomes	Diegeler 1999b (level III-2)		Kilger 2000 (level III-2)		Lazzara 1999 (level III-3)		Lichtenberg 2000 (level III-3)	
	MIDCAB (n=65)	CCABG (n=95)	MIDCAB (n=29 [28])	CCABG (n=31 [30])	MIDCAB (n=16)	CCABG (n=10)	MIDCAB (n=15)	CCABG (n=15)
Mean operating time (mins)			147 (129/157)	133(122/157)*			140 [33]	189 [29] §
Mean ICU stay (days)	0.92	1.25*						
Mean duration of ventilation (hours)	8 [4.2]	14 [3.8]*					300 [168]	840 [342] §
Conversion to CABG			0	NA	1 (6.3%)	NA		
Grafts/patient	1.05	2.21†					1 [0]	2.7 [0.7] §
Quality of life POD 7								
Mobility	84%	84%*						
Activity	53%	68%†						
Pain	26%	35%*						
Sleep	50%	62%*						
Emotional	51%	60%*						
Social	25%	14%*						
Postoperative outcomes	3 months follow-up				Follow-up not stated		Follow-up not stated	
Re-intervention rate					5 (31%)	0 (0%)*		
Graft patency Grade ^a					4.06 [0.98]	4.77 [0.33]*		
Quality of life at 3 months								
Mobility	27%	37%†						
Activity	33%	40%*						
Pain	20%	35%†						
Sleep	21%	27%*						
Emotional	46%	45%*						
Social	15%	15%*						

^a grade based on one point each for anastomotic patency, pedicle patency, intercostal obliteration, proper placement into the correct native artery and thrombosis in myocardial ischaemia grade III flow
†p≤0.05; ‡p≤0.01; §p≤0.001; *no statistically significant difference between comparisons (p>0.05)

Table 9.2 (continued) Effectiveness outcomes for MIDCAB versus conventional CABG (non-randomised comparative studies)

Perioperative outcomes	Ott 1999 (level III-3)		Reichenspurner 1999 (level III-3)		Struber (level III-3)		Tevaearai 1999 (level III-3)	
	MIDCAB (n=29)	CCABG (n=104)	MIDCAB (n=121)	CCABG (n=475)	MIDCAB (n=12)	CCABG (n=12)	MIDCAB (n=14)	CCABG (n=81)
Mean operating time (mins)	121 [35]	151 [31] §	132	210	115 [18]	167 [23] †	99 {18}	190 {35}§
Mean ICU stay (days)			24 ^a	48 ^a			1.7 {0.6}	2.2 {0.93}§
Mean hospital stay (days)	3.9 [1.8]	4.8 [2.4] *	5.0	8.5			5.5 {1.63}	8.8 {3.0}§
Conversion to CABG	3 (10.3%)	NA						
Grafts/patient	1.0 [0.2]	3.6 [0.1] ‡						
LAD occlusion time (mins)					17 [8]		23.2 {5.7}	
Re-intervention rate			2 (1.6%)	10 (2.2%)				
Postoperative outcomes			Follow-up not stated					
Costs								
Overall			US\$14,050 ^b	US\$16,230				
Staff			US\$ 3,820	US\$ 3,940				
Material			US\$ 5,060	US\$ 6,880				
General			US\$ 5,170	US\$ 5,410				

^a cited as 1 hour and 2 hours in paper

^b based on a subset of 5 MIDCAB patients

†p≤0.05; ‡p≤0.01; §p≤0.001; *no statistically significant difference between comparisons (p>0.05)

Table 9.3 Effectiveness outcomes for MIDCAB case series: Perioperative

	Mean operating time (mins)	Mean ICU stay (hours)	Mean hospital stay (days)	Mean duration of ventilation (hours)	Conversion to CABG with CPB	Grafts/ patient (mean)	Anastomoses/ patient (mean)	LAD occlusion time (mins)	Complete revascularisation
Azoury 2001 (n=21)			Median 6.0 (range 4 to 16)		0	1.1	1.1		20 (95.2%)
Boonstra 1997 (n=35)	71 {12}		4.4 {0.9}	6.5 {3.9}				8 {3}	
Coulson 1998a (n=8)			8 (3 to 9)						
Cremer 1997 (n=44)				14.9 {5.0}	2/45 (4.4%)				
D'Ancona 2000 (n=67)			8		0	1.3	1.3		
Diegeler 1998 (n=209)	Single vessel: 109 [41.5] Double vessel: 172 [34.2]	14.3 [4.3]	7.8 [2.8]	6.8 [3.3]	10 (4.7%)	1.05		16.2 [4.7]	
Diegeler 1999 (n=130)		12.2 [4.6]	8.3 [2.9]	4.6 [2.8]	12 (4.4%)				
Dullum 1999 (n=7)			5						
Flege 2000 (n=10)									8 (80%)
Lazzara 1997 (n=10)	170.3 {40.7} (incl angiography)	20 {7.6}	4.2 {0.97}		1 (10%)			25.5 {8.22}	
Lin 2000 (n=35)					0				
Mack 1999 (n=103)	139.85 {12.49}		4.12 {2.72}		0				No; targeted
Magovern 2001 (n=22)			6 (range 2 to 15) ^a	5.8 {6}					
Ng 2000 (n=165)	150 {52.8}		3.2 {1.5}						
Niinami 2001 (n=22)	189 [67] range 124 to 405								
Oster 1998 (n=27)	68.2 range 50 to 100	20.3 range 16 to 28	7.4 range 5 to 12		1 (3.7%)	1.1			
Shiga 2000 (n=23)				4.3 median (12.1 to 2.4)	0	1.3		27 median (10 to 49)	
Watanabe 1999 (n=20)	276 {90}	Median 1 day	'typical' range 7 days to 2 weeks		0	1.7	2.4 {0/7}	14.5 {4.0} (LAD) 16.8 {5.1} LCX	

^a excluding one patient who stayed 22 days

Table 9.3 (continued) Effectiveness outcomes for MIDCAB case series: Postoperative

	Follow-up	Re-intervention rate	Graft patency	Occlusion	Stenosis	Successful revascularisation
Azoury 2001 (n=21)	15 [13] months	0				
Baumgartner 1999 (n=7)	2 to 6 months					7 (100%)
Calafiore 1998a (n=190) ^a	29 months?		188 (98.9%); 95% CI 90.6% to 100%		5 (2.6%)	
Coulson 1998a (n=8)	1 to 3 months	4 (50%)				6/6 (2 not measured) [75% to 100%]
Cremer 1997 (n=44)	3 months		31/40 (77.5%)			
Diegeler 1998 (n=209)	Six months	5 (2.4%) early 1/58 (1.7%) late redo CABG	186/191 (97.3%) (postop) 57/58 (98.2%)			
Diegeler 1999 (n=130)	Six months	7 (3.1%) early; 3 (2.3%) 6 months; 1 (0.7%) late redo CABG	126 (95.4%)	3 (2.3%)	11 (8.5%)	
Kim 1999 (n=4)	Not stated		All 'adequate'			
Lazzara 1997 (n=10)	Postoperative only	3 (30%)	7 (70%)			
Lin 2000 (n=35)	> 2 years	2/34 (6%)	32 (91%)			
Mack 1999 (n=103)	Up to 96 hours		99/100 (99%) [91% grade A; 8% grade B] ^a			
Niinami 2001 (n=22)	1 month		21 (96%) 95% CI 51.4% to 99.9%)			
Oster 1998 (n=27)	10 days		9/9 (100%)			
Shiga 2000 (n=23)	24 hours	7 (30.4%) PTCA or stenting				
Watanabe 1999 (n=20)	Mean 7.0 months {5.6}		20 (100%) angiography 7-15 days			
Wolf 1999 (n=13)	Postoperative At least 6 months		12/12 (100%) 5/5 (100%)			

^a grade A: no significant stenosis (greater than or equal to 50%); Grade B: significant angiographic abnormality

Table 10 Comparison 2 Effectiveness outcomes: comparison of MIDCAB over time (non-randomised comparative studies)

Perioperative outcomes	Tevearai 1999 (level III-3)				
	July to December 1997 (n=7)	January to June 1998 (n=4)	July to December 1998 (n=7)	January to March 1999 (n=7)	TOTAL (n=25)
Mean operative time (mins)	124 {14}*	118 {20}*	99 {18}†	98 {18}†	109 {20}
Mean ICU stay (days)	2.6 {1.1}*	1.5 {0.6}*	1.7 {0.8}*	1.6 {0.5}†	1.9 {0.9}
Mean hospital stay (days)	9.0 {1.4}*	6.3 {4.6}*	5.2 {1.7}†	5.9 {1.5}†	6.7 {2.6}
Conversion to CABG					2 (8%)
LAD occlusion time (mins)	26.8 {8.6}*	29.0 {7.6}*	22.0 {5.9}*	24.7 {5.6}*	25.2 {6.9}

†p≤0.05; ‡p≤0.01; §p≤0.001; *no statistically significant difference between comparisons (p>0.05)

Table 11 Comparison 3 Effectiveness outcomes for MIDCAB redos versus first time MIDCAB (non-randomised comparative studies)

Perioperative outcomes	Mijayi 1999 (level III-3)	
	MIDCAB redos (n=25)	MIDCAB first-time (n=95)
Mean operating time (mins)	229.6 {52.1}	219.2 {57.5}*
Mean ICU stay (days)	28.0 {14.9}	Not reported
Mean hospital stay (days)	4.3 {2.3}	4.4 {2.1}*
Mean duration of ventilation (hours)	3.1 {4.3}	Not reported
Postoperative outcomes	Mean follow-up of 3 to 6 months	
Graft patency	24/24 (100%) postoperative 12/12 (Doppler or angiography at 3 to 6 months)	Not reported

†p≤0.05; ‡p≤0.01; §p≤0.001; *no statistically significant difference between comparisons (p>0.05)

Table 12 Comparison 4 Effectiveness outcomes for MIDCAB with and without stabilisers (non-randomised comparative studies)

Perioperative outcomes	Calafiore 1998c (level III-3)		Douville 1999 (level III-3)		Maslow 1999 (level III-3)		Possati 1998 (level III-3)		Subramanian 1997 (level III-3)	
	stabiliser (n=168)	no stabiliser (n=93)	stabiliser (n=28)	no stabiliser (n=11)	stabiliser (n=40)	no stabiliser (n=20)	stabiliser (n=21)	no stabiliser (n=56)	stabiliser (n=52)	no stabiliser (n=104)
Mean operating time (mins)	132 [36]	120 [30] ‡								
Mean ICU stay (hours)	3.7 [2.4]	4.3 [5.6]*			45.6 [64.8]	31.2 [26.4]*				
Mean hospital stay (days)	3.1 [1.2]	2.6 [1.1] ‡ ^a	3	5.5	4.9 [3.3]	5.2 [5.9]*				
Conversion to CABG with CPB and full sternotomy	5 (3.0%)	4 (4.3%)*	1 (3.6%)	4 (36.3%)†	2 (5%)	1 (5%)* ^c				
LAD occlusion time (mins)	30.4 [9.0]	27.7 [6.5] †								
Complete revascularisation			27 (96.4%)	11 (100%)						
Postoperative outcomes	Follow-up 19 months		Follow-up 30 days		Follow-up not stated		Follow-up 18 months		Follow-up mean 9.2 (7.4) months	
Re-intervention rate PTCA	3 (1.8%)	9 (9.7%)§			3 (7.5%) 1 (2.5%)	3 (15%)* ^d 1 (5%)*				
Graft patency	166 (98.8%) 2 (1.7%)	86 (92.5%)† ^b 7 (11.5%)†	27 (97.4%)	7 (60%)‡			21 (100%)	46 (81.8%)†	50 (96.2%)	97 (93.3)*
Occlusion							0	1 (1.8%)		
Patent grafts with major anomalies							0	9 (16.1%)		

^a longer hospital stay because of need to stay for angiography

^b patency (measured by cumulating angiography and Doppler)

^c late CABG – conversion done on return to operating time

^d late conversions not included

†p≤0.05; ‡p≤0.01; §p≤0.001; *no statistically significant difference between comparisons (p>0.05)

MIDCAB versus CABG: Randomised controlled trials (n=4)

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
GU 1998 <u>Location:</u> NETHERLANDS Department of Cardiothoracic Surgery, University Hospital, Groningen	MIDCAB versus CCABG MIDCAB: <u>Surgical access:</u> Small anterolateral thoracotomy – 8-10 cm incision at the fifth intercostal space, with the medial edge of the incision 3-4 cm lateral to the LIMA <u>Stabiliser:</u> CTS <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> sufentanil citrate, midazolam, pancuronium bromide <u>Graft type:</u> LIMA-LAD <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Not stated <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated CCABG: <u>Surgical access:</u> Median sternotomy <u>Pre-ischaemic conditioning:</u> Not stated <u>Anaesthesia:</u> sufentanil citrate, midazolam, pancuronium bromide with dexamethasone <u>Heart rate:</u> not stated <u>Body temperature:</u> Moderate hypothermia (30-32°C) <u>Graft type:</u> Not stated <u>Previous revascularisation:</u> Not stated <u>Pain management:</u> Not stated	RCT <u>Method of allocation concealment:</u> not stated <u>Basis of patient selection:</u> 'assigned randomly' to the two groups. Not clear how the subgroup of 20 (in whom inflammatory response was measured) was selected, but they are likely to have been less ill than the rest. <u>Study period:</u> June 1995 to June 1996 <u>Operator details:</u> Not stated <u>Length of follow-up:</u> Duration of hospital stay <u>Losses to follow-up:</u> None <u>Level of evidence:</u> II	62 patients: 31 MIDCAB; 31 CCABG <u>Diagnosis:</u> Isolated stenosis of the LAD <u>Age, mean years:</u> <u>(MIDCAB):</u> 61 [10.7]; <u>(CCABG):</u> 60.0 [8.5]* <u>Gender mix (MIDCAB):</u> male 22 (70.9%); female 19 (61.3%) <u>Gender mix (CCABG):</u> Male 9 (29.1%); female 12 (38.7%)* <u>Lesion type:</u> Not stated <u>Lesion position:</u> LAD <u>Operative status:</u> Not stated RISK FACTORS <u>Ejection fraction, mean :</u> <u>MIDCAB</u> 0.55 [0.09] ; <u>CCABG</u> 0.51[0.09]* <u>Preop LVEDP (mmHg)</u> <u>MIDCAB</u> 5.8 [4.2]; <u>CCABG</u> 6.1 [4.2]* <u>Preop CCS class (grade)</u> <u>MIDCAB</u> 3.0 [0.5] <u>CCABG</u> 3.2 [0.6]* COMORBIDITY <u>Preop hypertension</u> <u>MIDCAB</u> 6 (19.4%); <u>CCABG</u> 4 (12.9%)* History of diabetes <u>MIDCAB</u> 3 (9.7%); <u>CCABG</u> 2 (6.5%)* History of MI <u>MIDCAB</u> 11 (35.5%); <u>CCABG</u> 9 (29.0%)*	<u>Inclusions:</u> Not stated <u>Exclusions:</u> Any associated cardiac disease

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
GULIELMOS 1999 <u>Location:</u> GERMANY Cardiovascular Institute, University Hospital, Dresden	MIDCAB versus CCABG [versus OPCAB versus MIDCAB onpump] MIDCAB: <u>Surgical access:</u> minithoracotomy <u>Stabiliser:</u> CTS <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> Not stated <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Not stated <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated CCABG and Dresden CABG: <u>Anaesthesia:</u> Mehtohexital, fentanyl, succinylcholin and vecuronium <u>Other details:</u> Not stated All patients received aprotinin	RCT (using MIDCAB and CCABG arms only) <u>Method of allocation</u> <u>concealment:</u> Not stated <u>Basis of patient selection:</u> Not stated <u>Study period:</u> Not stated <u>Operator details:</u> Not stated <u>Length of follow-up:</u> 3 months <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> II	27 patients (9 MIDCAB; 18 CABG (10 CCABG and 8 Dresden CABG) <u>Diagnosis:</u> Not stated <u>Age, mean years:</u> MIDCAB: 63.8 [11.3]; CCABG: 59.6 [11.0] <u>Gender mix:</u> MIDCAB: 8 males; CCABG: 8 males; Dresden: 5 males <u>Lesion type:</u> MIDCAB 3/9 with multivessel disease CCABG 4/10 with multivessel disease Dresden 2/10 with multivessel disease <u>Lesion position:</u> Not stated <u>Operative status:</u> Not stated RISK FACTORS <u>Ejection fraction: LVEF (median)</u> MIDCAB 63.8%; CCABG 71.3%; Dresden 77%, p=ns <u>Previous MI</u> MIDCAB 3/10; CCABG 6/10; Dresden 2/10, p=ns <u>CCS:</u> MIDCAB stage 1) 1/9; 2) 3/9; 3) 3/9; 4) 2/9; CCABG 1) 1/10; 2) 3/10; 3) 4/10; 4) 2/10; Dresden 1) 1/8; 2) 4/8; 3) 2/8; 4) 1/8, p=ns <u>NYHA:</u> MIDCAB Class I) 1/9; II) 4/9; III) 4/9; IV) 0/9 CCABG I) 2/10; II) 3/10; III) 4/10; IV) 1/10 Dresden I) 3/8; II) 3/8; III) 2/8, p=ns	<u>Inclusions:</u> Single LIMA-LAD bypass for CAD or patients with double or multi-vessel disease, with only the LAD amenable to surgery <u>Exclusions:</u> Impaired LVEF (<30%); major calcification of the ascending aorta; obesity (BMI >30kg/m ²) CAD – coronary artery disease

