Trends in coronary artery bypass graft surgery in Victoria, 2001–2006: findings from the Australasian Society of Cardiac and Thoracic Surgeons database project

Diem T Dinh, Geraldine A Lee, Baki Billah, Julian A Smith, Gilbert C Shardey and Christopher M Reid

ABSTRACT

Objective: To examine trends in preoperative clinical characteristics, risk profiles and postoperative outcomes of patients undergoing isolated coronary artery bypass graft (CABG) surgery in Victoria.

Design, setting and patients: A prospective analysis of 9372 patients undergoing isolated CABG surgery between 1 July 2001 and 30 June 2006 in six Victorian public hospitals, using the Australasian Society of Cardiac and Thoracic Surgeons database.

Main outcome measures: Trends in patient baseline characteristics and risk factors, postoperative morbidity and 30-day mortality rate.

Results: Over the 5 years, the mean age of patients undergoing isolated CABG surgery increased, from 65.4 years in 2001–02 to 66.0 years in 2005–06 ($P < 0.001$). There was also an increase in the proportion of patients with hypertension (70.2% to 75.8%; $P < 0.001$), respiratory disease (83.2% to 89.5%; $P < 0.001$) and left main coronary artery disease (22.1% to 26.1%; $P = 0.03$), while the number of patients undergoing repeat CABG surgery decreased (4.4% to 2.6%; $P = 0.002$). The overall 30-day mortality rate remained unchanged (2.2% to 1.8%; $P = 0.983$). Rates of other major postoperative complications showed no significant change over the study period.

Conclusion: Rates of 30-day mortality and postoperative morbidity after CABG surgery have remained steady, despite the surgical population being older. Short-term outcomes after CABG surgery in Victoria remain among the most favourable reported in any population undergoing this surgery.

MJA 2008; 188: 214–217

Over the past few decades, the risk profile of patients referred for isolated coronary artery bypass graft (CABG) surgery has changed considerably.[1-3] Historical data supporting the notion that patients undergoing surgical revascularisation today are much older and sicker have come from single and multi-institution studies.[1-5] CABG surgery is increasingly being performed on older people, including octogenarians with multiple comorbidities.[6,7]

In addition, the number of patients undergoing percutaneous coronary intervention (PCI) has risen dramatically with advancements in the technology of interventional cardiology, including angioplasty and stent deployment.[8,9] PCI has not only been used in low-risk patients with straightforward lesions but is increasingly being attempted in high-risk patients with multivessel coronary lesions.[10]

However, surgical revascularisation has benefits that include a significant reduction in 30-day operative mortality rates, despite a substantial increase in preoperative comorbidities of isolated CABG patients,[2,3] indicating a major improvement in outcomes from cardiac surgery. About 13 000 CABG operations are performed annually in Australia.

Until the Australasian Society of Cardiac and Thoracic Surgeons (ASCTS) database registry was established in 2001, there was no opportunity to monitor trends in preoperative risk and postoperative outcomes for patients undergoing CABG surgery in Australia. Here, we investigate changes in the preoperative clinical characteristics of this population and their major postoperative morbidities for the 5 financial years from 2001–02 to 2005–06.

METHODS

Data collection and validation

The development of the ASCTS cardiac surgery database project in Victoria has been previously described.[11] Ethics approval was gained from all participating hospitals for the purpose of quality assurance activity and subsequent analyses.

Data validation has been a major focus since the establishment of the ASCTS database. Each participating centre has a data manager who is responsible for the completeness of data collection at the site. The data are subjected to both local validation and an external data quality audit program, which is performed on site to evaluate the completeness (defined as < 1% missing data for any variable) and accuracy (97.4%) of the data held in the combined database. Audit outcomes are used to assist in further development of appropriate standards.

Preoperative, intraoperative and postoperative data (using an agreed dataset and definitions, available at <http://www.ascts.org/documents/PDF/definitions.pdf>) were prospectively collected for cardiac procedures conducted between 1 July 2001 and 30 June 2006. Six Victorian public hospitals — Austin Hospital, Geelong Hospital, Monash Medical Centre, Royal Melbourne Hospital, St Vincent's Hospital and The Alfred Hospital — contributed data to the ASCTS project during this period. Patients having concomitant valve surgery or other concurrent cardiac surgical procedures were excluded from this study. The remaining subset of patients undergoing isolated CABG procedures was analysed.

Statistical analysis

Trends in preoperative risk factors and subsequent outcomes were determined using the regression method and χ^2 test for trend in Stata, version 9.2 (StataCorp, College Station, Tex, USA).[12] A P value of < 0.05 was regarded as significant for all analyses.

