The role of hospital volume in coronary artery bypass grafting: is more always better? 

Record Status
This is a critical abstract of an economic evaluation that meets the criteria for inclusion on NHS EED. Each abstract contains a brief summary of the methods, the results and conclusions followed by a detailed critical assessment on the reliability of the study and the conclusions drawn.

Health technology
The study examined the differences in the outcomes of nonemergent coronary artery bypass grafting (CABG) between low- and high-volume hospitals, in patients at different levels of surgical risk.

Type of intervention
Treatment.

Economic study type
Cost-effectiveness analysis.

Study population
The study population consisted of all patients who had undergone CABG procedures, which had been classified as code 36.10 to 36.16 and 36.19 by the International Classification of Diseases, Ninth Edition (ICD-9-CM).

Setting
The setting was secondary and tertiary care. The economic study was carried out in the USA.

Dates to which data relate
The effectiveness and resource use data were gathered between January 1997 and December 1997. No price year was given.

Source of effectiveness data
The effectiveness evidence was derived from a single study.

Link between effectiveness and cost data
The costing was carried out retrospectively using the same sample of patients as that used in the effectiveness analysis. The hospital costs for each patient were estimated using a comparative costing methodology, which included both the direct and indirect hospital costs from the in-house accounting system of each facility. The hospital costs were then standardised across all facilities using a two-tier method that allocated the costs from the general ledger to standardised cost centres, and then to standardised transaction codes employing primarily a Relative Value Unit costing methodology.

Study sample
The study sample consisted of all patients from 56 hospitals in 26 different US states, who were 35 years or older, and who had undergone isolated, nonemergent CABG. The sample size was 13,644. This included 2,029 patients who underwent CABG at 25 low-volume hospitals and 11,615 patients at 31 high-volume hospitals. Patients who had
undergone emergent CABG, other type or surgery and coronary angioplasty with CABG were excluded. No power calculations to determine the sample size were conducted.

Study design
This was a retrospective multi-centre cohort study carried out using data from the Solucient EXPLORE database.

Analysis of effectiveness
The primary health outcomes used in the study were the in-hospital mortality rates, length of stay, number of deaths avoided, number of transfers, and the number of patients needed to transfer to avoid a death. The groups were stated to have been comparable in terms of age and gender.

The predicted risks of in-hospital mortality for each patient included in the study were calculated using a logistic regression model. The predictors used for CABG-related in-hospital mortality were age, gender, surgical priority and severity of illness. The patients were divided into five groups according to the likelihood of suffering in-hospital mortality. Based on this risk model, 7,047 patients were classified as minimal risk (51.7%), 4,409 as low risk (32.3%), 1,273 as moderate risk (9.3%), and 461 as high risk (3.4%).

The Hosmer-Lemeshow goodness-of-fit statistic was used to establish goodness-of-fit in the model. Model discrimination was measured using the C-index. Differences between in-hospital mortality rates were assessed using chi-squared tests. Variance estimates were used to adjust for the potential effects of clustering at the hospital level.

Effectiveness results
The authors observed a significant difference with respect to in-hospital mortality rates between low- and high-volume hospitals, 3.3% (low-volume) versus 1.9% (high-volume), (p=0.001). Patients at low-volume centres (with less than 200 CABG/year) presented a longer in-hospital length of stay in relation to patients from high-volume centres (more than 200 CABG/year), 8.5 (+/- 0.27) days versus 7.8 (+/- 0.32) days, (p=0.09).

With respect to the different risk groups, the study showed significant differences between low- and high-volume centres for patients at moderate and high risk. The in-hospital mortality rates were 5.3% (low-volume) versus 2.2% (high-volume) for moderate-risk patients, and 22.6% (low-volume) versus 11.9% (high-volume) for high-risk patients, (p=0.026). For low-risk patients, the in-hospital mortality rate in low-volume hospitals was slightly higher (1.7%) than in high-volume centres (1.0%), but not statistically significant, (p=0.19). The authors observed no statistically significant differences in in-hospital mortality for those patients with minimal or severe risk.

The authors did not find any statistically significant difference in relation to the length of stay between the two types of centres. If a policy of full regionalisation was implemented (transferring all type of patients from a low- to a high-volume centre), 2,029 transfers would have to take place and 20 deaths would be avoided, with 101 patients requiring a transfer to avoid one death. If a strategy of targeted regionalisation was implemented (transferring moderate- or high-risk patients from low- to high-volume centres), there would have been 370 transfers and 16 avoided deaths, with 23 patients requiring transfer to avoid one death. Targeted regionalisation (low risk and above) would have led to 1,083 transfers and 20 deaths avoided, with 54 patients requiring a transfer to avoid one death.

Clinical conclusions
There were no statistically significant differences in the in-hospital mortality rates between the two types of centres (low- and high-volume) in patients at minimal or moderate surgical risk. Full regionalisation (transfer of all type of patients from a low-volume centre) may result in little or no benefit when the number of patients classified in the group of minimal to moderate risk is high (84%). For patients with moderate to high risk, the in-hospital mortality in low-volume centres is two-fold greater than in high-volume hospitals. Targeted regionalisation strategies, which focus on identifying high-risk patients and referring them to high-volume centres, may be as effective as full regionalisation strategies.
Measure of benefits used in the economic analysis
There was no summary measure of benefit. A cost-consequences analysis was therefore conducted.