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
<p>GULIELMOS 2000</p> <p><u>Location:</u> GERMANY</p> <p>Cardiovascular Institute, University Hospital, Dresden</p>	<p>MIDCAB versus CCABG versus MIDCAB onpump [versus OPCAB]</p> <p>MIDCAB:</p> <p><u>Surgical access:</u> minithoracotomy <u>Stabiliser:</u> CTS <u>Pre-ischæmic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Mehtohexital, fentanyl, succinylcholin and vecuronium <u>Graft type:</u> LIMA-LAD <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> 2/10 <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated</p> <p>CCABG:</p> <p><u>Surgical access:</u> Median sternotomy <u>Anaesthesia:</u> ehtohexital, fentanyl, succinylcholin and vecuronium <u>Heart rate:</u> Not stated <u>Body temperature:</u> . Not stated <u>Graft type:</u> LIMA-LAD <u>Previous revascularisation:</u> 2/10 <u>Pain management:</u> Not stated</p> <p>All patients received aprotinin</p>	<p>RCT</p> <p><u>Method of allocation concealment:</u> 'one out of four techniques was prospectively chosen for each patient at random'</p> <p><u>Basis of patient selection:</u> Random</p> <p><u>Study period:</u> Not stated</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up:</u> 3 months</p> <p><u>Losses to follow-up:</u> None</p> <p><u>Level of evidence:</u> II</p>	<p>30 patients 10 MIDCAB; 10 CCABG; 10 MIDCAB onpump (Dresden); [10 OPCAB]</p> <p><u>Diagnosis:</u> need for LIMA-LAD bypass, due to coronary artery disease</p> <p><u>Age, mean years:</u> MIDCAB 62.9 [9.8] (range 45 to 77) CCABG 59.6 [11.0] (range 47-77)</p> <p><u>Gender mix</u> MIDCAB 9 male, 1 female CCABG 8 male, 2 female</p> <p><u>Lesion type:</u> MIDCAB: 3 patients had multivessel disease CCABG: All patients were referred for single LIMA-LAD, but four patients were suffering from multivessel disease, the other vessels not being amenable for surgery</p> <p><u>Lesion position:</u> LAD</p> <p><u>Operative status:</u> not stated</p> <p>RISK FACTORS</p> <p><u>Ejection fraction LVEF:</u> <u>MIDCAB:</u> 60.1 [12.8%]; <u>CCABG:</u> 71.3 [12.6%]</p> <p><u>BMI:</u> MIDCAB: 25.4 [1.4] kg/m²; CCABG: 26.7 [2.9] kg/m²</p> <p><u>Previous MI:</u> MIDCAB 3/10; <u>CCABG</u> 7/10</p> <p><u>Previous PTCA:</u> <u>MIDCAB:</u> 2/10 (with stenting) CCABG: 2/10 (and/or stenting)</p> <p>COMORBIDITY: Not stated</p>	<p><u>Inclusions:</u> Single LIMA-LAD bypass for CAD or patients with double or multi-vessel disease, with only the LAD amenable to surgery</p> <p><u>Exclusions:</u> Impaired LVEF (<30%) Impaired lung and renal function Unstable angina Major calcification of the ascending aorta Obesity (BMI >30kg/m²) Use of dipyridamole, anticoagulants or immunosuppression Previous cardiac operations Previous MI less than 2 weeks before</p>

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POEM 2001 (Mehran 2001) <u>Location:</u> USA Lennox Hill Hospital, New York, NY (9 clinical sites – 8 US, 1 Canadian)	MIDCAB vs CCABG MIDCAB: <u>Surgical access:</u> left mini-thoracotomy <u>Stabiliser:</u> CTS <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> LIMA-LAD <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Prior CABG 7.9% <u>Direct vision or video-assisted:</u> Direct <u>Pain management:</u> Not stated CCABG: <u>Surgical access:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Heart rate:</u> Not stated <u>Body temperature:</u> Not stated <u>Graft type:</u> IMA-LAD <u>Previous revascularisation:</u> 3.4%, p=ns <u>Pain management:</u> Not stated	RCT <u>Method of allocation concealment:</u> Not stated <u>Basis of patient selection:</u> random allocation <u>Study period:</u> Not stated <u>Operator details:</u> Experienced surgeons (must have done at least 50 MIDCAB procedures) <u>Length of follow-up:</u> 6 months <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> II Note: Designed to have 400 patients (200 in each arm)	310 patients: 165 MIDCAB; 145 CCABG 'Baseline patient characteristics were similar in both groups' MIDCAB and CCABG <u>Diagnosis:</u> Not stated <u>Age:</u> MIDCAB 61 {11}; CCABG 61 {10} p=ns <u>Gender mix:</u> MIDCAB 73.3% male; CCABG 75.9% male, p=ns <u>Lesion type:</u> Not stated <u>Lesion position:</u> Not stated <u>Operative status:</u> Not stated RISK FACTORS: <u>Ejection fraction:</u> Not stated Prior MI: MIDCAB 38.2%; CCABG 35.9%, p=ns COMORBIDITY: <u>Diabetes:</u> MIDCAB 27.9%; CCABG 33.8%, p=ns <u>Hypertension:</u> MIDCAB 61.2%; CCABG 57.2, p=ns <u>CHE:</u> MIDCAB 1.8%; CCABG 2.1%, p=ns <u>Renal failure:</u> MIDCAB 2.4%; CCABG 1.4%, p=ns	<u>Inclusions:</u> target vessel LAD (type II), patent LIMA, patient suitable for CPB, patient agreeable to six month angiographic follow-up <u>Exclusions:</u> acute MI < 24 hours; age <18 or >90; LVEF<20%; >5 bypass grafts during CABG; LAD smaller than 1.5 mm, calcified, intramyocardial or diffusely diseased; FEV1<55% predicted; history of chest wall trauma or irradiation; renal failure with creatinine>3.0

MIDCAB versus CABG: Non-randomised comparative studies

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<p>ALLEN 1997</p> <p><u>Location:</u></p> <p>USA</p> <p>Dept of Cardiovascular and Thoracic Surgery, St Vincent Hospital and Health Care Center, Indianapolis, Indiana</p>	<p>MIDCAB redos versus CCABG redos</p> <p>MIDCAB:</p> <p><u>Surgical access:</u> Fourth or occasionally fifth intercostal incision, beginning 3 to 4 cm lateral to the sternal border; anterior</p> <p><u>Stabiliser:</u> MIDCAB System (CardioThoracic Systems Inc, Cupertino, CA) which consists of two disposable retractors and a regional cardiac wall stabiliser</p> <p><u>Pre-ischaemic conditioning:</u> Not stated</p> <p><u>Coronary shunts:</u> Not stated</p> <p><u>Anaesthesia:</u> Short-acting inhalation agents supplemented with low-dose narcotics and propofol</p> <p><u>Graft type:</u> LIMA-LAD</p> <p><u>Occlusion time prior to anastomoses:</u> Not stated</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u> Yes – almost always LAD bypass</p> <p><u>Direct vision or video-assisted:</u> Not stated</p> <p><u>Pain management:</u> Intracostal bupivacaine blocks; post-operative patient-controlled analgesia pump and ketorolac for 24 hours</p> <p>CCABG:</p> <p>All redos, other details not stated</p>	<p>Retrospective comparison</p> <p><u>Basis of patient selection for each comparison:</u></p> <p><u>MIDCAB group:</u> consecutive</p> <p><u>CCABG group:</u> consecutive</p> <p><u>Study period</u></p> <p><u>MIDCAB:</u> September 1995 to July 1996</p> <p><u>CCABG:</u> November 1984 to July 1994</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up (months):</u></p> <p>MIDCAB: mean 12 {6}; range 6 to 17</p> <p>CCABG: Mean 98 {29}; range 30 to 146</p> <p><u>Losses to follow-up :</u> Not stated</p> <p><u>Level of evidence</u> III-3</p>	<p>37 patients: 23 MIDCAB, 12 CCABG</p> <p><u>Diagnosis:</u> Not stated</p> <p><u>Age (median):</u> <u>MIDCAB</u> 65.0 [8.2]; <u>CCABG</u> 59.5 [8.3]</p> <p><u>Gender mix:</u> MIDCAB: 7 female (30%); CCABG: 3 female (25%)</p> <p><u>Lesion type:</u> MIDCAB: single or multivessel</p> <p><u>Lesion position:</u> MIDCAB: all LAD</p> <p><u>Patient NYHA and CCS class:</u> MIDCAB: 7.4 [2.7]; CCABG: 6.6 [3.3]</p> <p><u>Parsonnet score:</u> MIDCAB: 8.4 ± 2.5; CCABG: 8.3 ± 4.8</p> <p><u>Operative status:</u> Not stated</p> <p><u>Comorbidities:</u> Not stated</p>	<p><u>MIDCAB inclusions:</u></p> <p>Good quality distal LAD that did not appear to be calcified or intra-myocardial, and a patent LIMA; 'not good candidates' for PTCA (n=14); high risk for CPB (n=9)</p> <p>NOTE: only 10/23 MIDCAB patients had angiograms – these were a select group biased towards those with recurrent symptoms; 4 due to recurrent symptoms and 6 were randomly assigned as part of another study. No angiograms were done in the control group.</p>

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
BYRNE 2001 <u>Location:</u> USA Division of Cardiac Surgery, Brigham and Women's Hospital, Massachusetts	MIDCAB versus CCABG (redo) all left thoracotomy MIDCAB: <u>Surgical access:</u> left thoracotomy, fourth intercostal space <u>Stabiliser:</u> variety, including Octopus and CTS <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> Not stated <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> 36/50 (72%) LIMA-LAD - 70% (25/36) of these LIMA-LADs were patent <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated CCABG: Mostly femoral cannulation, Patient cooled to 20 to 25°C	Retrospective comparison of MIDCAB and CCABG <u>Basis of patient selection:</u> 50 consecutive patients – majority of later patients were offpump <u>Study period:</u> October 1991 to October 1999 <u>Operator details:</u> Not stated <u>Length of follow-up:</u> Not stated <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> III-3	46 [50] patients; 13 MIDCAB, 33 CCABG [4 Heartport] <u>Diagnosis:</u> Not stated <u>Age, mean years:</u> 65 {9 years} <u>Gender mix:</u> 40 (80%) male <u>Lesion type:</u> Not stated <u>Lesion position:</u> Not stated <u>Operative status:</u> No emergency operations RISK FACTORS <u>Ejection fraction</u> (mean for all 50 patients): 40 {13}	Not stated

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
CONNOLLY 2000 <u>Location:</u> USA Lenox Hill Hospital, New York, NY	MIDCAB (redo) versus CCABG MIDCAB: <u>Surgical access:</u> Left anterior thoracotomy (n = 41); left anterolateral thoracotomy (n = 5); lateral thoracotomy (n = 39); transabdominal (n = 23); subxyphoid (n = 11); combination (n = 6) <u>Stabiliser:</u> Mechanical stabiliser <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> LIMA, RIMA, GEA, SVG and/or radial artery as a composite, or proximal to left subclavian artery, thoracodorsal artery or descending aorta <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> All patients were redos <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated CCABG: All redos, other details not stated	Retrospective comparison of MIDCAB and CCABG <u>Basis of patient selection:</u> Not stated <u>Study period:</u> MIDCAB: 1996 – 1999 CCABG: 1992 - 1999 <u>Operator details:</u> Not stated <u>Length of follow-up:</u> Not stated <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> III-3	473 patients: 125 MIDCAB; 348 CCABG <u>Diagnosis:</u> Not stated <u>Age:</u> Not stated <u>Gender mix:</u> MIDCAB: 33 (27%) female CCABG: 52 (15%) female p=0.006 <u>Lesion type:</u> Single and multi-vessel <u>Lesion position:</u> Not stated <u>Operative status:</u> Not stated RISK FACTORS <u>Ejection fraction <40% :</u> MIDCAB: 60 (50%) CCABG: 121 (34%) <u>Hypertension:</u> MIDCAB: 85 (68%) CCABG: 186 (53%) p=0.006 <u>CHF:</u> MIDCAB: 54 (43%) CCABG: 81(23%) p=0.0001 <u>COPD:</u> MIDCAB: 21 (17%) CCABG: 21 (6%) p=0.0006 <u>Calcified aorta:</u> MIDCAB: 17 (13%) CCABG: 15 (4%) p=0.0008 <u>PTCA:</u> MIDCAB: 45 (58%) CABG: 116 (33%) p=0.012 <u>Recent MI:</u> MIDCAB: 37 (29%) CABG: 52 (15%) p=0.001 <u>>1 reoperation:</u> MIDCAB: 25 (32%) CABG: 21 (6%) p=0.0001	Not stated

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<p>D'AMATO 2000</p> <p><u>Location:</u></p> <p>USA</p> <p>Department of Cardiothoracic Surgery, Allegheny General Hospital, Pittsburgh, Pennsylvania</p>	<p>MIDCAB versus single CCABG</p> <p>MIDCAB:</p> <p><u>Surgical access:</u> Left anterior thoracotomy in the fourth intercostal space</p> <p><u>Stabiliser:</u> CTS</p> <p><u>Pre-ischaemic conditioning:</u> Not stated</p> <p><u>Coronary shunts:</u> Not stated</p> <p><u>Anaesthesia:</u> Similar to CCABG except smaller doses of fentanyl and midazolam were used</p> <p><u>Graft type:</u> Not stated</p> <p><u>Occlusion time prior to anastomoses:</u> Not stated</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u> Not stated</p> <p><u>Direct vision or video-assisted:</u> Direct vision</p> <p><u>Pain management:</u> Intercostal nerve blocks (bupivacaine)</p> <p>CCABG:</p> <p><u>Surgical access:</u> Median sternotomy</p> <p><u>Cardioplegia:</u> Cold blood cardioplegia</p> <p><u>Pre-ischaemic conditioning:</u> Not stated</p> <p><u>Anaesthesia:</u> Etomidate, fentanyl, midazolam, neuromuscular blocking agents, and pavulon</p> <p><u>Heart rate:</u> Not stated</p> <p><u>Body temperature:</u> Allowed to 'drift down'</p> <p>Other details not stated</p>	<p>Retrospective comparison of MIDCAB and CCABG</p> <p><u>Basis of patient selection:</u> All patients having a single vessel LIMA-LAD – choice for MIDCAB or single CCABG was made by individual surgeon and patient preferences</p> <p><u>Study period:</u> November 1995 to May 1997 (for both MIDCAB and CCABG)</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up:</u> 6 weeks</p> <p><u>Losses to follow-up:</u> Complete follow-up for all patients</p> <p><u>Level of evidence:</u> III-3</p>	<p>138 patients: 96 MIDCAB; 42 single CCABG</p> <p><u>Diagnosis:</u> Not stated</p> <p><u>Age, mean years:</u> MIDCAB: 64.4 {12}; CCABG: 64.5 {12} p=ns</p> <p><u>Gender mix:</u> MIDCAB: 69 (72%) male ; CCABG: 24 (58%) male p=ns</p> <p><u>Lesion type:</u> Not stated</p> <p><u>Lesion position:</u> Not stated</p> <p><u>Operative status:</u> Not stated</p> <p>RISK FACTORS:</p> <p>Composite score of left ventricular function, comorbid diseases, urgency of operation and laboratory values: MIDCAB: 4.0 ± 3.3; CCABG: 3.6 ± 2.8 p=ns</p> <p><u>Ejection fraction:</u> MIDCAB: 42% {18}; CCABG: 44% {15} p=ns</p> <p><u>Preop. episodic AF:</u> MIDCAB: 6 (6%); CCABG: 4 (9.5%) p=ns</p>	<p>Not stated</p>