Preoperative mortality risk was calculated using AusSCORE, a validated predictive mortality outcome model developed for isolated CABG surgery.[13] The model was developed by selecting preoperative risk factors in a multiple logistic regression model using the bootstrap method, along with the backward elimination procedure for variable selection.

1 Baseline characteristics and risk factors for 9372 patients undergoing isolated coronary artery bypass graft surgery in Victoria

	Financial year					
	2001–02	2002–03	2003–04	2004–05	2005–06	*P*
No. of patients	1972	2027	1982	1638	1753	
Mean age in years (95% CI)	65.4 (65.0–65.8)	65.7 (65.3–66.1)	65.9 (65.5–66.3)	66.2 (65.7–66.7)	66.0 (65.5–66.5)	< 0.001
Aged ≥ 80 years	92 (4.7%)	109 (5.4%)	109 (5.5%)	101 (6.2%)	100 (5.7%)	0.563
Aged ≥ 70 years	745 (37.8%)	799 (39.4%)	775 (39.1%)	644 (39.3%)	688 (39.2%)	0.956
Male	1482 (75.2%)	1546 (76.3%)	1565 (79.0%)	1258 (76.8%)	1350 (77.0%)	0.699
Current smoker	270 (13.7%)	240 (11.8%)	310 (15.6%)	273 (16.7%)	253 (14.4%)	0.187
Diabetes	625 (31.7%)	665 (32.8%)	626 (31.6%)	542 (33.1%)	581 (33.1%)	0.935
Hypertension	1384 (70.2%)	1501 (74.1%)	1535 (77.4%)	1260 (76.9%)	1329 (75.8%)	< 0.001
Hypercholesterolaemia	1559 (79.1%)	1678 (82.8%)	1664 (84.0%)	1350 (82.4%)	1436 (81.9%)	0.397
Cerebrovascular disease	202 (10.2%)	250 (12.3%)	224 (11.3%)	201 (12.3%)	208 (11.9%)	0.764
Peripheral vascular disease	255 (12.9%)	281 (13.9%)	278 (14.0%)	216 (13.2%)	255 (14.5%)	0.897
Renal failure*	55 (2.8%)	48 (2.4%)	61 (3.1%)	55 (3.4%)	42 (2.4%)	0.999
Respiratory disease	1640 (83.2%)	1742 (85.9%)	1740 (87.8%)	1403 (85.7%)	1569 (89.5%)	< 0.001

* Serum creatinine > 200 μmol/L or dialysis-dependent. ◆

RESULTS

A total of 14 526 cardiac surgical procedures were conducted in Victorian public hospitals between July 2001 and June 2006. CABGs were consistently the most commonly conducted procedure, with 9372 procedures (65%) being isolated CABGs (92% performed with cardiopulmonary bypass).

Demographic and comorbidity details for patients undergoing isolated CABG surgery are shown in Box 1 and Box 2 for each financial year, to compare yearly trends in patient characteristics.

There was an increase in the mean age of patients undergoing CABG surgery over the observation period, from 65.4 years in 2001–02 to 66.0 years in 2005–06 ($P < 0.001$). Patients throughout the study period were predominantly male (range, 75.2%–79.0%). Increases were seen in the proportion of patients with hypertension ($P < 0.001$), respiratory disease ($P < 0.001$), and previous cardiac history including left main coronary artery stenosis > 50% ($P = 0.03$) and recent myocardial infarction occurring 1–21 days before surgery ($P < 0.001$). The number of patients undergoing repeat CABG surgery decreased from 4.4% to 2.6% ($P = 0.002$). Non-elective surgery accounted for 38% of total CABG surgery in 2001–02 but increased to 46% in 2005–06 ($P < 0.001$).

The data showed no significant changes in other risk factors, including diabetes, hypercholesterolaemia, cerebrovascular disease, peripheral vascular disease, renal dysfunction, congestive heart failure, unstable angina, arrhythmia, cardiogenic shock, triple vessel disease and severe left ventricular impairment.

The 30-day mortality rate for each financial year is shown in Box 3. The patients' AusSCORE-calculated preoperative predicted risk for isolated CABG surgery remained unchanged over the 5 years (1.7% to 1.8%). The observed mortality rate within 30 days of CABG surgery declined from 2.2% in 2001–02 to 1.8% in 2005–06, but this change was not statistically significant ($P = 0.983$). There was a non-significant 50% decrease in mortality for elective procedures, from 1.2% in 2001–02 to 0.6% in 2005–06 ($P = 0.151$), while the 30-day mortality rate for non-elective surgery ranged between 2.9% and 3.7% over the 5 years; this trend was also not statistically significant ($P = 0.977$).

