Evidence

Études

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Coronary artery bypass grafting in Canada: hospital mortality rates, 1992–1995

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Abstract

Background: Rates of in-hospital death after coronary artery bypass grafting (CABG) have been studied in many regions of Canada as possible indicators of hospital-specific quality of care. This nationwide study examined observed and risk-adjusted death rates for 23 Canadian hospitals performing CABG.

Methods: Hospital discharge data were obtained from the Canadian Institute for Health Information and were used to identify all CABG procedures performed in Canadian hospitals in fiscal years 1992/93 through 1995/96. Cases from Quebec hospitals were not studied because hospitals in that province do not report to the institute. Observed death rates were evaluated, and a logistic regression model was used to calculate a risk-adjusted death rate for each hospital for the 4-year period studied. Changes over time in hospital-specific death rates were also examined.

Results: A total of 50 357 CABG cases were studied, with an overall death rate of 3.6%. Interhospital comparisons showed that average severity of illness varied considerably across hospitals. Despite risk adjustment accounting for this variable severity, there was considerable variation in adjusted death rates across the 23 hospitals, from 1.95% to 5.76% ($p < 0.001$ for difference across hospitals). For some hospitals, death rates decreased between 1992/93 and 1995/96, whereas for others the rates were stable or increased.

Interpretation: Risk-adjusted rates of in-hospital death after CABG vary widely across Canadian hospitals. There may be differences in quality of care across hospitals, and focused quality-improvement initiatives may be necessary in some institutions.

Résumé

Contexte : On a étudié, dans de nombreuses régions du Canada, les taux de mortalité à l'hôpital après un pontage aortocoronarien (PAC) comme indicateurs possibles de la qualité des soins spécifique à un hôpital. Dans le cadre de cette étude nationale, on a analysé les taux de mortalité observés et corrigés en fonction du risque dans 23 hôpitaux canadiens qui effectuent des PAC.

Méthodes : On a obtenu, de l'Institut canadien d'information sur la santé, des données sur les congés d'hôpital qui ont servi à repérer tous les PAC réalisés dans des hôpitaux du Canada au cours des exercices 1992/1993 à 1995/1996. On n'a pas étudié les cas du Québec parce que les hôpitaux de la province n'en font pas rapport à l'Institut. Les taux de mortalité observés ont été évalués, et un modèle de régression logistique a été utilisé afin de calculer, pour chaque hôpital, un taux de mortalité corrigé en fonction du risque pendant la période de 4 ans à l'étude. On a aussi analysé l'évolution dans le temps des taux de mortalité particuliers à un hôpital.

Résultats : On a étudié au total 50 357 cas de PAC, qui ont produit un taux global de mortalité de 3,6 %. Des comparaisons entre hôpitaux ont montré que la gravité moyenne de la maladie a varié considérablement entre les hôpitaux. En dépit de la correction en fonction du risque qui tient compte de cette gravité variable, les taux de mortalité corrigés ont varié considérablement entre les 23 hôpitaux, de 1,95 % à 5,76 % ($p < 0,001$ pour la différence entre les hôpitaux). Les taux de mortalité ont diminué dans certains hôpitaux entre 1992/1993 et 1995/1996, tandis qu'ils sont demeurés stables ou ont augmenté dans d'autres.

Interprétation : Les taux corrigés en fonction du risque de mortalité à l'hôpital après un PAC varient considérablement entre les hôpitaux du Canada. Il peut y avoir des différences au niveau de la qualité des soins entre les hôpitaux. Des initiatives axées sur l'amélioration de la qualité pourront s'imposer dans certains établissements.

In an earlier paper[1] we used Canada-wide hospital discharge data to study national and provincial trends in risk-adjusted rates of in-hospital death after coronary artery bypass grafting (CABG). The value of that Canada-wide study was that it provided a broad perspective on rates of death after CABG and allowed for interprovincial comparisons. Although comparisons of in-hospital death rates within provinces are informative and useful for promoting provincial quality-improvement programs,[2] comparisons of hospital-specific death rates in one province with those in other provinces may also be valuable.

In this paper we present hospital-level analyses from our Canada-wide study of rates of death after CABG. Specifically, we present observed and risk-adjusted in-hospital death rates. The rates were adjusted for potential differences in severity of illness across hospitals, to permit cautious inferences about quality of care in Canadian hospitals performing CABG.