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<p>DIEGELER 2000a</p> <p><u>Location:</u></p> <p>GERMANY</p> <p>Department of Cardiac Surgery, Herzzentrum, Universitat Leipzig, Leipzig</p>	<p>MIDCAB versus CCABG</p> <p>MIDCAB:</p> <p><u>Surgical access:</u> Anterolateral (7 to 10cm) thoracotomy at the left fourth intercostal space</p> <p><u>Stabiliser:</u> CTS or Octopus</p> <p><u>Pre-ischaemic conditioning:</u> Not stated</p> <p><u>Coronary shunts:</u> Not stated</p> <p><u>Anaesthesia:</u> Same for MIDCAB and CCABG – sufentanil and propofol</p> <p><u>Graft type:</u> Not stated</p> <p><u>Occlusion time prior to anastomoses:</u> Not stated</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u> Not stated</p> <p><u>Direct vision or video-assisted:</u> Not stated</p> <p><u>Pain management:</u> Not stated</p> <p>CCABG:</p> <p>Cannulation of the ascending aorta and right atrium</p>	<p>Comparison of MIDCAB and CCABG</p> <p><u>Basis of patient selection:</u> 'patients were separated into three groups'</p> <p><u>Study period:</u> Not stated</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up:</u> Not stated</p> <p><u>Losses to follow-up:</u> Not stated</p> <p><u>Level of evidence:</u> III-3</p>	<p>30 patients: 10 CCABG; 10 MIDCAB; [10 OPCAB]</p> <p><u>Diagnosis:</u> Not stated</p> <p><u>Age, mean years:</u> MIDCAB 57.3 [30.4]; CCABG 66.7 [26.4]</p> <p><u>Gender mix:</u> MIDCAB 2 female CCABG 2 female</p> <p><u>Lesion type - 1, 2 or 3 vessel disease:</u> MIDCAB 6 1-vessel; 3 2-vessel; 1 3-vessel; CCABG 10 3-vessel</p> <p><u>Lesion position:</u> Not stated</p> <p><u>Operative status:</u> Non-emergency</p> <p>RISK FACTORS</p> <p><u>CCS class:</u> MIDCAB I 1 (10%); II 8 (80%); III 1 10%); CCABG II 7 (70%); III 3 (30%)</p> <p><u>NYHA class:</u> MIDCAB I 2 (20%); II 7 (20%); III 1 (10%); CCABG II 8 (80%); III 2 (20%)</p> <p><u>Ejection fraction, %, mean:</u> MIDCAB 65.30 (SE 15.72); CCABG 66.6 (SE 20.11)</p> <p><u>Hyperlipoproteinemia:</u> MIDCAB 6 (60%); CCABG 7 (70%)</p> <p><u>Hypertension:</u> MIDCAB 8 (80%); CCABG 10 (100%)</p> <p><u>Diabetes:</u> MIDCAB 2 (20%); CCABG 7 (70%)</p>	<p><u>Inclusions:</u> age less than 75 years, stable angina, ejection fraction greater than 35%</p> <p><u>Exclusions:</u> AMI in previous 2 weeks, active or prior history of autoimmune disorders, medication with immune-modulating agents, elevated white blood cell or C-reactive protein levels, or any history or signs of infectious disease before surgery</p> <p>AMI – acute myocardial infarction</p>

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<p>DIEGELER 1999b</p> <p><u>Location:</u></p> <p>GERMANY</p> <p>Klinik für Herzchirurgie, Herzzentrum, Universität Leipzig</p>	<p>MIDCAB versus CCABG</p> <p>MIDCAB:</p> <p><u>Surgical access:</u> Anterolateral minithoracotomy through the 4th intercostal space</p> <p><u>Stabiliser:</u> Different devices for mechanical stabilisation</p> <p><u>Pre-ischaemic conditioning:</u> Not stated</p> <p><u>Coronary shunts:</u> Not stated</p> <p><u>Anaesthesia/analgesia:</u> Disoprivan/sufentanil</p> <p><u>Graft type:</u> Not stated</p> <p><u>Occlusion time prior to anastomoses:</u> Not stated</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u> Not stated</p> <p><u>Direct vision or video-assisted:</u> Direct vision</p> <p><u>Pain management:</u> Pethidine or piritramid on POD 1 and 2, oral tramadol between POD 2 and 4, oral paracetamol and indomethacine from POD 4 onwards at the patient's request</p> <p>CCABG:</p> <p><u>Surgical access:</u> Median sternotomy</p> <p>Moderate hypothermia (32-34°C) and cold cardioplegic arrest</p> <p><u>Anaesthesia/analgesia:</u> Disoprivan/sufentanil</p> <p><u>Pain management:</u> as for MIDCAB</p>	<p>Prospective comparison of MIDCAB and CCABG</p> <p><u>Basis of patient selection:</u> MIDCAB: consecutive CCABG: computer-matched</p> <p><u>Study period:</u> Not stated</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up:</u> 3 months</p> <p><u>Losses to follow-up:</u> 5 (3.2%)</p> <p><u>Level of evidence:</u> III-2</p>	<p>160 patients: 65 MIDCAB; 95 CCABG</p> <p><u>Diagnosis:</u> MIDCAB: Stable angina pectoris with angiographically proven single vessel proximal LAD disease CCABG: Stable angina pectoris with angiographically proven two vessel disease, at least one of which was a high-grade proximal LAD lesion along with another vessel suitable for a standard graft</p> <p><u>Age (years):</u> MIDCAB 61.8 [9.7]; CCABG 64.0 [9.1] p=ns</p> <p><u>Gender mix:</u> MIDCAB: 66.2% male; CCABG: 67.4% male p=ns</p> <p><u>BSA (m²):</u> MIDCAB: 1.78 [0.2]; CCABG: 1.84 [0.2] p=ns</p> <p><u>Lesion type:</u> MIDCAB: mostly single vessel, but some multivessel patients were accepted for MIDCAB if other non-LAD vessels were diseased but not suitable for grafting</p> <p><u>Lesion position:</u> Not stated</p> <p><u>Operative status:</u> Not stated</p> <p>RISK FACTORS</p> <p><u>Ejection fraction, mean:</u> MIDCAB: 69.9 [8.8]; CCABG: 59.7 [15] p<0.05</p> <p><u>Diabetes:</u> MIDCAB: 22 (33.8%); CCABG: 38 (40%) p=ns</p> <p><u>Hypertension:</u> MIDCAB: 28 (43.0%); CCABG: 56 (58.9%) p=ns</p> <p><u>COPD:</u> MIDCAB: 1 (3.0%); CCABG: 7 (7.3%) p=ns</p> <p><u>Obesity:</u> MIDCAB: 22 (33.8%); CCABG: 58 (61.0%) p<0.05</p>	<p><u>Inclusions:</u> Not stated</p> <p><u>Exclusions:</u> Patients with diffuse multiple vessel disease requiring three or more grafts and redo procedures were excluded;</p> <p>Patients taking chronic pain medication preoperatively</p> <p>NOTE: The protocol allowed for patients to be excluded from analysis if severe complications (low cardiac output or pulmonary, renal or neurological disorders) caused a prolonged postoperative course (1 patient from each group)</p>

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<p>DIEGELER 1998b</p> <p><u>Location:</u></p> <p>GERMANY</p> <p>Department of Cardiac Surgery, Department of Pediatric Cardiology, Heart Center, University of Leipzig, Leipzig</p>	<p>MIDCAB versus CCABG</p> <p>MIDCAB:</p> <p><u>Surgical access:</u> Limited access (7 to 10 cm) through the left fourth intercostal space</p> <p><u>Stabiliser:</u> CTS or Octopus</p> <p><u>Pre-ischaemic conditioning:</u> Not stated</p> <p><u>Coronary shunts:</u> Not stated</p> <p><u>Anaesthesia:</u> Same for MIDCAB and CCABG – sufentanil and propofol</p> <p><u>Graft type:</u> Not stated</p> <p><u>Occlusion time prior to anastomoses:</u> Not stated</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u> Not stated</p> <p><u>Direct vision or video-assisted:</u> Not stated</p> <p><u>Pain management:</u> Not stated</p> <p>CCABG:</p> <p>Cannulation of the ascending aorta and right atrium</p>	<p>Comparison of MIDCAB and CCABG</p> <p><u>Basis of patient selection:</u> 'patients were separated into three groups'</p> <p><u>Study period:</u> Not stated</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up:</u> Not stated</p> <p><u>Losses to follow-up:</u> Not stated</p> <p><u>Level of evidence:</u> III-3</p>	<p>30 patients: 10 CCABG; 10 MIDCAB; [10 OPCAB]</p> <p><u>Diagnosis:</u> Not stated</p> <p><u>Age, mean (years):</u> MIDCAB 58.3 {8.8}; CCABG 66.7 {7.9}</p> <p><u>Gender mix:</u> MIDCAB 2 female; CCABG 2 female</p> <p><u>Lesion type - 1, 2 or 3 vessel disease:</u> MIDCAB 6 1-vessel; 4 2-vessel; CCABG 4 2-vessel; 6 3-vessel</p> <p><u>Lesion position:</u> Not stated</p> <p><u>Operative status:</u> Non-emergency</p> <p>RISK FACTORS</p> <p><u>Ejection fraction, %, mean:</u> MIDCAB 65.1 (SE 16.8); CCABG 64.6 (SE 19.1)</p> <p><u>Myocardial infarction:</u> MIDCAB 5 (50%); CCABG 7 (70%)</p> <p><u>Diabetes:</u> MIDCAB 2 (20%); CCABG 3 (30%)</p> <p><u>COPD:</u> MIDCAB 2 (20%); CCABG 1 (10%)</p>	<p><u>Inclusions:</u> not emergency surgery, age less than 75 years, stable angina, ejection fraction greater than 35%</p> <p><u>Exclusions:</u> AMI in previous 2 weeks, active or prior history of autoimmune disorders, medication with immune-modulating agents, or any history or signs of infectious disease before surgery</p>

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<p>KILGER 2000</p> <p><u>Location:</u></p> <p>GERMANY</p> <p>Departments of Anesthesiology, Cardiac Surgery and Clinical Chemistry, Ludwig-Maxmilian University of Munich, Munich,</p>	<p>MIDCAB versus CCABG [versus OPCAB]</p> <p>MIDCAB:</p> <p><u>Surgical access:</u> small left anterolateral thoracotomy (7 to 8 cm)</p> <p><u>Stabiliser:</u> CTS</p> <p><u>Pre-ischaemic conditioning:</u> several brief periods (1 to 2 mins) of clamping and unclamping of the referring vessels</p> <p><u>Coronary shunts:</u> Not stated</p> <p><u>Anaesthesia:</u> sufentanil, midazolam, pancuronium bromide and isoflurane</p> <p><u>Graft type:</u> Not stated</p> <p><u>Occlusion time prior to anastomoses:</u> Not stated</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u> Not stated</p> <p><u>Direct vision or video-assisted:</u> Not stated</p> <p><u>Pain management:</u> Not stated</p> <p>CCABG:</p> <p><u>Anaesthesia:</u> sufentanil, midazolam, pancuronium bromide and isoflurane</p>	<p>Prospective comparison</p> <p><u>Basis of patient selection:</u> 87 consecutive patients: decision as to which surgical method to apply made on:</p> <p>MIDCAB indications – isolated proximal stenosis of LAD or diagonal branch with nearly normal body weight and no history of thoracic radiation</p> <p><u>Study period:</u> April 1997 and August 1998</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up:</u> Not stated</p> <p><u>Losses to follow-up:</u> 2:</p> <p>1 MIDCAB; 1 CCABG</p> <p><u>Level of evidence</u> III-2</p> <p>NOTE: The inclusion/exclusion criteria were designed to demonstrate only the difference of the different surgical methods</p>	<p>87 patients: 29 (28) MIDCAB; 31(30) CCABG; [27 OPCAB]</p> <p><u>Diagnosis:</u> Diagnosis of CAD made by a cardiologist after angiography (stenosis >50%)</p> <p><u>Age, years (median, IQR):</u> MIDCAB 61 (56/68); CCABG 61 (49/66) p=ns</p> <p><u>Gender mix:</u> MIDCAB 10 female; CCABG 11 female, p=ns</p> <p><u>Lesion type:</u> MIDCAB: Single vessel (n = 17) Double vessel (n = 12 (11)) CCABG: Single vessel (n = 14) Double vessel (n = 17 (16)), p=ns</p> <p><u>Lesion position:</u> Not stated</p> <p><u>Operative status:</u> Not stated</p> <p>RISK FACTORS</p> <p><u>Ejection fraction:</u> Not stated</p> <p><u>COMORBIDITY:</u> Not stated</p>	<p><u>Inclusions:</u></p> <p>Indications:</p> <p>Degree of stenosis as well as length; Stable angina; Not suitable for balloon angioplasty; Not more than 2 vessels diseased; Ejection fraction above 50%; No severe cerebral, pulmonary or vascular disease</p> <p>MIDCAB:</p> <p>Isolated proximal stenosis of the LAD or diagonal branch with nearly normal body weight; No history of thoracic radiation</p> <p><u>Exclusions:</u></p> <p>Age less than 18; Unstable angina; Myocardial infarction within the last 6 months; Skeletal muscle disease; Postoperative complications: Postoperative MI as indicated by ECG; Significant increases in cardiac enzymes; Discharge from ICU later than 42 hours after admission for clinical reasons; suspected intramyocardial course of the LAD or a LAD less than 1.5mm or calcified vessels; pre-existing AF</p>

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LAZZARA 1999 <u>Location:</u> USA Division of Cardiac Services, St. Charles Medical Center, Bend, Oregon	MIDCAB versus CCABG MIDCAB: <u>Surgical access:</u> left anterior thoracotomy <u>Stabiliser:</u> CTS <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> LITA-LAD <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Not stated <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated CCABG: ischaemic fibrillatory arrest <u>Graft type:</u> LITA-LAD	Retrospective comparison <u>Basis of patient selection:</u> Not stated <u>Study period:</u> Not stated <u>Operator details:</u> MIDCAB operations were done during the initial learning curve of the surgeon <u>Length of follow-up:</u> Not stated <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> III-3	26 patients: 16 MIDCAB; 10 CCABG <u>Diagnosis:</u> Not stated <u>Age:</u> MIDCAB: 65.8 [13.6] ; CCABG: 68 [7.6] <u>Gender mix:</u> MIDCAB: 11 males ; CCABG: 9 males <u>Lesion type:</u> MIDCAB: Not stated; CCABG: All multivessel <u>Lesion position:</u> <u>MIDCAB:</u> LAD <u>CCABG:</u> LAD, others not stated <u>Operative status:</u> MIDCAB: Not stated; CCABG: Elective <u>RISK FACTORS:</u> Not stated <u>Ejection fraction:</u> Not stated <u>COMORBIDITY:</u> Not stated	<u>Inclusions:</u> Not stated <u>Exclusions:</u> High risk patients

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<p>LICHTENBERG 2000</p> <p><u>Location:</u> GERMANY Division of Thoracic and Cardiovascular Surgery, Hannover</p>	<p>MIDCAB versus CCABG</p> <p>MIDCAB: <u>Surgical access:</u> left hemithorax was entered through the fourth or fifth intercostal space, usually 8 cm <u>Stabiliser:</u> CTS (U-shaped) <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Usually etomidate, fentanyl, pancuronium bromide and sodium thiopental <u>Graft type:</u> LITA-LAD <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Not stated <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Standard analgesic medication with diclofenac</p> <p>CCABG: <u>Surgical access:</u> Median sternotomy <u>Anaesthesia:</u> as above <u>Extubation:</u> after 840 [342] mins <u>Ventilation:</u> Not stated <u>Heart rate:</u> Not stated <u>Body temperature:</u> Moderate hypothermia 32 to 34°C <u>Graft type:</u> Not stated <u>Previous revascularisation:</u> Not stated <u>Pain management:</u> as above</p>	<p>Prospective? comparison</p> <p><u>Basis of patient selection:</u> Not stated</p> <p><u>Study period:</u> Not stated</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up:</u> Not stated</p> <p><u>Losses to follow-up:</u> Not stated</p> <p><u>Level of evidence:</u> III-3</p>	<p>30 patients: 15 MIDCAB; 15 CCABG</p> <p><u>Diagnosis:</u> Not stated</p> <p><u>Age, years:</u> MIDCAB: 65.2 [10.9]; CCABG: 60.7 [9.4]</p> <p><u>Gender mix:</u> MIDCAB: 15 males; CCABG: 15 males</p> <p><u>Lesion type:</u> Not stated</p> <p><u>Lesion position:</u> Not stated</p> <p><u>Operative status:</u> Not stated</p> <p><u>RISK FACTORS:</u> Not stated</p> <p><u>Ejection fraction:</u> Not stated</p> <p><u>COMORBIDITY:</u> Not stated</p>	<p><u>Inclusions:</u> Male gender, normal cardiac function (ejection fraction > 55%), NYHA classification I or II, absence of pulmonary or chest wall diseases</p> <p><u>Exclusions:</u> Not stated</p>