Postoperative morbidity trends for CABG surgery remained steady over the 5 years (Box 3).

DISCUSSION

The main finding from this study is that the 30-day mortality rate remained unchanged over the 5 years, despite an increase in older patients undergoing isolated CABG surgery. The unadjusted mortality rate of 1.8% for the study period is the same as the 30-day mortality rate reported in the United Kingdom and is lower than the United States figure of 2.3%.[1,14] Postoperative complications after CABG surgery also remained steady and consistently low over the study period and compared well with international rates.[4,15] The data suggest that 30-day outcomes after CABG surgery in Victoria are favourable compared with any population undergoing this surgery.

We found that the mean age of patients undergoing isolated CABG surgery in Victorian public hospitals increased over the study period, reflecting other studies' findings that older patients are being increasingly referred for surgical coronary artery revascularisation.[6,7] Benefits of CABG surgery in older people include demonstrated improvement in functional status.[16]

Interestingly, the frequency of repeat CABG surgery declined, possibly due to the introduction of coronary stenting or to improved medical management.[8,9] Although studies have reported no differences in mortality between multivessel stenting and CABGs, high rates of reintervention with repeat revascularisation being needed after PCI continue to be a problem.[10]

We found an increased incidence of some cardiovascular risk factors and increasing acuity of patients presenting for surgical treatment, along with an associated increase in non-elective surgery. Despite these increases, the trend in 30-day mortality rates in patients undergoing non-elective surgery was not statistically significant.

The AusSCORE predictive mortality outcome model was developed and has been deemed suitable for use in the Australian context.[13] It has demonstrated accuracy in predicting risk — the observed/expected outcome ratio ranges between 0.9% and 1.2%. Minimal change in predicted mortality was observed in this cohort, presumably because only a few of the risk factors used in the model increased over the study period (see Box 1 and Box 2).

The ASCTS database was established for quality control and improvement purposes, and its strength lies in the inclusion of data from all six Victorian public hospitals that perform CABG surgery. The quality of data collected has been high and, importantly, with very few missing data (less than 1%). This ensures an accurate presentation of trends in CABG surgery. It also allows valid performance indicators to be established and assists with forecasting trends in the population presenting for CABG surgery.

2 Preoperative cardiac characteristics of 9372 patients undergoing isolated coronary artery bypass graft surgery in Victoria

	Financial year					
	2001–02	2002–03	2003–04	2004–05	2005–06	*P*
No. of patients	1972	2027	1982	1638	1753	
Previous CABG	87 (4.4%)	86 (4.2%)	68 (3.4%)	39 (2.4%)	45 (2.6%)	0.002
Previous PTCA/stent	227 (11.5%)	224 (11.1%)	226 (11.4%)	178 (10.9%)	239 (13.6%)	0.572
Congestive heart failure	356 (18.1%)	416 (20.5%)	436 (22.0%)	313 (19.1%)	375 (21.4%)	0.472
Unstable angina	587 (29.8%)	563 (27.8%)	645 (32.5%)	485 (29.6%)	521 (29.7%)	0.985
Arrhythmia	189 (9.6%)	186 (9.2%)	159 (8.0%)	123 (7.5%)	140 (8.0%)	0.223
Cardiogenic shock	35 (1.8%)	28 (1.4%)	37 (1.9%)	25 (1.5%)	50 (2.9%)	0.255
Triple vessel disease	1413 (71.7%)	1471 (72.6%)	1459 (73.6%)	1220 (74.5%)	1289 (73.5%)	0.523
Myocardial infarction (MI)	1015 (51.5%)	1068 (52.7%)	1149 (58.0%)	899 (54.9%)	971 (55.4%)	0.086
MI timing						
> 21 d	680 (67.0%)	686 (64.2%)	672 (58.5%)	490 (54.5%)	519 (53.5%)	< 0.001
1–21 d	305 (30.0%)	337 (31.6%)	429 (37.3%)	369 (41.0%)	403 (41.5%)	< 0.001
6–24 h	12 (1.2%)	26 (2.4%)	26 (2.3%)	22 (2.4%)	28 (2.9%)	0.262
< 6 h	17 (1.7%)	19 (1.8%)	22 (1.9%)	18 (2.0%)	21 (2.2%)	0.944
Severe LV impairment*	98 (5.0%)	68 (3.4%)	103 (5.2%)	63 (3.8%)	84 (4.8%)	0.999
Left main coronary artery stenosis > 50%	435 (22.1%)	475 (23.4%)	463 (23.4%)	420 (25.6%)	458 (26.1%)	0.030
Status						
Elective	1224 (62.1%)	1263 (62.3%)	1128 (56.9%)	882 (53.8%)	944 (53.9%)	< 0.001
Urgent	667 (33.8%)	671 (33.1%)	754 (38.0%)	681 (41.6%)	702 (40.0%)	< 0.001
Emergency/salvage†	81 (4.1%)	93 (4.6%)	100 (5.0%)	75 (4.6%)	106 (6.0%)	0.191

