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Early mortality following percutaneous coronary intervention and cardiac surgery: Correlations within providers and operators

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ABSTRACT

Background: It is not clear whether correlations exist within hospitals or operators among risk-adjusted mortality rates (RAMRs) for the most common cardiac interventions and how much of variations in outcomes are residually explained by providers and physicians. We examined these aspects by using recent national data on percutaneous coronary intervention (PCI) and cardiac surgery.

Methods: Publically available data from New York State aggregated at hospital and operator level were downloaded by Department of Health website for in-hospital/30-day mortality after PCI, coronary artery bypass graft (CABG) and valve surgery. Correlations between RAMRs were evaluated by using Spearman's coefficient (rho). The proportion of mortality variation attributed to hospitals and operators was estimated.

Results: During the period 2008–2013, 390 cardiologists from 63 hospitals and 163 surgeons from 41 centres were evaluated. The RAMRs during 2008–2010 correlated with the RAMRs during 2011–2013 for valve surgery within providers (rho = 0.55;$p < 0.001$) and within interventionists for PCI (rho = 0.21;$p < 0.001$), isolated CABG (rho = 0.25;$p = 0.009$), and any valve surgery or CABG procedure (rho = 0.49;$p < 0.001$). The most recent hospital's RAMRs (year 2012 and 2013) significantly correlated in PCI (rho = 0.40;$p = 0.002$) but not in CABG (rho = 0.13;$p = 0.413$). <2% of mortality variations was attributed to providers and 2–3% to difference between operators.

Conclusions: A correlation exists at provider and operator level in RAMRs for PCI and cardiac surgery procedures performed in New York State. Beyond patient's risk profile, that is the strongest predictor of early mortality after a cardiac procedure, hospitals and operators have a small but statistically significant contribution to variation in post-operative outcome.

1. Introduction

The measure of quality of care is an important focus for health care providers and policy makers [1,2]. Public reporting has been proposed as a strategy to improve health care quality also in the area of interventional cardiology and cardiac surgery [3,4]. The demand for high-quality care is increasing and public reports of hospital performance are available to patients. Government-mandated publication of named physician-specific outcome data, publically available for health care providers and patients who are considering surgical and non-surgical treatments, has been introduced to provide a significant advancement in health service transparency [5]. The evaluation of outcomes serves as incentive for the implementation of quality improvement initiatives aimed to reduce variation in risks rates across hospitals, surgeons, and clinicians [4,6].

Nonetheless cardiovascular procedures are one of the most intensely studied interventional sector, patients remain at risk for considerable morbidity and mortality. Short-term outcomes are used as indicators that reflect the quality of care provided to patients during and immediately after a cardiac procedure [7–10]. Most of the differences in early mortality may be explained by patients' risk profile but a residual unexplained variation remains [11–16]. Although several preoperative predictors of outcome have been identified and used in risk scores, hospital and surgeon factors may also contribute to variability in the performance measures. In particular, the medical practice is often influenced by training, local practice patterns, and possibility to use and be familial with novel techniques. In this setting, considering the changes over time in case-mix and the improvements in operative results, it may be useful estimate at national level the impact of hospitals and operators on mortality after a cardiac intervention and verify the degree of concordance

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in their risk-adjusted mortality rates. By using contemporary data from New York State on early mortality after PCI and cardiac surgery, the aim of this study was to assess 1) the correlations by hospitals and operators between consecutive risk adjusted rates from a national public reporting and 2) the proportion of outcome variations related to hospitals, cardiologists, and cardiac surgeons.

2. Methods

We analysed data from the New York State Department of Health that produces public reports on PCI treatment since 1995 and for cardiac surgery since 1992 (https://www.health.ny.gov/statistics/diseases/cardiovascular/). The most recent reports, including PCI and cardiac surgery performed during the period 2011–2013, were released in September 2016. The State of New York publishes data, datasets, information, content, files, documents, material on OPEN-NY website (https://data.ny.gov/) and gives access to information about New York for promoting the sharing, utilization, and reuse of Open Data (https://data.ny.gov/download/77gx-ii52/application/pdf). Data files were downloaded by the institutional website (https://health.data.ny.gov/) in aggregated form at hospital and operator level. The most recent available file for cardiac interventions (updated on December 13, 2016; accessed the last time on February 3, 2017) included hospital data for PCI and coronary artery bypass graft (CABG) on yearly basis (2010 to 2013) and valve surgery on three-year basis (valve surgery alone or valve surgery plus CABG for 2008–2010 and 2011–2013). Two files (updated on November 9, 2016; accessed the last time on February 3, 2017) were downloaded for cardiologists and surgeons with data on three-year basis (2008–2010 and 2011–2013) for PCI and cardiac surgery interventions (isolated CABG and any valve surgery or CABG procedure). Data were those used for the public reporting since 2008 to 2013. Each annual report included patients discharged up to November of each year by December of the year before with the exception of 2008 that included patients by January. Data were reported for each cardiologist and surgeon who performed 200 or more interventions during the last three-years or performed at least one procedure in each of the last three years. The following variables were extracted from datasets: hospital identification number, New York State physician license number, the type of procedures, the number of cases, the number of deaths, the expected mortality, the risk-adjusted mortality rate (RAMR) with 95% confidence interval (95%CI). The expected mortality was the sum of the predicted probabilities of death calculated by a multivariable logistic equation for mortality including patient' risk factors. The RAMR was obtained by multiplying the overall state-wide rate for crude rate divided by the expected value. The RAMR represents the estimate, based on the associated statistical model, of what the mortality rate would have been if the provider or operator had a mix of patients identical to the state-wide mix. The mortality definition was in-hospital/30-day: deaths occurring during the same hospital stay in which a patient underwent intervention or after hospital discharge but within 30 days from procedure date. The statistical models, based on logistic equations, are reported in the technical notes of the public reports. The predictive scores had a high discrimination in distinguish patients' outcome: the C-statistic was >0.85 for each PCI model and it was in the range from 0.75 to 0.80 for cardiac surgery.