Methods

Data source

Our method for identifying CABG cases was described in our earlier paper.[1] Briefly, we used hospital discharge abstract data from the Canadian Institute for Health Information to identify all CABG procedures performed in Canada, excluding Quebec, in fiscal years 1992/93 through 1995/96. Data from Quebec were not used in this study because the Canadian Institute for Health Information does not compile discharge data from that province. The CABG cases were identified by screening discharge abstracts for Canadian Classification of Procedures[3] codes 48.11 through 48.19. We included all CABG procedures performed in adults (aged 18 years or more) in 23 hospitals, which yielded a study population of 50 357 cases. The 23 hospitals studied were located in 8 provinces (CABG procedures are not performed in Prince Edward Island).

Definitions of study variables

The outcome variables of interest were observed and risk-adjusted rates of in-hospital death. In our risk-adjustment analysis we used logistic regression to adjust death rates for differences across hospitals in sociodemographic, comorbidity and condition-specific indicators of severity of illness.

The sociodemographic variables studied were age and sex. We identified a total of 17 comorbidity variables (e.g., chronic pulmonary disease, kidney disease) using the comorbidity coding scheme described by Deyo and colleagues.[4] The condition-specific variables studied were congestive heart failure, recent myocardial infarction, prior CABG, angioplasty on same admission, combined CABG and valve surgery, ventricular aneurysm and urgent admission status (i.e., urgent or emergent v. elective admission). The details of how each of these variables was defined have previously been described.[1]

Analysis

We used logistic regression to develop a risk-adjustment model, and CABG data from Massachusetts to validate the model, as described previously.[1] The main-effect risk variables in the risk-adjustment model were female sex, increasing age, urgent admission status, cerebrovascular disease, ventricular aneurysm, peripheral vascular disease, prior CABG, angioplasty on same admission, congestive heart failure, recent myocardial infarction, hemiplegia or paraplegia, combined CABG and valve surgery, chronic kidney disease, metastatic disease and moderate to severe liver disease. The model demonstrated very good predictive performance on validation testing, with excellent discrimination (c statistic 0.765) and goodness-of-fit (Hosmer–Lemeshow χ^2 10.3, $p = 0.24$).[1]

We used the model to calculate the predicted probability of in-hospital death for each patient who underwent CABG, based on the combination of clinical risk variables present in a given patient. We then calculated the average of these predicted probabilities of death for patients in each hospital to yield an expected death rate. We compared observed (O) and expected (E) death rates in each hospital and also calculated hospital-specific O/E ratios. To calculate risk-adjusted death rates, we then multiplied the hospital-specific O/E ratios by the overall death rate for the 4 years studied. In this paper we present the hospital-specific death rates in 3 different ways: a plot of expected against observed death rate for each hospital; a plot of the risk-adjusted death rate with 95% confidence intervals for each hospital; and an "improvement grid," in which the adjusted death rate for 1992/93 is plotted against the change in death rates between 1992/93 and 1995/96.

We tested the statistical significance of differences in risk-adjusted death rates between hospitals by examining increments in the –2 log likelihood χ^2 statistic when

dummy variables for hospitals were added to the logistic regression model used for risk adjustment. Confidence intervals around the adjusted death rates were derived by applying "propagation of errors"[5] (based on first-order Taylor series expansions) to provide an approximation to the variance of the adjusted rate based on the joint covariance structure of the basic quantities: observed, expected and Canada-wide death rates. The variance and covariances relating to the expected death rates were based on an asymptotic expansion of the expected rates in terms of the error in the variable estimates.

The study was reviewed and approved by the Research Ethics Board of the University of Calgary.

Results

The 23 hospitals studied performed a total of 50 357 CABG procedures between 1992/93 and 1995/96, with an overall Canada-wide death rate for that period of 3.6%. Hospital case volumes for the 4 years ranged from 861 (mean of 215 cases per year) to 6548 (mean of 1637 cases per year). The mean age of the patients was 63.3 years, and 22.9% of the patients were women. Admission status was urgent for 52.0% of the patients, and 10.0% of the cases involved both CABG and valve procedures. The other clinical characteristics of the patients (e.g., prevalence of coexisting illnesses) have been described previously.[1]

In Fig. 1 the expected death rate is plotted against the observed death rate for the 23 hospitals. The expected rate for each hospital was derived from our risk-adjustment model, which assigned higher expected death rates to hospitals that care for sicker patients. Hospitals positioned below the diagonal line in the figure had an observed death rate that was lower than the expected rate, whereas hospitals above the line had higher-than-expected death rates. The spread of hospitals along the *x*-axis of the figure indicates that severity of illness was variable across hospitals. Calculated expected death rates — a proxy for severity of illness — ranged from about 2.5% to over 5%.