Direct costs
The hospital costs were calculated using a comparative costing methodology, and standardised across centres using a two-tiered method. The authors did not apply discounting. However, although not stated it appeared that the costs were incurred during a one-year period and, consequently, discounting would not have been required. The quantities were not reported separately from the costs, and the study did not report which quantities or costs were measured. No price year was reported.

Statistical analysis of costs
The differences in the hospital costs and length of stay were assessed using Student's t-test. Due to a highly skewed distribution, logarithmic transformations were performed prior to the statistical analyses. This type of transformation was justified given the properties of the distribution.

Indirect Costs
The authors stated that the indirect hospital costs were included for each patient. However, they did not report which quantities or costs were measured.

Currency
US dollars $.

Sensitivity analysis
The only sensitivity analysis conducted was on the volume threshold variable. This was varied between the ranges of 100 to 300 annual cases.

Estimated benefits used in the economic analysis
No summary benefit measure was used. See the 'Effectiveness Results' section.

Cost results
The general costs at low-volume hospitals for patients undergoing CABG appeared to be greater than those at high-volume centres, $21,611 (+/- $1,043) versus $19,090 (+/- $1,265), (p=0.052).

No statistically significant differences in hospital costs were found across the risk groups. For patients classified at minimal risk, the mean low-volume hospital costs were $16,700 (95% confidence interval, CI: 15,500 - 18,000) whereas the mean high-volume hospital cost were $15,400 (95% CI: 14,500 - 16,400), (p=0.18). For low-risk patients, the mean hospital costs in low-volume centres were slightly higher ($20,400, 95% CI: 18,500 - 23,400) than in high-volume centres ($18,000, 95% CI: 16,900 - 19,300), (p=0.09). For the other risk groups, the differences observed between the mean costs were not statistically significant

Synthesis of costs and benefits
Not relevant as a cost-consequences analyses was conducted.

Authors' conclusions
In patients with moderate or high surgery risk, the in-hospital mortality rates for CABG differed for low- and high-volume hospitals. No differences in in-hospital mortality were observed in patients with low or minimal risks. After
stratification into the five risk groups, the authors did not find any statistically significant differences in the hospital costs or length of stay for low- and high-volume centres.

**CRD COMMENTARY - Selection of comparators**
The selection of the comparator appears to have been appropriate. You should decide if stratifying the risk groups and comparing between low- and high-volume hospitals represents a valid comparison in your own setting.

**Validity of estimate of measure of effectiveness**
Since this was a retrospective observational study, the internal validity of the estimates of the measure of benefit tends to be reduced. The authors admitted that it is impossible to establish causal relationships. Not all of the parameters that may be related to adverse CABG outcomes were included, and the authors acknowledged that this may have introduced some degree of residual confounding when calculating the in-hospital mortality rates. The study sample may not have been representative of the overall population. With the exception of a small number of characteristics, the patients were not shown to have been comparable at baseline. The authors acknowledged that they were unable to establish pre-existing risk factors for procedure complications. No statistical tests were carried out in order to deal with confounding variables or potential bias, although the stratification of risk groups may have reduced some of the confounding variables.

**Validity of estimate of measure of benefit**
No summary measure of benefit was used.

**Validity of estimate of costs**
It would appear that all the cost categories relevant to the perspective adopted in the analysis were included in the economic evaluation. The costs and the quantities were not reported separately and no price year was given. The authors included both the direct and indirect costs in the analysis, but there was no mention of which kind of cost or quantities were considered when calculating the total hospital cost per patient. No sensitivity analyses were conducted on the cost variables. Consequently, the robustness of the cost results is difficult to establish.

**Other issues**
The issue of generalisability was clearly a concern to the authors, as they acknowledged that the hospitals included in the database used may not have been representative of all the hospitals performing CABG in the USA. In addition, the choice of in-hospital mortality as the primary clinical outcome meant that they were unable to account for other outcomes that might have been relevant. The results were comprehensively reported and the authors' conclusions appear justified within the caveats outlined.

**Implications of the study**
The authors suggest that “targeted regionalisation, transferring subjects at moderate or higher risks from hospital with less than 200 annual cases to high volume centres, might be a desirable option that takes into account both the clinical benefits and the patient's desires in terms of choice and access”.

**Source of funding**
Dr Nallamothu completed this work while under a grant from the Agency for Healthcare Research and Quality.

**Bibliographic details**
PubMedID
11738295

Indexing Status
Subject indexing assigned by NLM

MeSH
Adult; Aged; Aged, 80 and over; Coronary Artery Bypass /economics /mortality; Female; Health Facility Size /statistics & numerical data; Hospital Costs /statistics & numerical data; Hospital Mortality; Humans; Length of Stay /economics /statistics & numerical data; Male; Middle Aged; Outcome Assessment (Health Care); Referral and Consultation /economics /statistics & numerical data; Risk Assessment; United States

AccessionNumber
22001002228

Date bibliographic record published
30/04/2003

Date abstract record published
30/04/2003