2.1. Ethical considerations

For quality improvement in the areas of cardiac interventions, the Department of Health of New York State releases each year public data in aggregated form on mortality after PCI and cardiac surgery procedures. The research, based on data reported at provider and operator level, did not required informed consent and approval by local ethics committee.

3. Statistical analysis

Data are reported as median and interquartile range. The Spearman's rank correlation coefficient (rho) was used to test for concordance between pairs of values. To evaluate the effect on correlations of RAMRs estimated with a large random variation caused by small cases volume, a sensitivity analysis was performed after excluding those values with a 95%CI larger than 10%. Using a linear mixed regression model, the intra-class correlation coefficient (ICC) of the RAMRs was evaluated as measure of concordance within hospitals and operators. To estimate the proportion of mortality variation that can be attributed to hospitals and operators, we estimated the ICC by fitting a multilevel random-effects logistic regression model for death, clustering patients within providers and interventionists [17,18]. For each type of procedure, considering data grouped in the form of number of events and number of patients, we performed a mixed logistic model for binomial responses without covariates (unadjusted) and a model with the logit of expected mortality rate as offset (coefficient constrained to be 1 without re-estimation). Likelihood ratio test was used to test the significance of the random effects in comparison to ordinary model. To investigate the effects of physicians within hospitals, we also fitted a three-level model with patients by operators nested with centres. For this analysis, cardiologists and surgeons that in the study period operated in more hospitals were included only in the centre where they performed the highest number of procedures. The analyses were carried out using STATA software, version 14 (StataCorp, College Station, Texas). A p value of <0.05 was considered statistically significant.

4. Results

During the period 2008–2013, 390 cardiologists from 63 hospitals and 163 cardiac surgeons from 41 cardiac surgery centres were included. Table 1 shows data by providers and physicians. Volumes and mortality rates, for the range of interventions analysed, were variable at hospitals and operators level. Table 2 shows Spearman's rank correlation coefficient between volumes and between RAMRs. A strong correlation was observed between the numbers of procedures performed. On yearly basis from 2010 to 2013 at hospital level, consecutive RAMRs were concordant for PCI but not for isolated CABG (Table 2). The RAMRs during 2008–2010 correlated with the RAMRs during 2011–2013 for valve surgery within providers, PCI and cardiac surgery within operators (isolated CABG and any valve surgery or CABG procedure; Table 2). All correlations between pairs of RAMRs were confirmed after the exclusion of less reliable values (Table 2). Fig. 1 shows scatter plots of RAMRs in different periods by hospitals (panel A, B, and C) and operators (panel D, E, and F).

The RAMRs differed between hospitals and between operators for PCI (ICC of 0.266 and 0.191; both $p < 0.001$) and valve procedures (ICC of 0.578 and 0.714; both $p < 0.001$). Differences in RAMRs for CABG procedures were significant between surgeons (ICC of 0.855; $p < 0.001$) but not between hospitals (ICC of 0.034 with $p = 0.308$). Table 3 shows the proportion of mortality variation explained by hospitals and operators. The effect of providers and physicians was small but significant. The unadjusted models, that did not include patients' risk profile, showed a larger variability in outcome among hospitals and operators in comparison to models adjusted for expected mortality. The ICCs, based on data analysed in the same three-level model considering patients by operators within hospitals, confirmed a limited variation in outcome by providers and a slightly greater effect of operators in determining mortality within institutions (Table 3).

5. Discussion

In this study, including recent national data from public reporting aimed to assess the performance of hospitals and physicians after PCI or cardiac surgery intervention, we observed a significant correlation in consecutive adjusted mortality rates of institutions and operators. Moreover, we estimated the impact of providers and physicians on early mortality in large cohorts of patients underwent to PCI, CABG or valve surgery.

Aimed to improve the quality of care, public reporting of providers' performance have taken place in several countries. In USA, several states currently mandate reporting of PCI outcomes [3]. For individual cardiac surgeons, risk-adjusted mortality rate data are currently available for >25% of the population [5]. Nonetheless cardiac operations are among the most frequent interventional procedures performed, it is unclear whether performance measures of hospitals and operators may be correlated and used as indicators of outcome in different periods.

We used data from the New York State that has released PCI and cardiac surgery data to the public with robust methodology over the course of 20 years and has served as a model for current federal and professional association initiatives [4]. The annual report elaborated by the Department of Health includes the list of hospitals and operators with volumes and mortality rates. The analysis of period 2008–2013 showed a significant concordance between consecutive RAMRs by operator