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<p>OTT 1999</p> <p><u>Location:</u> USA</p> <p>Department of Surgery, Anaheim Memorial Medical Center, Anaheim, California</p>	<p>Comparison of MIDCAB, CCABG (fast-track) [and OPCAB]</p> <p>MIDCAB:</p> <p><u>Surgical access:</u> Small left anterior thoracotomy</p> <p><u>Stabiliser:</u> CTS</p> <p><u>Pre-ischaemic conditioning:</u> Not stated</p> <p><u>Coronary shunts:</u> Not stated</p> <p><u>Anaesthesia:</u> Not stated</p> <p><u>Graft type:</u> Not stated</p> <p><u>Occlusion time prior to anastomoses:</u> Not stated</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u></p> <p><u>Previous CABG:</u> MIDCAB - 20%; CCABG - 9%, p = ns</p> <p><u>Previous PTCA:</u> MIDCAB - 12%; CCABG - 8%, p=ns</p> <p><u>Failed PTCA:</u> MIDCAB - 0%; CCABG - 8%, p=ns</p> <p><u>Direct vision or video-assisted:</u> Not stated</p> <p><u>Pain management:</u> Not stated</p> <p>CCABG:</p> <p>'fast-track'</p> <p><u>Previous revascularisation:</u> see above</p>	<p>Retrospective comparison</p> <p><u>Basis of patient selection:</u> Consecutive patients 'divided into 3 groups'</p> <p><u>Study period:</u> January 1996 to September 1996</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up:</u> Not stated</p> <p><u>Losses to follow-up:</u> Not stated</p> <p><u>Level of evidence:</u> III-3</p>	<p>158 patients: 104 CCABG; 29 MIDCAB (single vessel); [25 OPCAB multivessel]</p> <p><u>Diagnosis:</u> Not stated</p> <p><u>Age, years:</u> MIDCAB 58 [15] ; CCABG 67 [10], p<0.01</p> <p><u>Gender mix:</u> MIDCAB 36% female; CABG 28% female, p=ns</p> <p><u>Lesion type:</u> single vessel for MIDCAB</p> <p><u>Lesion position:</u> Not stated</p> <p><u>Operative status:</u> Not stated</p> <p>RISK FACTORS/ COMORBIDITY</p> <p><u>Acute MI:</u> MIDCAB 16% CCABG 23%, p=ns</p> <p>Cardiogenic shock MIDCAB 0% CCABG 2%, p=ns</p> <p>Parsonnet score MIDCAB 9 [9] CCABG 10 [8], p=ns</p> <p><u>Ejection fraction</u> MIDCAB 59 [13] CCABG 58 [13], p=ns</p> <p><u>Ejection fraction < 40%</u> MIDCAB 12% CCABG 6%, p=ns</p> <p><u>Obesity</u> MIDCAB 20% CCABG 14%, p=ns</p> <p><u>Diabetes</u> MIDCAB 52% CCABG 22%, p<0.01</p> <p><u>Hypertension</u> MIDCAB 56% CCABG 49%, p=ns</p> <p><u>Vascular disease</u> MIDCAB 12% CCABG 8%, p=ns</p> <p><u>CHF</u> MIDCAB 16% CCABG 15%, p=ns</p> <p><u>COPD</u> MIDCAB 8% CCABG 7%, p=ns</p>	<p>Not stated</p>

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REICHENSPURNER 1999 <u>Location:</u> GERMANY Department of Cardiac Surgery, University Hospital Grosshadern, Munich	MIDCAB versus conventional CABG [versus OPCAB versus Port Access versus Endovascular CABG versus minimal access CABG] MIDCAB <u>Surgical access:</u> Left antero-laterolateral minithoracotomy <u>Stabiliser:</u> CTS <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> LIMA-LAD <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Not stated <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated CCABG: No details given for conventional CABG	Retrospective comparison <u>Basis of patient selection:</u> Consecutive (cost analysis done on a subset of patients) <u>Study period:</u> May 1997 to December 1998 <u>Operator details:</u> Not stated <u>Length of follow-up:</u> Not stated <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> III-3	596 patients: 121 MIDCAB; 475 conventional CABG <u>Costs:</u> 5 MIDCAB; 60 CCABG <u>Diagnosis:</u> Not stated <u>Age:</u> Not stated <u>Gender mix:</u> Not stated <u>Lesion type:</u> Not stated <u>Lesion position:</u> Not stated <u>Operative status:</u> Not stated <u>RISK FACTORS:</u> Not stated <u>COMORBIDITY:</u> Not stated	Not stated

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<p>STRUBER 1999</p> <p><u>Location:</u> GERMANY Division of Thoracic and Cardiovascular Surgery, Department of Anesthesia and Department of Pharmacology, Hannover Medical School, Hannover</p>	<p>MIDCAB versus CCABG</p> <p>MIDCAB: <u>Surgical access:</u> Left anterior minithoracotomy 8 to 10 cm through the fifth intercostal space <u>Stabiliser:</u> Horseshoe retractor <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Sodium thiopental, fentanyl and pancuronium bromide <u>Graft type:</u> IMA-LAD <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Not stated <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated</p> <p>CCABG: <u>Surgical access:</u> Median sternotomy <u>Anaesthesia:</u> Sodium thiopental, fentanyl and pancuronium bromide <u>Graft type:</u> IMA-LAD</p>	<p>Retrospective? comparison</p> <p><u>Basis of patient selection:</u> Not stated</p> <p><u>Study period:</u> Not stated</p> <p><u>Operator details:</u> Not stated</p> <p><u>Losses to follow-up:</u> Not stated</p> <p><u>Length of follow-up:</u> 24 hours</p> <p><u>Level of evidence:</u> III-3</p>	<p>24 patients: 12 MIDCAB; 12 CCABG</p> <p><u>Diagnosis:</u> not stated</p> <p><u>Age, mean (years):</u> MIDCAB 64 [9] ; CCABG 61 [13]</p> <p><u>Gender mix:</u> MIDCAB 2 female; CCABG 3 female</p> <p><u>Lesion type:</u> MIDCAB: Single vessel disease CCABG: Three-vessel disease</p> <p><u>Lesion position:</u> Not stated</p> <p><u>Operative status:</u> No patient required an emergency procedure</p> <p><u>RISK FACTORS:</u> Not stated</p> <p><u>COMORBIDITY:</u> Not stated</p>	<p>Not stated</p>

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TEVAEARAI 1999 <u>Location:</u> SWITZERLAND Hopital de Sion, Lausanne	MIDCAB versus CCABG [versus OPCAB] MIDCAB: <u>Surgical access:</u> Anterior mini-thoracotomy, in the fourth intercostal space <u>Stabiliser:</u> Auto Suture <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> LIMA [IVA] <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Not stated Direct vision or video-assisted: Not stated <u>Pain management:</u> Not stated CCABG: No details stated	Retrospective comparison <u>Basis of patient selection:</u> Not stated <u>Study period:</u> July 1998 to March 1999 <u>Operator details:</u> Not stated <u>Length of follow-up:</u> Not stated <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> III-3	95 patients 14 MIDCAB; 81 CCABG <u>Diagnosis:</u> Not stated <u>Age, mean (years):</u> MIDCAB 61.1 {8.7} CCABG 63.0 {8.5}, p=ns <u>Gender mix:</u> MIDCAB 11 male; CABG 61 male <u>Lesion type:</u> Not stated <u>Lesion position:</u> Not stated <u>Operative status:</u> Not stated <u>RISK FACTORS:</u> Not stated <u>Ejection fraction:</u> Not stated <u>COMORBIDITY:</u> Not stated	Not stated

Comparison 2 MIDCAB over time

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
TEVAEARAI 1999 <u>Location:</u> SWITZERLAND Hopital de Sion, Lausanne	MIDCAB <u>Surgical access:</u> Anterior mini-thoracotomy, in the fourth intercostal space <u>Stabiliser:</u> Auto Suture <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> LIMA <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Not stated <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated	Comparison over four consecutive periods of time <u>Basis of patient selection:</u> Not stated <u>Study period:</u> July 1997 to March 1999 <u>Operator details:</u> Not stated <u>Length of follow-up:</u> Not stated <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> IV	25 patients 1) July to Dec 1997 (n=7) 2) Jan to June 1998 (n=4) 3) July to Dec 1998 (n=7) 4) Jan to Mar 1999 (n=7) <u>Diagnosis:</u> Not stated <u>Age, mean (years):</u> 1) 66.8 {8.9} 2) 48.1 {11.2} 3) 62.9 {7.0} 4) 59.3 {10.9} total 60.6 {10.8} <u>Gender mix:</u> 1) 5m/2f 2) 4m/0f 3) 5m/2f 4) 6m/1f total 20m/5f <u>Lesion type:</u> Not stated <u>Lesion position:</u> Not stated <u>Operative status:</u> Not stated <u>RISK FACTORS:</u> Not stated <u>Ejection fraction:</u> Not stated <u>COMORBIDITY:</u> Not stated	Not stated

Comparison 3 Redo MIDCAB compared with first-time MIDCAB

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
MIJAYI 1999 <u>Location:</u> USA Department of Cardiac Surgery, The Christ and Jewish Hospital, University of Cincinnati, Ohio	MIDCAB <u>Surgical access:</u> Small left anterior thoracotomy 12; Partial sternotomy and median laparotomy 7; Small right anterior thoracotomy 2; Small right anterior thoracotomy and partial sternotomy 2; Small left anterior thoracotomy and partial sternotomy and median laparotomy 2 <u>Stabiliser:</u> DiamondGrip, Genzyme <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> LIMA-LAD 9 (including one H-graft and one T-graft); GEA to PDA or LAD 8 SVG to LAD or right MCA 5 RIMA to old SVG 3 <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> 25 redo cases (20.8%) <u>Direct vision or video-assisted:</u> Video-assisted in 9 patients <u>Pain management:</u> Not stated	Comparison of first-time versus redo MIDCAB <u>Basis of patient selection:</u> Not stated <u>Study period:</u> Since November 1995 [to late 1998?] <u>Operator details:</u> Not stated <u>Length of follow-up (mean):</u> 18.2 months <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> III-3	120 patients: 25 redo; 95 first-time <u>Diagnosis:</u> Not stated <u>Age (mean, years):</u> Redo 66.2 {13.5} range 40 to 87 Firsts 63.3 {13.0} p=0.33 <u>Gender mix:</u> Redo 19 male (76%); Firsts 54 male (57%) <u>Lesion type:</u> Not stated <u>Lesion position:</u> LAD 15 Posterior descending artery 7 Right main coronary artery 3 <u>Operative status:</u> Not stated <u>RISK FACTORS:</u> 12 redo patients with significant risk factors, including 4 patients with COPD, 4 older than 80. 3 with low left ventricular ejection fraction (less than 30%), 1 with a recent cerebral infarction and 1 with lung cancer	Not stated

Comparison 4 MIDCAB stabiliser vs no stabiliser: Non-randomised comparative studies (n=5)

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
<p>CALAFIORE 1998</p> <p><u>Location:</u> ITALY Department of Cardiac Surgery, 'San Camillo de' Lellis' Hospital, Chieti</p>	<p>MIDCAB</p> <p><u>Surgical access:</u> Left anterior small thoracotomy <u>Stabiliser:</u> CTS (for stabiliser group only) <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> LIMA-LAD <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> no stabiliser group 1; stabiliser group 2 <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated</p>	<p>Retrospective comparison of no stabiliser versus stabiliser</p> <p><u>Basis of patient selection:</u> Not stated (but see inclusions column)</p> <p><u>Study period:</u> Overall: November 21, 1994 to December 20, 1997 No stabiliser group: November 21, 1994 to April 20, 1996 Stabiliser group: April 21, 1996 to December 20, 1997</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up:</u> Mean 16.5 [9.9] months No stabiliser group 26.5 [6.3] Stabiliser group 10.1 [5.4] p=0.001</p> <p><u>Losses to follow-up:</u> 9 conversions to sternotomy, not included in study results</p> <p><u>Level of evidence</u> III-3</p>	<p>261 patients; 93 no stabiliser, 168 with stabiliser</p> <p><u>Diagnosis:</u> LAD disease</p> <p><u>Age (mean, years):</u> No stabiliser group 60 [2.6]; Stabiliser group 59.4 [9.9]</p> <p><u>Gender mix:</u> Not stated</p> <p><u>Lesion type:</u> Not stated</p> <p><u>Lesion position:</u> Not stated</p> <p><u>Operative status:</u> No stabiliser group urgent 21 (22.6%); Stabiliser group urgent 20 (11.9%), p=0.038</p> <p><u>Risk factors:</u> No stabiliser group 10; Stabiliser group 14</p> <p><u>Age >75 y:</u> No stabiliser group 5; Stabiliser group 9</p> <p><u>Malignancy:</u> No stabiliser group 1</p> <p><u>CVA:</u> No stabiliser group 1; Stabiliser group 1</p> <p><u>Vascular disease:</u> No stabiliser group 1; Stabiliser group 3</p> <p><u>COPD:</u> No stabiliser group 1</p> <p><u>Chronic renal failure:</u> Stabiliser group 1</p> <p><u>Ejection fraction:</u> no stabiliser group 0.63 [0.13]; stabiliser group 0.65 [0.11]</p>	<p><u>Inclusions:</u> Indications: 1) Type C lesions (n = 176) 2) Cardiologist's or patient's preferences (n = 56) 3) Restenosis after PCTA or stenting of the proximal LAD (n = 29)</p>

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
DOUVILLE 1999 <u>Location:</u> USA Oregon Clinic and Providence Portland Medical Center, Portland, Oregon	MIDCAB STABILISER GROUP: Surgical access: Left anterior small thoracotomy <u>Stabiliser:</u> CTS <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> LAD <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> 12/28 had undergone previous CAB <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated NO STABILISER GROUP: <u>Surgical access:</u> Left anterior small thoracotomy <u>Stabiliser:</u> None <u>Graft type:</u> LAD <u>Previous revascularisation:</u> 2/11 had undergone previous CABG Other details not stated	Retrospective comparison of no stabiliser versus stabiliser <u>Basis of patient selection:</u> Consecutive, with stabiliser group later <u>Study period:</u> June 1996 to January 1999 <u>Operator details:</u> Not stated <u>Length of follow-up:</u> 30 days <u>Losses to follow-up:</u> None <u>Level of evidence:</u> III-3 NOTE: intraoperative and postoperative management were identical for the 2 groups, except that alpha blockade, parenteral beta blockade and adenosine were abandoned for the last few in the stabiliser group.	39 patients: 11 no stabiliser; 28 stabiliser NO STABILISER GROUP <u>Diagnosis:</u> Not stated <u>Age:</u> Mean, years 64, range 48-76 <u>Gender mix:</u> 9 male, 2 female <u>Lesion type:</u> Not stated <u>Lesion position:</u> Not stated <u>Operative status:</u> Not stated <u>RISK FACTORS:</u> <u>Predicted mortality:</u> 4.3% <u>COMORBIDITY:</u> Not stated STABILISER GROUP <u>Diagnosis:</u> Not stated <u>Age:</u> Mean, years 66, range 37-82 <u>Gender mix:</u> 24 male, 4 female <u>Lesion type:</u> Not stated <u>Lesion position:</u> Not stated <u>Operative status:</u> Not stated <u>RISK FACTORS:</u> <u>Predicted mortality:</u> 4.4% <u>COMORBIDITY:</u> Not stated	Not stated