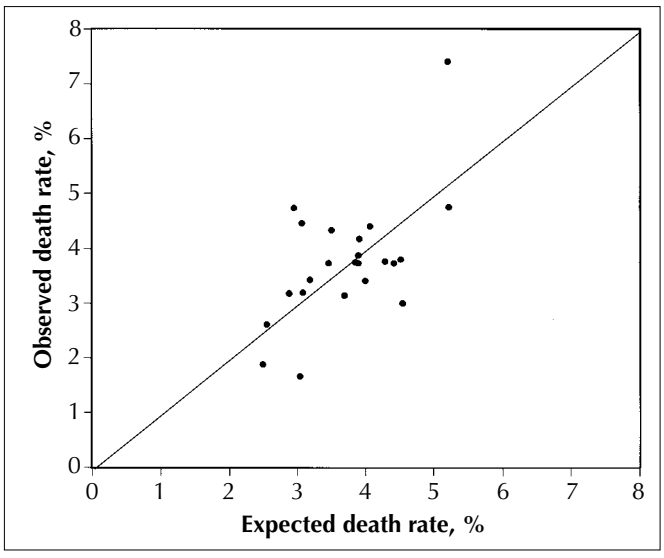

Fig. 1: Plot of expected against observed rates of death after coronary artery bypass grafting in fiscal years 1992/93 through 1995/96 for 23 hospitals in 8 Canadian provinces. Hospitals below the diagonal line had lower-than-expected death rates, and those above the line had higher-than-expected death rates.

Fig. 2 presents the risk-adjusted death rate for the 4-year period along with 95% confidence intervals for the 23 hospitals. Adjusted death rates varied considerably across hospitals, from 1.95% (hospital A) to 5.76% (hospital W) ($p < 0.001$ for the difference across hospitals). The risk-adjustment analysis that we performed accounts for measurable severity of illness in generating the risk-adjusted death rates in Fig. 2.

Adjusted rates of in-hospital death were not static between 1992/93 and 1995/96 (Table 1, Fig. 3). Some hospitals had significant decreases in adjusted mortality, whereas for others the rates did not change or even increased. Table 1 presents the risk-adjusted rates of in-hospital death by year for each of the 23 hospitals, providing a more complete description of the year-to-year changes in risk-adjusted rate of in-hospital death.

In Fig. 3 the adjusted death rate for 1992/93 is plotted

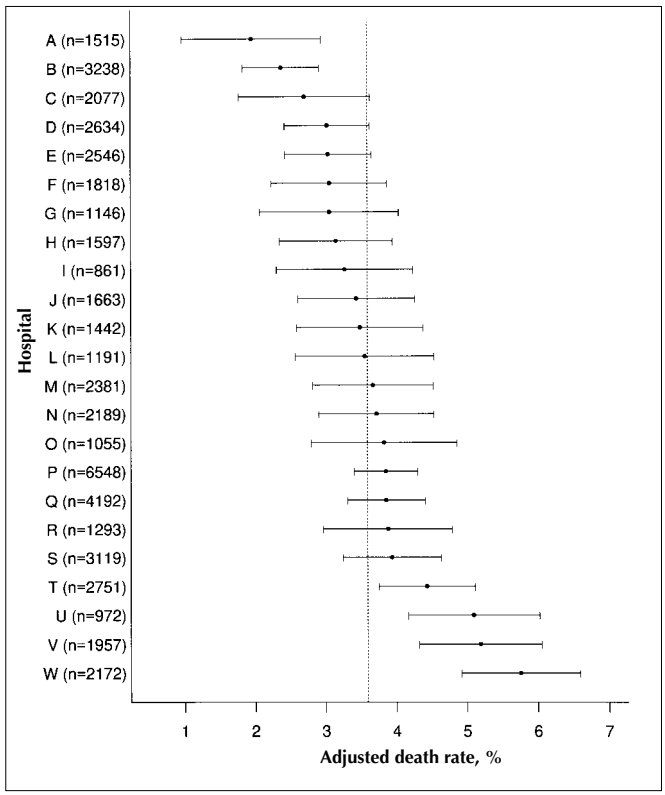

Fig. 2: Risk-adjusted death rate (with 95% confidence interval) over the study period for each hospital. Dashed line indicates mean for the 23 hospitals.