CABG = coronary artery bypass graft. PTCA = percutaneous transluminal coronary angioplasty. LV = left ventricular. * Ejection fraction < 30%. † Salvage is an urgent attempt to save the patient's life. ◆

Implementation of routine data collection and reporting programs for quality improvement, including the ASCTS and other large international cardiac surgery databases, has improved reported operative mortality rates after CABG surgery.[1,3,15] Evidence from these databases suggests that feedback on benchmarks and performance indicators can favourably impact on the outcomes after CABG surgery. In addition, technical advances in cardiac surgery and cardiology, with the introduction of new pharmacological agents, techniques and devices, have led to reduced mortality over the past decade.

3 Observed 30-day mortality rate and postoperative complications for 9372 patients undergoing isolated coronary artery bypass graft surgery in Victoria

	Financial year					
	2001–02	2002–03	2003–04	2004–05	2005–06	*P*
No. of patients	1972	2027	1982	1638	1753	
30-day mortality rate	43 (2.2%)	30 (1.5%)	35 (1.8%)	26 (1.6%)	32 (1.8%)	0.983
New renal failure	74 (3.8%)	65 (3.2%)	70 (3.5%)	65 (4.0%)	90 (5.1%)	0.201
Stroke	20 (1.0%)	19 (0.9%)	32 (1.6%)	28 (1.7%)	24 (1.4%)	0.517
Postoperative MI	23 (1.2%)	4 (0.2%)	9 (0.5%)	9 (0.5%)	7 (0.4%)	0.295
Deep sternal infection	14 (0.7%)	16 (0.8%)	10 (0.5%)	11 (0.7%)	12 (0.7%)	0.999
Septicaemia	24 (1.2%)	21 (1.0%)	19 (1.0%)	24 (1.5%)	12 (0.7%)	0.944
RTT for any cause	86 (4.4%)	86 (4.2%)	92 (4.6%)	80 (4.9%)	90 (5.1%)	0.738
RTT for haemorrhage	47 (2.4%)	39 (1.9%)	50 (2.5%)	38 (2.3%)	46 (2.6%)	0.959

MI = myocardial infarction. RTT = return to theatre. ◆

Interestingly, the authors of one study that reported reduced rates of hospitalisation for acute myocardial infarction and revascularisation (PCI and cardiac surgery) believed better control of risk factors was one explanation for the reduction,[17] although they questioned the sensitivity of their database.

Some limitations of our study need to be acknowledged. First, at the time of the study, the ASCTS database was in use in only one Australian state and therefore did not represent a comprehensive national experience. However, the ASCTS database has since expanded into a national program, with the recent participation of 13 cardiac units from four other states. This now represents over 70% of public cardiac surgical units in Australia.

Second, the database only collects information on inhospital postoperative morbidities and does not capture events that occur after discharge from hospital, which may represent a significant proportion of all events. It is therefore likely to underestimate the real burden of complications, given the number of comorbid conditions in the cohort of patients presenting for surgery.

Further expansion of the database to incorporate other states will allow for accurate comparisons and identification of risk factors associated with complications, and the development of models for all types of cardiac surgery. We are in the process of developing a web-based system that will streamline data collection and provide real-time benchmarking measures. Although understanding short-term mortality and complications is important, the next step is to follow up these patients for several years to examine the outcomes of CABG surgery over time.

ACKNOWLEDGEMENTS

The Victorian Cardiac Surgery Database is an initiative of the ASCTS and is funded by the Victorian Department of Health and Human Services.

COMPETING INTERESTS

None identified.