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
<p>MASLOW 1999</p> <p><u>Location:</u> USA</p> <p>Department of Anesthesia and Critical Care and Surgery, Beth Israel Deaconess Medical Center, Boston, MA</p>	<p>MIDCAB</p> <p><u>Surgical access:</u> anterior thoracotomy</p> <p><u>Stabiliser:</u> Cohn coronary artery stabiliser</p> <p><u>Pre-ischaemic conditioning:</u> 5 minute occlusion of the native diseased artery, followed by a 10 minute period of reperfusion in some patients only:</p> <p>Stabiliser 4 (10%); No stabiliser 18 (90%), p<0.001</p> <p><u>Coronary shunts:</u> Not stated</p> <p><u>Anaesthesia:</u> similar for 2 groups – etomidate/thiopental, fentanyl/sufentanil, pancuronium/vecuronium, isoflurane/desflurane, thoracic epidurals used in 18 patients</p> <p><u>Graft type:</u> LIMA-LAD</p> <p><u>LMA direct anastomosis</u> Stabiliser: 14 LIMA; 0 RIMA No stabiliser: 11 LIMA; 1 RIMA, p<0.05</p> <p><u>H-graft:</u> Stabiliser: 6; No stabiliser: 28, p<0.05</p> <p>Saphenous vein: Stabiliser: 0; No stabiliser: 4, p=ns</p> <p>Radial artery: Stabiliser: 1; No stabiliser: 13, p=ns</p> <p>Epigastric artery: Stabiliser: 5; No stabiliser: 11, p=ns</p> <p><u>Occlusion time prior to anastomoses:</u> Not stated</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u> Stabiliser: 13 (75%); No stabiliser: 19 (53%), p=ns</p> <p><u>Direct vision or video-assisted:</u> : Not stated</p> <p><u>Pain management:</u> Initially bupivacaine and ketorolac and then epidural analgesia</p>	<p>Retrospective comparison of stabiliser versus no stabiliser</p> <p><u>Basis of patient selection:</u> review of hospital records</p> <p><u>Study period:</u> Not stated</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up:</u> Not stated</p> <p><u>Losses to follow-up:</u> Not stated</p> <p><u>Level of evidence:</u> III-3</p>	<p>60 patients: 40 stabiliser; 20 no stabiliser</p> <p><u>Diagnosis:</u> Not stated</p> <p><u>Age, mean (years):</u> Stabiliser: 64.7 [15.1]; No stabiliser: 66.1 [12.2], p=ns</p> <p><u>Gender mix:</u> Stabiliser: 27 male (13%) No stabiliser: 14 male (6%), p=ns</p> <p><u>Lesion type:</u> Single vessel 26 (43%) Stabiliser 15 (37%); No stabiliser 11 (55%) Multivessel 34 (57%) Stabiliser 25 (62%); No stabiliser 9 (45%)</p> <p><u>Lesion position:</u> <u>Left main:</u> Stabiliser: 8 (20%) No stabiliser: 5 (25%) p=ns</p> <p><u>One (LAD or RCA):</u> Stabiliser: 15 (37%); No stabiliser: 11 (55%) p=ns</p> <p><u>Two:</u> Stabiliser: 11 (27%) No stabiliser: 3 (15%), p=ns</p> <p><u>Three:</u> Stabiliser: 14 (35%) No stabiliser: 6 (30%), p=ns</p> <p><u>Operative status:</u> Not stated</p> <p>RISK FACTORS Not stated</p> <p><u>COMORBIDITY (overall):</u> Stabiliser 0 (0%) No stabiliser 6 (30%) p<0.001</p>	<p>Not stated</p>

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POSSATI 1998 <u>Location:</u> ITALY Department of Cardiac Surgery, Catholic University, Rome and Department of Cardiology, 'Calai' Hospital, Gualdo Tadino	MIDCAB All patients: <u>Surgical access:</u> Chest opened at the fourth intercostal space (the fourth sternocostal joint was transected only in 3 initial cases) <u>Stabiliser:</u> CTS (stabiliser group only) <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> Not stated <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Not stated <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated	Comparison of no instrumentation and instrumentation <u>Basis of patient selection:</u> consecutive <u>Study period:</u> January 1995 to June 1997 <u>Operator details:</u> All operations performed by the same surgeon <u>Length of follow-up (mean):</u> 18 months <u>Losses to follow-up:</u> 5 patients excluded from this report were switched to beating heart bypass through a median sternotomy because of the unusual position, the intramyocardial course, or the poor quality of the LAD <u>Level of evidence</u> III-3	77 patients; 56 using traditional instrumentation; 21 using dedicated chest retractor and stabiliser <u>Diagnosis:</u> 55 isolated LAD disease; 22 multivessel (18 had reversible ischaemia and 4 had end-stage systemic disease with MIDCAB as palliative) <u>Age:</u> Mean age of men 60 years (range 40 to 81 years) <u>Gender mix:</u> 54/77 male <u>Lesion type:</u> Not stated <u>Lesion position:</u> Not stated <u>Operative status:</u> Not stated <u>RISK FACTORS:</u> Not stated <u>Ejection fraction:</u> Not stated <u>COMORBIDITY:</u> Not stated	Not stated

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SUBRAMANIAN 1997 <u>Location:</u> USA Department of Surgery, Lenox Hill Hospital, New York, NY	MIDCAB <u>Stabiliser group only:</u> CTS <u>OVERALL</u> (stabiliser and no stabiliser group details not reported separately) <u>Surgical access:</u> minithoracotomy, subxiphoid incision, or both <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> IMA, RGEA or RA <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> 4 (2.6%) <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated	Comparison of stabiliser and no stabiliser <u>Basis of patient selection:</u> Time – the 52 stabiliser patients were recent consecutive patients <u>OVERALL</u> (stabiliser and no stabiliser details not reported separately) <u>Study period:</u> April 1994 to September 1996 <u>Operator details:</u> Not stated <u>Length of follow-up (mean):</u> 9.2 {7.4} months <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> III-3	156 patients 52 stabiliser; 104 no stabiliser <u>OVERALL</u> (stabiliser and no stabiliser details not reported separately) <u>Diagnosis:</u> Not stated <u>Age, years:</u> 67 {10} <u>Gender mix:</u> Not stated <u>Lesion type:</u> Not stated <u>Lesion position:</u> Not stated <u>Operative status:</u> Not stated <u>RISK FACTORS:</u> Not stated <u>Ejection fraction:</u> Not stated <u>COMORBIDITY:</u> Not stated	Not stated

MIDCAB case series

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
AZOURY 2001 <u>Location:</u> USA Department of Thoracic and Cardiovascular Surgery, The Cleveland Clinic Foundation, Cleveland, Ohio	MIDCAB redos <u>Surgical access:</u> Posterolateral thoracotomy, fourth or fifth intercostal space <u>Stabiliser:</u> Octopus or CTS <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> <u>Target:</u> Circumflex (n=23) LAD diagonal (n=1) <u>Conduits:</u> SVG (n=14) Radial artery (n=10) <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> All Second procedure 11 (52%) Third 8 (38%) Fourth 2 (10%) <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated	Case series <u>Basis of patient selection:</u> Not stated <u>Study period:</u> January 1996 to December 1999 <u>Operator details:</u> Not stated <u>Length of follow-up:</u> 15 [13] months <u>Losses to follow-up:</u> None <u>Level of evidence:</u> IV	21 patients <u>Diagnosis:</u> Symptomatic coronary artery disease unresponsive to maximal medical therapy; patent graft at particular risk for re-sternotomy (n=17), calcified ascending aorta (n=3), serious comorbidities (n=5), diffuse atherosclerosis (n=4) <u>Age, mean (years):</u> 64 [10] range 48 to 79 <u>Gender mix:</u> 17 male (81%) <u>Lesion type:</u> Not stated <u>Lesion position:</u> circumflex <u>Operative status:</u> 20 elective (95.2%) <u>LVEF:</u> Normal 9 (43%); mildly depressed 1 (5%); moderately depressed 8 (38%); severely depressed 3 (14%) <u>NYHA class:</u> I – 1 (5%); II – 8 (38%); III – 8 (38%); IV – 4 (19%) <u>COMORBIDITIES</u> <u>Hypertension</u> 12 (57%) <u>Diabetes</u> 6 (29%) <u>Renal dysfunction</u> 2 (10%) <u>Carotid stenosis >70%</u> 3 (14%)	<u>Inclusions:</u> Contraindications to conventional redo CABG; accessible targets and technical or patient factors rendering CPB or sternotomy undesirable

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BAUMGARTNER 1999 <u>Location:</u> USA Pacific Cardiothoracic Surgery Group, St John's Regional Medical Center, Oxnard CA	MIDCAB (redo marginal grafts) <u>Surgical access:</u> Posterolateral thoracotomy in the fifth interspace <u>Stabiliser:</u> CTS immobiliser foot plate <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> SVG to OM (n = 4); SVG to OM, then diagonal (n = 1); SVG to OM1, then OM2 (n = 1); SVG to OM2 (n = 1) <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Yes – mostly LIMA-LAD <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated	Case series <u>Basis of patient selection:</u> consecutive (subset of 180 off-pump patients) <u>Study period:</u> Not stated <u>Operator details:</u> Not stated <u>Length of follow-up:</u> 2 to 6 months <u>Level of evidence:</u> IV	7 patients <u>Diagnosis:</u> Significant disease in the circumflex (obtuse marginal) distribution; Recurrent angina and/or heart failure after prior CABG; 5/7 had patent LIMA-LAD grafts. <u>Age, years:</u> median 66 (range 49 – 88) <u>Gender mix:</u> 6 male, 1 female <u>Lesion type:</u> single and multivessel <u>Lesion position:</u> marginals <u>Operative status:</u> Not stated <u>Ejection fraction:</u> 40% median (range 30 – 50%) <u>Risk factors:</u> Not stated <u>Comorbidities:</u> Not stated	Not stated

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BOONSTRA 1997 <u>Location:</u> NETHERLANDS Thorax Center, University Hospital Groningen, Groningen	MIDCAB <u>Surgical access:</u> left anterolateral thoracotomy <u>Stabiliser:</u> CTS <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> LIMA-LAD <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Not stated <u>Direct vision or video-assisted:</u> Direct vision <u>Pain management:</u> Not stated	Case series <u>Basis of patient selection:</u> Consecutive <u>Study period:</u> April to September 1996 <u>Operator details:</u> Not stated <u>Length of follow-up:</u> Not stated <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> IV	35 patients <u>Diagnosis:</u> Isolated stenosis of the LAD <u>Age:</u> Mean 64 {9} years <u>Gender mix:</u> 26 male, 9 female <u>Lesion type:</u> Single vessel <u>Lesion position:</u> LAD <u>Operative status:</u> Not stated <u>Ejection fraction:</u> Not stated <u>Risk factors:</u> Not stated <u>Comorbidities:</u> Not stated	Not stated

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
CALAFIORE 1998a <u>Location:</u> ITALY Department of Cardiac Surgery, 'San Camillo de' Lellis' Hospital, Chieti <u>NOTE:</u> Partial description and results only available	MIDCAB <u>Surgical access:</u> Left anterior small thoracotomy <u>Stabiliser:</u> CTS <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> Not stated <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Not stated <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated	Case series <u>Basis of patient selection:</u> Last 190 only had MIDCAB <u>Study period:</u> Overall: November 21, 1994 to April 20, 1997 – MIDCAB with CTS were the last 190 patients <u>Operator details:</u> Not stated <u>Length of follow-up:</u> 29 months? <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> IV	190 patients (out of 434 total) <u>Diagnosis:</u> LAD disease <u>Age:</u> Not stated <u>Gender mix:</u> Not stated <u>Lesion type:</u> Not stated <u>Lesion position:</u> Not stated <u>Operative status:</u> Not stated <u>Ejection fraction:</u> Not stated <u>Risk factors:</u> Not stated <u>Comorbidities:</u> Not stated	<u>Inclusions:</u> 1) where PCTA was not technically feasible 2) where cardiologist or patient chose MIDCAB 3) restenosis after PCTA

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<p>COULSON 1998a</p> <p><u>Location:</u></p> <p>USA</p> <p>Dameron Heart Institute, Stockton CA</p>	<p>T-MIDCAB (bridge graft of short segment of donor vessel (either radial artery or saphenous vein) between the undisturbed IMA and the target coronary artery)</p> <p><u>Surgical access:</u> Small thoracotomy centred over the fourth costal cartilage on the left or the fifth cartilage on the right</p> <p><u>Stabiliser:</u> Estech</p> <p><u>Pre-ischaemic conditioning:</u> Not stated</p> <p><u>Coronary shunts:</u> Not stated</p> <p><u>Anaesthesia:</u> Not stated</p> <p><u>Graft type:</u> LIMA-RA-LAD (n = 7); RIMA-RA- RCA/PDA (n = 3); RIMA-SVG-PDA (n = 1); Thoracic aorta-RA-OM1 (n = 1)</p> <p><u>Occlusion time prior to anastomoses:</u> Not stated</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u> Not stated</p> <p><u>Direct vision or video-assisted:</u> Not stated</p> <p><u>Pain management:</u> Avoidance of retraction/ pressure; Selective denervation of intercostal nerves; bupivacaine injection</p>	<p>Case series</p> <p><u>Basis of patient selection:</u> consecutive</p> <p><u>Study period:</u> September 10, 1997 to December 19, 1997</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up:</u> 1-3 months</p> <p><u>Losses to follow-up:</u> None</p> <p><u>Level of evidence:</u> IV</p>	<p>8 patients; high risk</p> <p><u>Diagnosis:</u> Not stated</p> <p><u>Age:</u> average 73 years (range 58 to 83)</p> <p><u>Gender mix:</u> 5 males, three females</p> <p><u>Lesion type:</u> Not stated</p> <p><u>Lesion position:</u> LIMA-RA-LAD (n = 7); RIMA-RA-RCA/PDA (n = 3); RIMA-SV-PDA (n = 1); Thoracic aorta-RA-OM1 (n = 1)</p> <p><u>Operative status:</u> Not stated</p> <p>RISK FACTORS</p> <p>High risk: Hepatic coma and GI bleed (n = 1)</p> <p>Stroke (n = 1)</p> <p>von Willebrand's (n = 1)</p> <p>AMI (n = 2)</p> <p>Previous cardiac surgery (n = 2)</p> <p><u>Ejection fraction:</u> Mean 43% (range 25 to 80%)</p> <p><u>Parsonnet scores:</u> Average 34 (range 21 to 43)</p> <p><u>Predicted mortalities:</u> range 30 to 40%</p>	<p><u>Inclusions:</u> Standard CABG too risky</p>

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COULSON 1998c <u>Location:</u> USA Dameron Hospital and St Joseph's Medical Center, Stockton, California	MIDCAB Circumflex redo <u>Surgical access:</u> Small left thoracotomy <u>Stabiliser:</u> Estech <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Yes <u>Anaesthesia:</u> Not stated <u>Graft type:</u> Not stated <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> All redos (n=4); Multiple previous procedures <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated	Case series <u>Basis of patient selection:</u> Consecutive <u>Study period:</u> Since May 1996 <u>Operator details:</u> Not stated <u>Length of follow-up:</u> Up to 22 months <u>Losses to follow-up:</u> Not stated <u>Level of evidence</u> IV	4 patients <u>Diagnosis:</u> Not stated <u>Age, years:</u> 64, 52, 62, 72 <u>Gender mix:</u> All male <u>Lesion type:</u> Not stated <u>Lesion position:</u> Circumflex coronary artery <u>Operative status:</u> Not stated <u>Ejection fraction:</u> Not stated <u>RISK FACTORS:</u> Not stated <u>COMORBIDITY:</u> Not stated	Not stated