against the change in death rate between 1992/93 and 1995/96 for each of the 23 hospitals. The resulting graph allows the hospitals to be grouped into 1 of 4 "outcome categories." Quadrant A contains 7 hospitals that had relatively low death rates in 1992/93 but increasing rates in subsequent years. Quadrant B contains 3 hospitals that had relatively high death rates in 1992/93 and higher rates subsequently. Quadrant C contains 4 hospitals with relatively low death rates in 1992/93 and subsequent decline in those rates. Quadrant D contains 9 hospitals that had relatively high death rates in 1992/93 but decreasing rates in subsequent years. Such presentation of outcome data can be of value to CABG providers seeking to understand their hospital's outcome trends over time.

We explored the possibility of an association between case volume and outcome by comparing the adjusted death rates at the 5 hospitals with the lowest volumes with the rates at the 5 highest-volume hospitals. We found no significant difference in the mean risk-adjusted death rate (3.77% v. 3.63%) (p = 0.55). However, it is important to note that the lowest-volume hospital still performed an average of more than 200 CABG procedures per year.

Interpretation

Our finding of variable risk-adjusted rates of death after CABG across 23 hospitals raises the possibility of variable quality of care across Canadian hospitals performing this procedure. By adjusting hospital outcomes for baseline differences in severity of illness, we have attempted to isolate quality of care as the explanation for the "residual" variation in death rates across hospitals.[6]

However, it is difficult to attribute all the variation in adjusted death rates to quality alone, because the variation is probably explained by a combination of chance, unmeasured severity of illness and variable quality of care. Our statistical analyses indicated that chance alone does not explain the differences in death rates. It is difficult to determine the extent to which unmeasured severity of illness explains outcome differences across hospitals. This is particularly a concern in outcome studies that use administrative data based on the ninth revision of the International Classification of Diseases (ICD-9).[7] Such data are valuable because of their relatively low cost, broad coverage and reasonable clinical detail.[8] However, several investigators have raised concerns regarding the depth of clinical information in such data.[9–11] Of particular concern in studies of CABG outcome is the lack of refined clinical information on severity of coexisting conditions and on physiologic variables, such as left ventricular ejection fraction.[10,11]

In light of these concerns, we acknowledge that some — although probably not all — of the variation in adjusted death rates may be due to unmeasured severity of illness. For this reason, hospital-specific outcome rates need to be interpreted with caution. Reassuringly, Landon and associates[12] reported that adjusted rates (and rankings) of in-hospital death after CABG derived from administrative data are similar to those generated by more detailed clinical databases. In discussing the strengths and weaknesses of ICD-9 administrative data, Iezzoni[8] recently suggested that

Table 1: Risk-adjusted rates of in-hospital death after coronary artery bypass graft surgery in fiscal years 1992/93 through 1995/96 for 23 Canadian hospitals

	Year; risk-adjusted death rate, %				
Hospital	1992/93	1993/94	1994/95	1995/96	**Overall**
A	3.60	2.88	1.25	0.53	**1.95**
B	2.47	3.13	1.56	2.48	**2.37**
C	2.66	2.43	2.78	2.85	**2.70**
D	3.24	3.11	3.72	1.75	**3.02**
E	2.16	3.28	4.13	2.64	**3.03**
F	2.56	4.08	3.72	1.95	**3.05**
G	1.84	3.84	3.32	2.98	**3.05**
H	3.17	2.85	1.70	4.73	**3.15**
I	3.59	1.71	4.20	3.16	**3.27**
J	3.99	5.62	2.68	1.91	**3.43**
K	4.98	3.53	2.31	3.42	**3.49**
L	2.08	3.50	4.73	4.02	**3.55**
M	3.23	4.63	3.20	3.67	**3.67**
N	3.97	2.34	3.98	4.21	**3.72**
O	5.12	4.51	2.85	2.83	**3.82**
P	3.90	4.79	3.72	3.24	**3.85**
Q	5.02	3.84	4.12	2.64	**3.85**
R	4.22	4.49	3.11	3.85	**3.88**
S	5.36	4.19	2.64	3.72	**3.94**
T	5.27	4.58	4.31	3.69	**4.43**
U	7.96	4.83	5.19	3.32	**5.10**
V	3.90	7.63	3.96	5.69	**5.19**
W	4.85	6.44	6.04	5.51	**5.76**