AUTHOR DETAILS

Diem T Dinh, PhD, Research Fellow[1]
Geraldine A Lee, BSc, RGN, PGDE, Postgraduate Researcher[2]
Baki Billah, PhD, MAS, Lecturer[1]
Julian A Smith, FRACS, Professor,[3] and Head[4]
Gilbert C Shardey, FRACS, Cardiac Surgeon[3]
Christopher M Reid, DipEd, MSc, PhD, Associate Professor and Associate Director[1]

1 Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, VIC.
2 Preventative Cardiology, Baker Heart Research Institute, Melbourne, VIC.
3 Cardiothoracic Surgery Unit, Southern Health, Monash Medical Centre, Melbourne, VIC.
4 Department of Surgery, Monash University, Melbourne, VIC.
Correspondence:
diem.dinh@med.monash.edu.au

REFERENCES

1 Bridgewater B, Grayson AD, Brooks N, et al. Has the publication of cardiac surgery outcome data been associated with changes in practice in northwest England: an analysis of 25,730 patients undergoing CABG surgery under 30 surgeons over eight years. *Heart* 2007; 93: 744-748.
2 Clark RE, Edwards FH, Schwartz M. Profile of preoperative characteristics of patients having CABG over the past decade. *Ann Thorac Surg* 1994; 58: 1863-1865.
3 Ferguson TB Jr, Hammill BG, Peterson ED, et al. A decade of change — risk profiles and outcomes for isolated coronary artery bypass grafting procedures, 1990-1999: a report from the STS National Database Committee and the Duke Clinical Research Institute. Society of Thoracic Surgeons. *Ann Thorac Surg* 2002; 73: 480-489.
4 Keogh BE, Kinsman R. The Society of Cardiothoracic Surgeons of Great Britain and Ireland: fifth National Adult Cardiac Surgical Database report 2003. Improving outcomes for patients. Henley-on-Thames: Dendrite Clinical Systems Ltd, 2004. http://www.scts.org/documents/PDF/5thBlueBook2003.pdf (accessed May 2007).
5 Bryan AJ, Cohen AM, Finch DJ. Cardiac services: adult cardiac surgery audit report 2004–05. http://www.ubht.nhs.uk/cardiothoracic/Patients_and_public/ACSAR2004-05.pdf (accessed May 2007).
6 Bardakci H, Cheema FH, Topkara VK, et al. Discharge to home rates are significantly lower for octogenarians undergoing coronary artery bypass graft surgery. *Ann Thorac Surg* 2007; 83: 483-489.
7 Johnson WM, Smith JM, Woods SE, et al. Cardiac surgery in octogenarians: does age alone influence outcomes? *Arch Surg* 2005; 140: 1089-1093.
8 Haan CK, Chiong JR, Coombs LP, et al. Comparison of risk profiles and outcomes in women versus men >or=75 years of age undergoing coronary artery bypass grafting. *Am J Cardiol* 2003; 91: 1255-1258.
9 Mack MJ, Brown PP, Kugelmass AD, et al. Current status and outcomes of coronary revascularization 1999 to 2002: 148,396 surgical and percutaneous procedures. *Ann Thorac Surg* 2004; 77: 761-766.
10 Serruys PW, Ong AT, van Herwerden LA, et al. Five-year outcomes after coronary stenting versus bypass surgery for the treatment of multivessel disease: the final analysis of the Arterial Revascularization Therapies Study (ARTS) randomized trial. *J Am Coll Cardiol* 2005; 46: 575-581.
11 Reid CM, Rockell M, Skillington PD, et al. Initial twelve months experience and analysis for 2001-2002 from the Australasian Society of Cardiac and Thoracic Surgeons — Victorian database project. *Heart Lung Circ* 2004; 13: 291-297.
12 Bland M. An introduction to medical statistics. 2nd ed. New York: Oxford University Press, 1995.
13 Reid CM, Billah B, Dinh D, et al. The AusSCORE — a validated model for predicting outcome following isolated coronary bypass graft procedures in Australia. *Heart Lung Circ* 2007; 16 Suppl 2: S179.
14 The Society of Thoracic Surgeons. Executive summary: STS Spring 2005 report. http://www.sts.org/documents/pdf/Spring2005STS-ExecutiveSummary.pdf (accessed May 2007).
15 Shroyer AL, Coombs LP, Peterson ED, et al. The Society of Thoracic Surgeons: 30-day operative mortality and morbidity risk models. *Ann Thorac Surg* 2003; 75: 1856-1864.
16 Huber CH, Goeber V, Berdat P, et al. Benefits of cardiac surgery in octogenarians — a postoperative quality of life assessment. *Eur J Cardiothorac Surg* 2007; 31: 1099-1105.
17 Nallamothu BK, Young J, Gurm HS, et al. Recent trends in hospital utilization for acute myocardial infarction and coronary revascularization in the United States. *Am J Cardiol* 2007; 99: 749-753.

(Received 17 May 2007, accepted 19 Nov 2007) ❑