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
<p>CREMER 1997</p> <p><u>Location:</u> GERMANY</p> <p>Division of Thoracic and Cardiovascular Surgery and Division of Anesthesiology, Hannover Medical School, Hannover</p>	<p>MIDCAB</p> <p><u>Surgical access:</u> Anterolateral minithoracotomy through the fourth (n=4) or fifth (n=40) intercostal space, 7-11 cm submammary incision</p> <p><u>Stabiliser:</u> CTS (horseshoe)</p> <p><u>Pre-ischaemic conditioning:</u> Not stated</p> <p><u>Coronary shunts:</u> Not stated</p> <p><u>Anaesthesia:</u> Etomidate, fentanyl, pancuronium bromide and thiopental; patients did not routinely receive aprotinin</p> <p><u>Graft type:</u> IMA-LAD (n=38); IMA-diagonal (n=2); Sequential LAD-D (n=3), diagonal 1-diagonal 2 (n=1)</p> <p><u>Occlusion time prior to anastomoses:</u> Not stated</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u> Three patients with 1 (n=1) or 2 (n=2) previous sternotomies of left thoracotomies, with 1 primary and 1 secondary redo grafting</p> <p><u>Direct vision or video-assisted:</u> Direct vision</p> <p><u>Pain management:</u> Bupivacaine on demand</p>	<p>Case series</p> <p><u>Basis of patient selection:</u> Not stated</p> <p><u>Study period:</u> June 1996 to January 1997</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up:</u> 3 months</p> <p><u>Losses to follow-up:</u> 1 (conversion to sternotomy and CPB)</p> <p><u>Level of evidence:</u> IV</p>	<p>44 patients</p> <p><u>Diagnosis:</u> Not stated</p> <p><u>Age, years:</u> 61.5 (10.9)</p> <p><u>Gender mix:</u> 32 male; 12 female</p> <p><u>Lesion type:</u> Single vessel (n = 27); Two vessel (n = 11); Three vessel (n = 6)</p> <p><u>Lesion position:</u> Proximal LAD stenosis /occlusion (n = 38/6); Left main coronary artery stenosis (n=2)</p> <p><u>Operative status:</u> Not stated</p> <p>RISK FACTORS:</p> <p>Unstable angina 8; Previous MI 18; Ejection fraction less than 30% 3; Severe pulmonary hypertension 4; Atrial fibrillation 3; Previous cardiac surgery 3; Previous PTCA/stenting 9</p> <p>COMORBIDITY</p> <p>24/44 patients</p> <p>chronic renal failure 2; compensated renal failure 4; chronic immunosuppression after renal transplantation 1; symptomatic carotid artery stenosis 1; peripheral arterial occlusive disease 3; calcification of the ascending aorta/aortic arch 1; IDDM 6; COPD 10; Renal cell carcinoma 1</p> <p>Hepatic insufficiency 1; Suspected mediastinal metastasis 1; Pectus excavatum 1</p>	<p>Not stated</p>

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
<p>D'ANCONA 2000</p> <p><u>Location:</u> USA</p> <p>Division of Cardiothoracic Surgery and the Center for Minimally Invasive Cardiac Surgery, Kaleida Health – Buffalo General Hospital Site and SUNY at Buffalo, Buffalo, New York, NY</p>	<p>MIDCAB (redo)</p> <p><u>Surgical access:</u> Left posterior thoracotomy through 6th intercostal space (and anterior if necessary)</p> <p><u>Stabiliser:</u> CTS</p> <p><u>Pre-ischaemic conditioning:</u> 3 minutes</p> <p><u>Coronary shunts:</u> Yes</p> <p><u>Anaesthesia:</u> Not stated</p> <p><u>Graft type:</u> LIMA-LAD (n = 2) LIMA-Circumflex or OM (n = 2) SVG-Circumflex or OM (n = 83)</p> <p><u>Occlusion time prior to anastomoses:</u> Not stated</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u> All redos</p> <p><u>Direct vision or video-assisted:</u> Direct vision</p> <p><u>Pain management:</u> Not stated</p>	<p>Case series</p> <p><u>Basis of patient selection:</u> 'selected' – no further details given</p> <p><u>Study period:</u> January 1995 to July 1999</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up:</u> 6 weeks</p> <p><u>Losses to follow-up:</u> Not stated</p> <p><u>Level of evidence</u> IV</p>	<p>67 patients</p> <p><u>Diagnosis:</u> Limited coronary artery disease localised to the lateral aspect of the heart</p> <p><u>Age, mean (years):</u> 65.4 (47-80)</p> <p><u>Gender mix:</u> 60 male</p> <p><u>Lesion type:</u> Not stated</p> <p><u>Lesion position:</u> LAD or circumflex</p> <p><u>Operative status:</u> Elective (n = 38) Urgent (n = 27) Emergent (n = 2)</p> <p><u>RISK FACTORS:</u></p> <p><u>Ejection fraction:</u> 46.6% (22-72)</p> <p><u>COMORBIDITY:</u></p> <p><u>CCS class I:</u> 1/67 II: 0/67 III: 21/67 IV: 45/67</p> <p><u>Preop AMI:</u> 57/67</p> <p><u>Preop stroke:</u> 11/67</p> <p><u>Calcified ascending aorta:</u> 1/67</p> <p><u>Diabetes:</u> 16/67</p> <p><u>Hypertension:</u> 50/67</p> <p><u>COPD:</u> 23/67</p> <p><u>CHF:</u> 9/67</p> <p><u>CRF (Creat >2.5):</u> 1/67</p> <p><u>Dialysis:</u> 1/67</p> <p><u>Preop IABP:</u> 1/67</p>	<p>Not stated</p>

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
<p>DIEGELER 1998a</p> <p><u>Location:</u> GERMANY Clinic of Heart Surgery, Heartcenter, University of Leipzig, Leipzig</p> <p>NOTE: Likely to overlap with Diegeler 1999a</p>	<p>MIDCAB</p> <p><u>Surgical access:</u> Left (or right) anterolateral minithoracotomy, 6-9 cm, through fourth intercostal space without dissecting any ribs</p> <p><u>Stabiliser:</u> CTS, Omnitract, Octopus</p> <p><u>Pre-ischaemic conditioning:</u> 5 minutes followed by another 5 minutes of reperfusion</p> <p><u>Coronary shunts:</u> Not stated</p> <p><u>Anaesthesia:</u> Not stated</p> <p><u>Graft type:</u> LITA-LAD 195; RITA-RCA 3 T-graft: (LITA-LAD + RA to RD) 7; (LITA-LAD + RA to RIM) 4</p> <p><u>Occlusion time prior to anastomoses:</u> Not stated</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u> Not stated</p> <p><u>Direct vision or video-assisted:</u> Direct vision</p> <p><u>Pain management:</u> bupivacaine</p>	<p>Case series</p> <p><u>Basis of patient selection:</u> Not stated</p> <p><u>Study period:</u> November 1996 to December 1997</p> <p><u>Operator details:</u> Most of the perioperative complications occurred during the initial learning period</p> <p><u>Length of follow-up:</u> Not stated</p> <p><u>Losses to follow-up:</u> Not stated</p> <p><u>Level of evidence:</u> IV</p>	<p>209 patients</p> <p><u>Diagnosis:</u> Isolated proximal stenosis of the LAD or RCA. Selected patients with an additional stenosis of a major diagonal or intermediate branch were also included and received radial artery T-grafts</p> <p><u>Age, years:</u> 61.1 {10.3}</p> <p><u>Gender mix:</u> 147 male (70.3%)</p> <p><u>Lesion type:</u> Single vessel 133 (64%) 2 vessel 44 (21%) 3 vessel 28 (13.5%) left main stenosis 4 (2%)</p> <p><u>Lesion position:</u> LAD 195; LAD + RA to diagonal 7; LAD + RA to intermediate branch 4; RCA 3</p> <p><u>Operative status:</u> Not stated</p> <p>RISK FACTORS: CCS class 1: 14 (6%) II: 108 (52%) III: 87 (42%)</p> <p><u>Ejection fraction:</u> 0.57 {0.10}</p> <p><u>COMORBIDITY:</u> Not stated</p>	<p>Not stated</p>

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
DIEGELER 1999a <u>Location:</u> GERMANY Clinic of Heart Surgery, Heartcenter, University of Leipzig, Leipzig NOTE: Likely to overlap with Diegeler 1998a	MIDCAB <u>Surgical access:</u> Left anterolateral minithoracotomy <u>Stabiliser:</u> Various commercially available mechanical stabilisers <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> LITA-LAD 247; RITA-RCA 5 Double Y-graft: (LITA-LAD + RA to RD) 14; (LITA-LAD + RA to (RIM) 5 <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Not stated <u>Direct vision or video-assisted:</u> direct vision <u>Pain management:</u> Not stated	Case series <u>Basis of patient selection:</u> Not stated <u>Study period:</u> November 1996 to December 1997 <u>Operator details:</u> Not stated <u>Length of follow-up:</u> 6.8 [1.2] months for 130 (47.9%) patients only <u>Losses to follow-up:</u> Early: 50 – only 221/271 patients gave their consent for an early angiogram 6 months: 141 (52.1%) patients <u>Level of evidence:</u> IV	271 patients <u>Diagnosis:</u> Not stated <u>Age, years:</u> 60.1 [10.3] <u>Gender mix:</u> 202 male (74.5%) <u>Lesion type:</u> Single vessel 182 (67.2%) 2 vessel 61 (22.5%) 3 vessel 28 (10.3%) <u>Lesion position:</u> LAD 247; LAD + RA to RD 14; LAD + RA to RIM branch 5; RCA 5 <u>Operative status:</u> Not stated RISK FACTORS: <u>Ejection fraction:</u> 61.2% [10.3], range 12-89 <u>COMORBIDITY:</u> Not stated	Not stated

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
DULLUM 1999 <u>Location:</u> USA Washington Hospital Center, Washington DC	MIDCAB <u>Surgical access:</u> Xiphoid and into the tip of the sternum if necessary <u>Stabiliser:</u> 'mechanical stabiliser' <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> LIMA-LAD <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> All were first operations <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated	Case series <u>Basis of patient selection:</u> Not stated <u>Study period:</u> Not stated <u>Operator details:</u> Not stated <u>Length of follow-up:</u> Not stated <u>Losses to follow-up:</u> Not stated <u>Level of evidence</u> IV	7 patients <u>Diagnosis:</u> Not stated <u>Age:</u> Mean 70 years <u>Gender mix:</u> Not stated <u>Lesion type:</u> Not stated <u>Lesion position:</u> Not stated <u>Operative status:</u> Not stated RISK FACTORS <u>Parsonnet score:</u> Mean 21.1 <u>Ejection fraction:</u> Not stated <u>COMORBIDITY:</u> Not stated	<u>Inclusions:</u> Not stated <u>Exclusions:</u> 3 patients who underwent hybrid procedures (angioplasty of additionally obstructed vessels following initial MIDCAB)

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
FLEGE 2000 <u>Location:</u> USA Department of Cardiac Surgery, The Christ Hospital, Cincinnati, Ohio	MIDCAB (axillary-coronary) <u>Surgical access:</u> Inframammary incision, fourth or fifth intercostal space <u>Stabiliser:</u> 'foot' stabiliser <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> 9 saphenous vein grafts, 1 radial arterial <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Coronary artery bypass – 7 patients (2 of them 3x); failed LIMA-LAD 5 patients; functioning LIMA- circumflex 1 patient; IMA damaged in preparation for a minimally invasive bypass 1 patient <u>Direct vision or video-assisted:</u> direct vision <u>Pain management:</u> Not stated	Case series <u>Basis of patient selection:</u> Not stated <u>Study period:</u> Not stated <u>Operator details:</u> Not stated <u>Length of follow-up:</u> up to 2 months <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> IV	10 patients <u>Diagnosis:</u> Proximal obstructive lesions of the LAD <u>Age:</u> 5 patients were over 80 years <u>Gender mix:</u> 7 male; 3 female <u>Lesion type:</u> Three vessel (n = 2) <u>Lesion position:</u> LAD <u>Operative status:</u> Not stated <u>RISK FACTORS:</u> Not stated <u>Ejection fraction:</u> Not stated <u>COMORBIDITY:</u> Not stated	Not stated

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
KIM 1999 <u>Location:</u> USA/GERMANY Department of Surgery, Medical College of Georgia, Augusta, Georgia; Department of Thoracic and Cardiovascular Surgery, Hannover Medical School, Hannover	MIDCAB <u>Surgical access:</u> 8 cm left submammary incision in the fifth intercostal space <u>Stabiliser:</u> CTS <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> LIMA-LAD <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Not stated <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated	Case series <u>Basis of patient selection:</u> Not stated <u>Study period:</u> Not stated <u>Operator details:</u> Not stated <u>Length of follow-up:</u> Not stated <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> IV	4 MIDCAB patients with pectus excavatum <u>Diagnosis:</u> CAD (type C lesion) <u>Age:</u> Not stated <u>Gender mix:</u> Not stated <u>Lesion type:</u> Single vessel <u>Lesion position:</u> Proximal stenosis of the LAD <u>Operative status:</u> Not stated <u>RISK FACTORS:</u> Not stated <u>Ejection fraction:</u> Not stated <u>COMORBIDITY:</u> Not stated	Not stated

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
<p>LAZZARA 1997</p> <p><u>Location:</u> USA Division of Cardiac Services, St. Charles Medical Center, Bend, Oregon</p>	<p>MIDCAB</p> <p><u>Surgical access:</u> 8–12 cm left anterior thoracotomy through the fourth or fifth intercostal space</p> <p><u>Stabiliser:</u> CTS</p> <p><u>Pre-ischaemic conditioning:</u> Not stated</p> <p><u>Coronary shunts:</u> Not stated</p> <p><u>Anaesthesia:</u> Not stated</p> <p><u>Graft type:</u> LITA-LAD</p> <p><u>Occlusion time prior to anastomoses:</u> Not stated</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u> Not stated</p> <p><u>Direct vision or video-assisted:</u> Direct vision?</p> <p><u>Pain management:</u> Not stated</p>	<p>Case series</p> <p><u>Basis of patient selection:</u> Patients offered the choice of MIDCAB or standard CABG ITA-LAD</p> <p><u>Study period:</u> November 1996 to March 1997</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up:</u> Postop only</p> <p><u>Losses to follow-up:</u> None</p> <p><u>Level of evidence:</u> IV</p>	<p>10 patients</p> <p><u>Diagnosis:</u> Not stated</p> <p><u>Age, mean (years):</u> 66.3 [10.2]</p> <p><u>Gender mix:</u> Not stated</p> <p><u>Lesion type:</u> Not stated</p> <p><u>Lesion position:</u> Not stated</p> <p><u>Operative status:</u> 9 elective; 1 emergency</p> <p>RISK FACTORS</p> <p><u>NYHA class:</u> 3.3 [0.5]</p> <p><u>Ejection fraction:</u> 0.61 [0.14]</p> <p><u>COMORBIDITY:</u> Not stated</p>	<p>Not stated</p>

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
LIN 2000 <u>Location:</u> USA Department of Cardiothoracic Surgery, and Division of Cardiology, Allegheny General Hospital, Pittsburgh, Pennsylvania	MIDCAB <u>Surgical access:</u> Fourth interspace anterior thoracotomy <u>Stabiliser:</u> CTS <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> LIMA-LAD <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> 3/35 (8.6%) <u>Direct vision or video-assisted:</u> Direct vision <u>Pain management:</u> Not stated	Case series <u>Basis of patient selection:</u> Consecutive <u>Study period:</u> March to October 1997 <u>Operator details:</u> Not stated <u>Length of follow-up:</u> More than 2 years <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> IV	35 patients <u>Diagnosis:</u> 100% LAD occlusion (n=7); <100% LAD occlusion (n=28) <u>Age:</u> 61 (10) years; range 34 to 80 <u>Gender mix:</u> 25/35 (71%) male <u>Lesion type:</u> Single vessel <u>Lesion position:</u> LAD <u>Operative status:</u> Elective <u>RISK FACTORS:</u> Not stated <u>Ejection fraction:</u> Not stated <u>COMORBIDITY:</u> 3 patients were refused conventional CABG because of associated conditions; hepatic cirrhosis (n=1) active GI bleeding (n=1) recent stroke (n=1)	Not stated

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
<p>MACK 1999</p> <p><u>Location:</u> USA</p> <p>Medical City Dallas Hospital, Dallas, Texas and Allegheny University Hospital, Medical College Pennsylvania, Pittsburgh PA</p>	<p>MIDCAB</p> <p><u>Surgical access:</u> Limited anterior thoracotomy</p> <p><u>Stabiliser:</u> Mechanical, not further specified</p> <p><u>Pre-ischaemic conditioning:</u> Not routinely employed</p> <p><u>Coronary shunts:</u> Not stated</p> <p><u>Anaesthesia:</u> Not stated</p> <p><u>Graft type:</u> LIMA-LAD</p> <p><u>Occlusion time prior to anastomoses:</u> Not stated</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u> 14 (13%) (previous bypass graft)</p> <p><u>Direct vision or video-assisted:</u> Direct vision (harvest); Video (dissection)</p> <p><u>Pain management:</u> Not stated</p>	<p>Case series</p> <p><u>Basis of patient selection:</u> Consecutive</p> <p><u>Study period:</u> December 1996 to December 1997</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up:</u> Up to 96 hours</p> <p><u>Losses to follow-up:</u> Not stated</p> <p><u>Level of evidence:</u> IV</p>	<p>103 patients</p> <p><u>Diagnosis:</u> young healthy patients with single-vessel disease who usually presented with LAD re-stenosis after a previous catheter based procedure</p> <p>higher risk ie Elderly (15 patients 15% >=80 years), had previous bypass surgery (14, 14%) or significant comorbidities that precluded cardiopulmonary bypass</p> <p><u>Age, years:</u> 64.9 (range 38-87)</p> <p><u>Gender mix:</u> 71% males</p> <p><u>Lesion type:</u> Not stated</p> <p><u>Lesion position:</u> Not stated</p> <p><u>Operative status:</u> Not stated</p> <p><u>RISK FACTORS:</u> included patients with chronic renal insufficiency, cerebral vascular disease, severe COPD</p> <p><u>Ejection fraction:</u> Depressed left ventricular function: 38 (37%)</p> <p><u>COMORBIDITY:</u> as above</p>	<p><u>Inclusions:</u> Not stated</p> <p><u>Exclusions:</u> Patients who underwent the following during the study period; Conventional coronary artery bypass grafting, beating heart revascularisation by a median sternotomy approach, or more than 1 bypass through a limited access incision.</p>