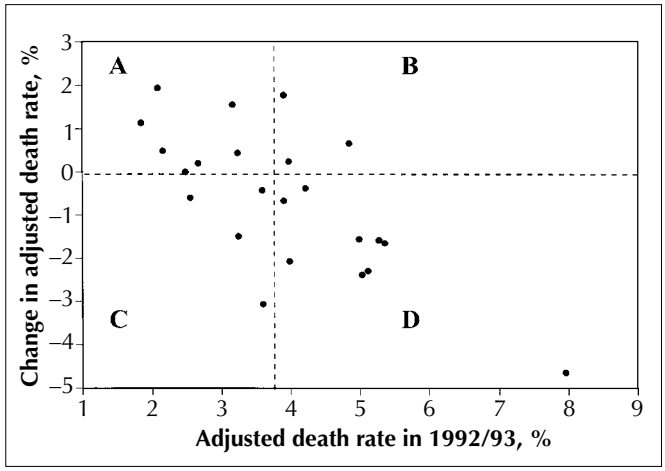

Fig. 3: Hospital outcome "improvement grid," with adjusted death rate for 1992/93 plotted against the change in adjusted death rates between 1992/93 and 1995/96 (see Results for interpretation).

such data are "a useful screening tool that highlights areas in which quality should be investigated in greater depth using detailed clinical information." As such, our Canada-wide data could be viewed by individual hospitals as a "screening indicator" of quality of care. Such information can then serve as a prompt for more detailed local quality assessments.

There has been considerable debate regarding the benefits and hazards of reporting hospital-specific or provider-specific outcomes of care.[13–16] On the positive side, regions with outcome reporting for CABG have seen impressive declines in risk-adjusted death rates, which some observers attribute to outcome reporting and the focused quality-improvement initiatives that have ensued.[16–18] On the negative side, concern has been expressed about the possibility of "patient skimming" — denying access to CABG for sicker patients because of concerns regarding mortality statistics.[14,15] Reassuringly, studies from regions with outcome reporting actually show no evidence of "skimming" and, in fact, suggest that the average severity of illness of patients undergoing CABG may be increasing.[17–19]

Some regions in the United States (e.g., New York State and Pennsylvania) have systems in place for public reporting of CABG outcomes by hospital and provider,[17,20] whereas other regions (e.g., Ontario and northern New England) have opted for confidential reporting of outcomes to hospitals and providers.[2,18] We favour the latter approach, for at least 2 reasons. First and foremost are the limitations of outcome "report cards" (particularly when derived from ICD-9 administrative data). Such reports should be viewed as preliminary and require verification with more detailed clinical data sources that focus on both outcomes and processes of care. A second argument for confidential reporting is that providers are less likely to respond defensively (and, in fact, may use the data in a positive manner to initiate quality-improvement activities) if the information is presented in a nonthreatening manner. Indeed, the public outcome-reporting programs in New York State and Pennsylvania have generated counterproductive anger and defensiveness among providers.[16,20]

Unlike studies from the US,[21,22] our study did not show an association between hospital case volumes and death rate. We suspect that this is because the lowest-volume hospitals in Canada still performed more than 200 CABG procedures per year (a consequence of the regionalization of tertiary care services in the Canadian health care system). Hospitals performing fewer than 100 procedures per year in the US collectively have very high risk-adjusted death rates.[22]

Using Canada-wide hospital discharge data, we have shown considerable variation in risk-adjusted rates of death after CABG across Canadian hospitals. Although some of this variation may be due to unmeasured severity of illness, we suspect that quality of care does vary across hospitals. We propose that providers in individual hospitals could benefit from examining their relative positions in the data figures in our study, to determine how their outcomes compare with those of other hospitals. Through increased attention to outcomes, the impetus for local quality-assessment and quality-improvement initiatives would increase, to the benefit of patients undergoing CABG in Canada.

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