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
<p>MAGOVERN 2001</p> <p><u>Location:</u> USA</p> <p>Department of Cardiothoracic Surgery, Allegheny General Hospital, Pittsburgh, Pennsylvania;</p> <p>Northside Medical Center/Forum Health, Youngstown, Ohio</p>	<p>MIDCAB (left axillary to LAD)</p> <p><u>Surgical access:</u> Anterior thoracotomy, fourth intercostal space</p> <p><u>Stabiliser:</u> Mechanical stabiliser</p> <p><u>Pre-ischaemic conditioning:</u> Not stated</p> <p><u>Coronary shunts:</u> Yes</p> <p><u>Anaesthesia:</u> Not stated</p> <p><u>Graft type:</u> Left axillary artery to LAD</p> <p><u>Conduits:</u> SVG (n=18); RA (n=4)</p> <p><u>Occlusion time prior to anastomoses:</u> Not stated</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u> 20/22 (91%) CABG</p> <p><u>Direct vision or video-assisted:</u> Not stated</p> <p><u>Pain management:</u> Not stated</p>	<p>Case series</p> <p><u>Basis of patient selection:</u> From approx 4,000 patients undergoing CABG</p> <p><u>Study period:</u> 3 years since 1997</p> <p><u>Operator details:</u> 2 institutions</p> <p><u>Length of follow-up:</u> Mean 6 months</p> <p><u>Losses to follow-up:</u> Not stated</p> <p><u>Level of evidence:</u> IV</p>	<p>22 patients; all high-risk</p> <p><u>Diagnosis:</u> Not stated</p> <p><u>Age:</u> 70 {7} years (range 52 to 83)</p> <p><u>Gender mix:</u> 10 male</p> <p><u>Lesion type:</u> Not stated</p> <p><u>Lesion position:</u> Not stated</p> <p><u>Operative status:</u> Not stated</p> <p><u>RISK FACTORS:</u></p> <p><u>Ejection fraction:</u></p> <p><u>Mean LVEF:</u> 38% {6%}</p> <p><u>Ejection fraction <40%:</u> 11 (55%)</p> <p><u>Age > 70 years:</u> 10 (45%)</p> <p><u>Previous heart operation (CABG):</u> 20/22 (91%)</p> <p><u>Third-time operation:</u> 3 (18%)</p> <p><u>Current smokers:</u> 13 (59%)</p> <p><u>PVD:</u> 6 (27%)</p> <p><u>Diabetes:</u> 10 (45%)</p> <p><u>COMORBIDITY:</u> see above</p>	<p><u>Inclusions:</u> Where a normal MIDCAB is not possible (eg redo patients when LAD is occluded and the other grafts are still patent but the LIMA has been used)</p> <p><u>Exclusions:</u> Not stated</p>

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
NG 2000 <u>Location:</u> USA Division of Cardiothoracic Surgery, East Carolina University School of Medicine, Greenville, North Carolina	MIDCAB <u>Surgical access:</u> Left anteriorthoracotomy at the 4 th intercostal space <u>Stabiliser:</u> Genzyme <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> LIMA-LAD <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Reoperations 3.6% <u>Direct vision or video-assisted:</u> Direct vision <u>Pain management:</u> Not stated	Case series <u>Basis of patient selection:</u> Not stated <u>Study period:</u> March 1996 to August 1999 <u>Operator details:</u> 2 surgeons performed all cases <u>Length of follow-up:</u> 2 weeks <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> IV	165 patients <u>Diagnosis:</u> Single-vessel coronary artery disease involving LAD, particularly ostial or complex lesions not optimally treated by percutaneous therapies <u>Age, years:</u> 60 {11.6} range 30-88 <u>Gender mix:</u> 115 male/50 female <u>Lesion type:</u> Not stated <u>Lesion position:</u> Not stated <u>Operative status:</u> Not stated <u>RISK FACTORS:</u> <u>Ejection fraction:</u> 0.55 {0.08} range 0.3- 0.7 <u>COMORBIDITY:</u> Diabetes mellitus 43 (25.4%) Smoking 71 (42.4 %) Pre-op steroid use 3 (1.8%) COPD 6 (3.6%) Morbid obesity 4 (2.4%)	<u>Inclusions:</u> Not stated <u>Exclusions:</u> Previous left thoracotomy, multi-vessel or significant distal coronary disease, or previous LIMA harvest

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
<p>NIINAMI 2001</p> <p><u>Location:</u> JAPAN</p> <p>Department of Cardiovascular Surgery, Daini Hospital, Tokyo Women's Medical University, Tokyo</p>	<p>MIDCAB (LESS – lower end sternal approach)</p> <p><u>Surgical access:</u> Partial sternotomy without a transverse cut (LESS) – lower midline incision (7-8cm) from the fourth intercostal space to the xiphoid process with longitudinal division up to the 3^d rib, without either a T- or reversed L- shaped division of the sternum [4 patients had a small laparotomy in addition to the lower sternotomy]</p> <p><u>Stabiliser:</u> CAB Super-Slide retractor or Octopus</p> <p><u>Pre-ischaemic conditioning:</u> Not stated</p> <p><u>Coronary shunts:</u> Not stated</p> <p><u>Anaesthesia:</u> Not stated</p> <p><u>Graft type:</u></p> <p>LITA-LAD; 15 patients, 15 grafts and 15 anastomoses</p> <p>LITA-LAD + RITA-RCA; 2 patients, 4 grafts, 4 anastomoses</p> <p>LITA-LAD + RITA-RCA + RA-PDA; 1 patient, 3 grafts, 4 anastomoses</p> <p>LITA-LAD + GEA-RCA; 1 patient, 2 grafts, 2 anastomoses</p> <p>LITA-LAD + GEA-PDA; 1 patient, 2 grafts, 2 anastomoses</p> <p>GEA-RCA; 2 patients, 2 grafts, 2 anastomoses</p> <p><u>Occlusion time prior to anastomoses:</u> 5 minute test occlusion</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u> 2/22 previous CABG;</p> <p>2/22 had previous PTCA</p> <p><u>Direct vision or video-assisted:</u> Not stated</p> <p><u>Pain management:</u> Not stated</p>	<p>Case series</p> <p><u>Basis of patient selection:</u> Not stated</p> <p><u>Study period:</u> November 1999 to November 2000</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up:</u> Not stated</p> <p><u>Losses to follow-up:</u> Not stated</p> <p><u>Level of evidence:</u> IV</p>	<p>22 patients</p> <p><u>Diagnosis:</u> Major coronary artery stenosis (>75% angiographic stenosis) limited to a single or double coronary distribution on the anterior and inferior surface of the heart.</p> <p><u>Age, years:</u> 69.5 [6.1] range 58 to 77 years</p> <p><u>Gender mix:</u> 16 men, 6 women</p> <p><u>Lesion type:</u> 17 single vessel; 5 double vessel</p> <p><u>Lesion position:</u> LAD disease only (n=14); LAD and RCA disease (n=5); RCA disease only (n=2)</p> <p>Left main trunk disease (n=1)</p> <p><u>Operative status:</u> Not stated</p> <p><u>RISK FACTORS:</u></p> <p>NYHA class: III (n=3); II (n=11); I (n=8)</p> <p><u>Ejection fraction: Mean LVEF:</u> 62.1% [13.4] (range 38% to 77%)</p> <p><u>MI:</u> 6 (one or more previous MI)</p> <p><u>Stroke:</u> 1</p> <p><u>Renal insufficiency:</u> 2; 1 on haemodialysis</p> <p><u>COMORBIDITY:</u> As above</p>	<p><u>Inclusions:</u> All patients had symptoms refractory to medical treatment and were not candidates for further catheter-based interventions.</p> <p>Patients were not excluded on the basis of the age, functional status, reoperation, or other preoperative risk factors, such as previous stroke or MI.</p> <p><u>Exclusions:</u> Presence of major coronary artery disease on the lateral or posterior surface of the heart and AMI requiring intravenous administration of nitrates or an intraaortic balloon pump</p>

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
OSTER 1998 <u>Location:</u> GERMANY Clinic for Cardiovascular Surgery, Rotenburg	MIDCAB (in older people) <u>Surgical access:</u> Anterolateral minithoracotomy, 8-12cm long <u>Stabiliser:</u> CTS <u>Pre-ischaemic conditioning:</u> Not stated <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Not stated <u>Graft type:</u> LIMA-LAD (n=25) LIMA-LAD and diagonal (n=2) <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> 12 patients: up to four PTCA (n=3) or PTCA and stenting (n=9) <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated	Case series <u>Basis of patient selection:</u> Not stated <u>Study period:</u> January 1997 to October 1997 <u>Operator details:</u> Not stated <u>Length of follow-up:</u> 10 days postoperative <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> IV	27 patients <u>Diagnosis:</u> 12 patients with previous PTCA or PTCA/stenting; the remaining 15 showed stenosis not suitable for PTCA or an occluded vessel; all patients had stable angina and a normal ejection fraction <u>Age, years (mean, range):</u> 75.5 range 70 to 85 <u>Gender mix:</u> 18 male (66.7%) <u>Lesion type:</u> Not stated <u>Lesion position:</u> Not stated <u>Operative status:</u> Not stated <u>RISK FACTORS:</u> Not stated <u>COMORBIDITY:</u> Not stated	Not stated

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/ Exclusion criteria
SHIGA 2000a <u>Location:</u> JAPAN Department of Anesthesiology, Nippon Medical School, Tokyo	MIDCAB <u>Surgical access:</u> minithoracotomy (n=13) or ministernotomy (n=10) <u>Stabiliser:</u> Genesee <u>Pre-ischaemic conditioning:</u> 5 minutes of occlusion followed by 5 minutes of reperfusion <u>Coronary shunts:</u> Not stated <u>Anaesthesia:</u> Fentanyl, midazolam, vecuronium, isoflurane <u>Graft type:</u> LIMA-LAD or RD: 20 RIMA-LAD: 3 RCA-RGEA: 3 RCA-RIMA: 2 RCA- ascending aorta: 2 <u>Occlusion time prior to anastomoses:</u> Not stated <u>Perfusion prior to anastomoses:</u> Not stated <u>Previous revascularisation:</u> Not stated <u>Direct vision or video-assisted:</u> Not stated <u>Pain management:</u> Not stated	Case series <u>Basis of patient selection:</u> 25 consecutive patients <u>Study period:</u> Not stated <u>Operator details:</u> Single university hospital <u>Length of follow-up:</u> 24 hours <u>Losses to follow-up:</u> Not stated <u>Level of evidence:</u> IV	23 patients <u>Diagnosis:</u> Not stated <u>Age, years:</u> 62 (45-84) <u>Gender mix:</u> 17 male (74%) <u>Lesion type:</u> Single 10, Double 10, Triple 3 <u>Lesion position:</u> Not stated <u>Operative status:</u> Not stated RISK FACTORS: <u>Previous MI:</u> 8 (28%) <u>NYHA:</u> I: 4, II: 16, III: 3, IV: 0 <u>Ejection fraction:</u> 46.2 (22.5 –80.4) <u>COMORBIDITY:</u> <u>Hypertension:</u> 15 <u>Diabetes:</u> 4	<u>Inclusions:</u> Not stated <u>Exclusions:</u> Acute MI within previous 2 weeks or unstable angina with the previous 24 hours or if TnT >0.2 ng/mL before surgery; pre-existing conduction abnormality, left ventricular hypertrophy or AF

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/Exclusion criteria
<p>WATANABE 1999</p> <p><u>Location:</u> JAPAN</p> <p>Department of Surgery, Toyama Medical and Pharmaceutical University, Toyama</p>	<p>MIDCAB (multiple)</p> <p><u>Surgical access:</u> Limited lateral thoracotomy in fourth or fifth intercostal spaces</p> <p><u>Stabiliser:</u> MIDCAB doughnut</p> <p><u>Pre-ischaemic conditioning:</u> Yes (no details given)</p> <p><u>Coronary shunts:</u> Not stated</p> <p><u>Anaesthesia:</u> Not stated</p> <p><u>Graft type:</u> LAD and LCX (in 4 patients triple and quadruple vessel grafting) - of the 18 free arterial conduits, 15 were LITA and 3 RGEA</p> <p><u>Conduits:</u> 20 LITAs; 1 RITA; 10 RGEAs; 12 RAs; 6 IEAs</p> <p><u>Occlusion time prior to anastomoses:</u> Not stated</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u> Not stated</p> <p><u>Direct vision or video-assisted:</u> Video assisted</p> <p><u>Pain management:</u> Not stated</p>	<p>Case series</p> <p><u>Basis of patient selection:</u> 20 of 70 MIDCAB patients (29%) and 16% of total coronary artery bypasses (124) during the period</p> <p><u>Study period:</u> May 1996 to May 1998</p> <p><u>Operator details:</u> Length of follow-up: mean 7.0 months, {5.6}range 2 to 22 months)</p> <p><u>Losses to follow-up:</u> Not stated</p> <p><u>Level of evidence:</u> IV</p>	<p>20 patients</p> <p><u>Diagnosis:</u> Patients with multivessel disease involving LCX as well as LAD or left main coronary artery disease</p> <p><u>Age, years:</u> 67.1 mean (range 55-81)</p> <p><u>Gender mix:</u> 15 male</p> <p><u>Lesion type:</u> 2 vessel: 11 3 vessel: 7 LMT: 2</p> <p><u>Lesion position:</u> LAD and left circumflex</p> <p><u>Operative status:</u> Not stated</p> <p>RISK FACTORS:</p> <p><u>Ejection fraction:</u> Mean 56 (range 27-78)</p> <p><u>COMORBIDITY:</u> Not stated</p>	<p><u>Inclusions:</u> Distal LAD had to be at least 1.5mm in diameter and non-calcified</p> <p><u>Exclusions:</u> Myocardial bridging</p>

Study identifier and location	Intervention/comparison	Study design	Study population	Inclusion/ Exclusion criteria
<p>WOLF 1999</p> <p><u>Location:</u> USA</p> <p>Cardiovascular and Thoracic Surgeons Inc., The Christ Hospital and the University of Cincinnati, Cincinnati, Ohio</p>	<p>MIDCAB (using saphenous vein grafts)</p> <p><u>Surgical access:</u> short incision in the fourth intercostal space</p> <p><u>Stabiliser:</u> Foot stabiliser</p> <p><u>Pre-ischaemic conditioning:</u> Not stated</p> <p><u>Coronary shunts:</u> Not stated</p> <p><u>Anaesthesia:</u> Not stated</p> <p><u>Graft type:</u> SVG-LAD</p> <p><u>Occlusion time prior to anastomoses:</u> Not stated</p> <p><u>Perfusion prior to anastomoses:</u> Not stated</p> <p><u>Previous revascularisation:</u> 5</p> <p><u>Direct vision or video-assisted:</u> Not stated</p> <p><u>Pain management:</u> Not stated</p>	<p>Case series</p> <p><u>Basis of patient selection:</u> 13 patients having MIDCAB with SVGs during a period when 150 patients had MIDCAB</p> <p><u>Study period:</u> Not stated</p> <p><u>Operator details:</u> Not stated</p> <p><u>Length of follow-up:</u> at least 6 months</p> <p><u>Losses to follow-up:</u> Not stated</p> <p><u>Level of evidence:</u> IV</p>	<p>13 patients</p> <p><u>Diagnosis:</u> SVG was used in 4 patients in whom the ITA had been used, in 2 in whom the ITA was damaged during dissection, in 1 with atherosclerosis of the ITA, in 3 who were very elderly and in 3 in whom the target was the RCA beyond the acute margin of the heart</p> <p><u>Age, years:</u> 72 mean (range 40 to 89) - 5 older than 80</p> <p><u>Gender mix:</u> 9 male</p> <p><u>Lesion type:</u> Not stated</p> <p><u>Lesion position:</u> Proximal: RCA 5; LAD 5 Diagonal branch 1 Pre-existing SVGs 2 Distal: Common carotid artery 6 Axillary artery 5 Subclavian artery 1 ITA 1</p> <p><u>Operative status:</u> Not stated</p> <p><u>RISK FACTORS:</u> Not stated</p> <p><u>Ejection fraction:</u> Not stated</p> <p><u>COMORBIDITY:</u> Not stated</p>	<p>Not stated</p>

Appendix F List of excluded studies

Study identifier	Reason for exclusion
Acuff 1996	No stabiliser used
Ahonen 2001	No stabiliser used
Akhter 1997	No stabiliser mentioned; stabilisation by gentle traction
Akhter 1998	Stabilisation by gentle traction
Aleksic 2000	No stabiliser used
Alessandrini 1997	No stabiliser used
Alessandrini 1997b	No mechanical stabiliser used
Aliabadi 1997	No stabiliser mentioned
Andrew 1998	No stabiliser mentioned
Antona 1998	Mixed stabiliser/no stabiliser
Arom 1999	No mechanical stabiliser used for MIDCAB
Arom 1997	Some full sternotomy patients, results not presented separately
Arom 1996	No stabiliser used
Aronson 1999	No stabiliser used
Babatasi 1998	Some hybrid procedures
Babatasi 1998b	Mixed handheld and pressure stabilisers
Barstad 1997	No stabiliser used
Baumgartner 2000	Some full sternotomy patients, results not presented separately
Belov 1998	Some full sternotomy patients, results not presented separately
Benetti 1995	No stabiliser mentioned
Bergsland 1998a	Some full sternotomy patients, results not presented separately
Bergsland 1998b	Some full sternotomy patients, results not presented separately
Bergsland 1997	Some full sternotomy patients, results not presented separately
BhaskerRao 1998	Some full sternotomy patients, results not presented separately
Biglioli 2000	Mixed no stabilisers and stabilisers, results not presented separately
Birdi 1997	No stabiliser used?
Boehm 1999	Some full sternotomy patients, results not presented separately
Bonatti 2000	Some full sternotomy patients, results not presented separately
Bonatti 1998a	Mixed sutures and CTS, results not presented separately
Bonatti 1998b	Mixed sutures and CTS, results not presented separately
Boonstra 1997	No stabiliser used
Borges 1998	No stabiliser used? Case report – no complications
Borst 1997	Review of studies
Boyd 2001	Robotically assisted (RAVE CAB)
Boyd 2000	Mixed MIDCAB and sternotomy incisions and mixed stabilisers – separate results not given
Boyd 1999	Some full sternotomy patients, results not presented separately
Brown 1999	No mechanical stabilisers mentioned
Bucerius 2000	No mechanical stabilisers mentioned
Buffolo 1997	Some full sternotomy patients, results not presented separately
Buhre 1998	No mechanical stabilisers mentioned
Buhre 1999	No mechanical stabilisers mentioned
Byhahn 2001	Robotic (TECAB)
Calafiore 1996a	No mechanical stabiliser used

Study identifier	Reason for exclusion
Calafiore 1996b	Review
Calafiore 1997c	Stabiliser used in only some patients
Calafiore 1998	Mixed – no stabiliser and CTS
Calafiore 1998b	No stabiliser mentioned
Calafiore 1998d	Mixed – no stabiliser and CTS
Calafiore 1998e	Mixed stabiliser and no stabiliser
Carrel 1999	No stabiliser mentioned
Cattozzo 2001	No stabiliser mentioned
Caulfield 2000	No stabiliser mentioned
Chauhan 1997	No stabiliser mentioned
Chen 1998	No mechanical stabiliser mentioned
Chun 1999	Hand-held stabiliser
Cohen 1998	Hybrid procedure (MIDCAB/angioplasty)
Cohn 1999	No stabiliser mentioned (possibly mixed pharmacological and mechanical stabilisers)
Cohn 1998	No stabiliser
Cooley 1996	No stabiliser mentioned
Coulson 1998b	No mechanical stabiliser used
Cozzi 2000	No stabiliser mentioned
Cremer 2000	Some hybrid (PTCA) procedures
Cremer 1999	Mixed stabiliser/no stabiliser?
Cremer 1999b	Mixed stabiliser/no stabiliser
D'Ancona 2001	Some full sternotomy patients, results not presented separately
D'Ancona 2000b	Some full sternotomy patients, results not presented separately
D'Ancona 1999	Some full sternotomy patients, results not presented separately
De Paulis 1999a	Mixed stabiliser and no stabiliser
De Paulis 1999b	Mixed stabiliser and no stabiliser
Del Rizzo 1998	Some full sternotomy patients, results not presented separately
Dewey 2000	No stabiliser mentioned
Dhole 2001	No stabiliser mentioned
Dickes 1999	Some full sternotomy patients, results not presented separately
Diegeler 2000b	No mechanical stabilisers mentioned
Diegeler 1999c	No mechanical stabilisers mentioned
Diegeler 1999d	MIDCAB - mixed stabilisers?: 'variety of stabilizers, depending on individual anatomy'
Diegeler 1999e	Variety of stabilisers
Diegeler 1999g	Review article
Diegeler 1998c	Some concurrent PTCA (hybrid procedures)
Diegeler 1997	No mechanical stabilisers mentioned
Doty 1999	Hand-help clamp, not mechanical stabiliser
Doty 1998	No mechanical stabilisers mentioned
Doty 1997	No mechanical stabilisers mentioned
Duhaylongsod 1998	No mechanical stabilisers mentioned
Falk 2000	MIDCAB versus endoscopic MIDCAB
Falk 1997	Mixed beating and arrested heart
Fanning 1993	No mechanical stabilisers mentioned
Fonger 1999	Hand-held clamp and stabiliser
Fonger 1997	Hand-held clamp and stabiliser

Study identifier	Reason for exclusion
Galloway 1998	No mechanical stabilisers mentioned
Ganapathy 1999	No mechanical stabilisers mentioned
Ganapathy 1999b	Case study only (of paravertebral block) – without mention of any complications
Gandjbakhch 1997	Pharmacological stabilisation only?
Garrett 1997	No mechanical stabiliser
Gill 2000a	No mechanical stabiliser
Gill 2000b	No mechanical stabiliser
Gill 1997	Some full sternotomy patients, results not presented separately
Godje 1999	No clinically relevant outcomes
Goldstein 1998	Some hybrid procedures
Grandjean 1996	No mechanical stabiliser
Gulbins 1998	Some full sternotomy patients, results not presented separately
Guler 2001	No mechanical stabilisers mentioned
Hadjinikolaou 1997	No mechanical stabilisers mentioned
Hamano 2001	Valve surgery
Hart 2000	Some full sternotomy patients, results not presented separately
Hart 1999	Some full sternotomy patients, results not presented separately
Heres 1998	Mixed stabiliser/no stabiliser?
Higashiue 2001	Some full sternotomy patients, and some on-pump patients, results not presented separately
Hirata 2000	No mention of stabiliser
Hirose 1999a	Case report without complications
Hirose 1999b	Some full sternotomy patients, results not presented separately
Hirose 2000	Some full sternotomy patients, results not presented separately
Holubkov 1998	Some hybrid procedures
Hvrafnak 2001	No mechanical stabilisers mentioned
Imasaka 2000	Some full sternotomy patients, results not presented separately
Isik 1997	No mechanical stabilisers mentioned
Isomura 2000	Some hybrid procedures
Izzat 1998	Some full sternotomy patients, results not presented separately
Jaber 1998	Dog study
Jacobsohn 1997	No mechanical stabilisers mentioned
Jansen 1998b	No clinical outcomes reported
Jansen 1998c	Some full sternotomy patients, results not presented separately
Jansen 1997	Mixed MIDCAB/hybrid results
Jatene 1997	'Restraining device' used in some patients – mixed?
Jatene 2000	Mixed no stabiliser/stabiliser (CTS)
Jurmann 1998	Mixed MIDCAB/hybrid results
Jurmann 1997	Not clear whether the stabiliser was mechanical
Kappert 2000	MIDCAB versus endoscopic versus robotic MIDCAB
Karagoz 2000	No mechanical stabiliser
Karagoz 1998	No mechanical stabiliser
Katz 1999	Mixed MIDCAB/hybrid results
Kawata 1999	Technique, not clinical outcomes
Kilger 1998	No mechanical stabilisers mentioned
Kim 2001	Some full sternotomy patients, results not presented separately
King 1997	No mechanical stabiliser

Study identifier	Reason for exclusion
Koutlas 2000	Some full sternotomy patients, results not presented separately
Koyama 1999	No mechanical stabilisers mentioned
Lachat 1997	No mechanical stabiliser
Landreneau 1996	No mechanical stabiliser
Lichtenberg 2000c	Technique only – no outcomes reported
Liem 1998	No stabilisers mentioned
Lin 1999	No exact denominator 'we have performed over 250 cases to date'
Lockowandt 2000	Some full sternotomy patients, results not presented separately
Mack 1999	No mechanical stabilisers mentioned
Mack 1997	Mixed stabilisers
Magovern 1998	No mechanical stabiliser mentioned
Malkowski 1998	No mechanical stabilisers mentioned
Manjari 1998	Some full sternotomy patients, results not presented separately
Manneh 2000	No mechanical stabilisers mentioned; MIDCAB results mixed with PCTA results?
Mariani 1997a	MIDCAB versus PTCA
Mariani 1997b	Mixed no stabilisers/stabilisers
Mastoor 1998	No mechanical stabilisers mentioned
Mehran 2000	No mechanical stabilisers mentioned
Mehran 2000	No mechanical stabilisers mentioned
Mehta 1998	No mechanical stabilisers mentioned
Mishra 1998	No stabilisers mentioned
Mishra 1997	No mechanical stabiliser
Moiny 1998	No mechanical stabilisers mentioned
Moussa 2001	Mixed mechanical and other stabilisers
Mueller 2001	No mechanical stabilisers mentioned
Mueller 1998	No mechanical stabilisers mentioned
Nabuchi 2000	5 case reports, no complications
Nataf 1997a	No mechanical stabilisers mentioned
Nataf 1997b	Some full sternotomy patients, results not presented separately
Nataf 1997c	Mixed stabilisers/no stabilisers
Nauenberg 2000	Mixed stabilisers/no stabilisers
Nishizaki 2001	No mechanical stabilisers mentioned
Ohtsuka 1997	No mechanical stabilisers mentioned
Osborne 1998	No mechanical stabilisers mentioned
Oz 1997	Handheld stabiliser
Petro 2000	Some full sternotomy patients, results not presented separately
Poirier 1999	Some full sternotomy patients, results not presented separately
Puskas 1999	Some full sternotomy patients, results not presented separately
Puskas 1998	Some full sternotomy patients, results not presented separately
Reichenspurner 1998	MIDCAB, OPCAB and CABG comparison, but CABG is port access
Repossini 2000	Some hybrid procedures
Ricci 2000a	Some full sternotomy patients, results not presented separately
Riess 2000	Mixed MIDCAB and MIDCAB/angioplasty results
Riess 1999	Mixed MIDCAB and MIDCAB/angioplasty results
Riess 1998	Mixed MIDCAB and MIDCAB/angioplasty results
Robinson 1997	Mixed on and offpump

Study identifier	Reason for exclusion
Schutz 2001	Some full sternotomy patients, results not presented separately
Shiga 2000b	No prespecified outcomes
Siebert 2000	No stabilisers mentioned
Sinclair 2000	Likely to have mixed stabilisers/no stabilisers
Soltoski 1998	Some full sternotomy patients, results not presented separately
Spooner 1999	Some full sternotomy patients, results not presented separately
Spooner 1998	Some full sternotomy patients, results not presented separately
Stamou 2000c	Some full sternotomy patients, results not presented separately
Stamou 2000d	Some full sternotomy patients, results not presented separately
Stamou 2000e	Some hybrid (PTCA) procedures; results not presented separately
Stanbridge 1997	No mechanical stabilisers mentioned
Subramanian 1996	No mechanical stabiliser
Subramanian 1997b	Mixed pharmacological and mechanical stabilisers
Subramanian 2000	No results, technique only
Suen 1997	Mixed pharmacological and mechanical stabilisers
Suma 1995	Mixed on and offpump
Takahashi 2000	Some full sternotomy patients, results not presented separately
Tamis-Holland 2000	No mechanical stabilisers mentioned
Tamis 1998	No mechanical stabilisers mentioned
Tatoulis 1997	No mechanical stabiliser
Tezcaner 1998	Mixed on and offpump
Thijssens 2000	Some full sternotomy patients, results not presented separately
Trehan 2000a	Some full sternotomy patients, results not presented separately
Trehan 2000b	Some hybrid procedures
Trehan 2000c	Some hybrid procedures (PTCA)
Tsai 2000	No mechanical stabilisers mentioned
Turner 1999	Some full sternotomy patients, results not presented separately
Van Aarnhem 1999	Some full sternotomy patients, results not presented separately
Varghese 2001	Some full sternotomy patients, results not presented separately
Vassiliades 2000a	IMA harvested robotically, then MIDCAB
Verkkala 1999	No mechanical stabilisers used
Vlassov 2001	Mixed sternotomy and MIDCAB, no stabilisers (for sternotomy patients)
Voutilainen 1998	No mechanical stabilisers used
Walther 1999	No mechanical stabilisers mentioned
Wasnick 1997	No stabilisers mentioned
Wasnick 1995	No mechanical stabilisers mentioned
Weinschelbaum 1998	Some hybrid procedures and 2 onpump procedures included (results not presented separately)
Wolf 1999	No mechanical stabilisers mentioned
Yokoyama 2000	Some full sternotomy patients, results not presented separately
Zalaquett 1999	No mechanical stabilisers mentioned?
Zenati 1997a	No mechanical stabilisers mentioned
Zenati 1997b	Mixed stabilisers/no stabilisers
Zenati 1998	Some hybrid procedures

Abbreviations

AF	atrial fibrillation
AMI	acute myocardial infarction
ASERNIP-S	Australian Safety and Efficacy Register of New Interventional Procedures - Surgery
CABG	coronary artery bypass graft
CAD	coronary artery disease
CCABG	conventional CABG (ie on-pump with a median sternotomy)
CCS	Canadian Cardiovascular Society
CHF	congestive heart failure
CI	confidence interval
CK-MB	creatinine kinase-MB
COPD	chronic obstructive pulmonary disease
CPB	cardiopulmonary bypass
CRF	chronic renal failure
CTnI	cardiac troponin I
CTS	Cardio Thoracic Systems
CVA	cerebrovascular accident
FEV1	forced expiratory volume (1 minute)
GEA	gastroepiploic artery
GI	gastrointestinal
IABP	intraaortic balloon pump
ICU	intensive care unit
IL	interleukin
IU	International Units
IMA	internal mammary artery (synonym for internal thoracic artery)
IQR	interquartile range
ITA	internal thoracic artery (synonym for internal mammary artery)
LAD	left anterior descending artery
LAST	left anterior small thoracotomy
LCX	left circumflex coronary artery
LIMA	left internal mammary artery
LITA	left internal thoracic artery
LMT	left main trunk
LVEDP	left ventricular end-diastolic pressure
LVEF	left ventricular ejection fraction
MI	myocardial infarction
MIDCAB	minimally invasive direct coronary artery bypass
MSAC	Medical Services Advisory Committee
NA	not applicable
ns	not (statistically) significant
NYHA	New York Heart Association
OM	obtuse marginal
OPCAB	off-pump coronary artery bypass
PDA	posterior descending artery
POD	postoperative day
POEM	Patency, Outcomes and Economics of MIDCAB trial
PTCA	percutaneous transluminal coronary angioplasty

PVD	peripheral vascular disease
RA	radial artery
RCA	right coronary artery
RCT	randomised controlled trial
RD	diagonal branch
RGEA	right gastroepiploic artery
RIM	intermediate branch
RITA	right internal thoracic artery
SD	standard deviation
SE	standard error
SVG	saphenous vein graft
TNF	tumour necrosis factor
TnT	cardiac troponin T
TIMI	thrombolysis in myocardial infarction
VAS	visual analogue scale

References

Studies included in the review (listed by study identifier)

ALLEN 1997

Allen KB, Matheny RG, Robison RJ, Heimansohn DA, Shaar CJ. (1997) Minimally invasive versus conventional reoperative coronary artery bypass. *Annals of Thoracic Surgery* 64:616-622.

AZOURY 2001

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