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Comparative effectiveness and efficiency in peripheral vascular surgery

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Risk adjustment;
Adverse outcomes;
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Abstract

BACKGROUND: Elective peripheral vascular surgery provides quality outcomes that are of great benefit to patients, but have complications that result in severe morbidity and excessive costs.

METHODS: We studied elective carotid endarterectomy, aortofemoral bypass/aortic aneurysm repairs, and femoral-distal bypass surgeries among hospitals(N ≥ 20 cases) from 2002 to 2005 from the national Inpatient Sample of the Healthcare Cost and Utilization project. Adverse outcomes, mortality, and cost models were developed. Outlier hospitals were defined for excessive adverse outcomes ($P <$ .005) and excess cost ($P <$ .0005).

RESULTS: There were 43,700 carotid endarterectomy patients from 447 hospitals, 9,090 aortofemoral bypass/aortic aneurysm patients from 187 hospitals, and 14,453 femoral-distal bypass patients from 243 hospitals. Approximately 3% of hospitals were quality outliers, and 8% to 24% of hospitals were efficiency outliers by procedure.

CONCLUSIONS: Comparative effectiveness and efficiency modeling at the hospital level shows inefficiency and is responsible for 90% of excess costs. Overall reduced complication rates will further enhance cost reductions.

Comparative effectiveness research is proposed as a method for "generating evidence that compares treatments."[1] Traditionally, comparative effectiveness is the evaluation of different treatments used in the management of a disease or medical condition. This may include different drugs for a specific illness. It may be the comparison of different surgical options. It may compare a medical treatment and a surgical intervention. Many randomized clinical trials reported in the medical literature are studies for equivalency of drugs or interventions that may be underpowered for determination of large population differences or from which high-risk patients may have been excluded. In contrast, comparative effectiveness research attempts to use patient care databases to make determinations about which treatment is most cost effective in the context of real-world patient care. Comparative effectiveness as a concept hinges on the premise that changing a single variable within complex arrays of interventions makes a consistent difference in observed outcomes.

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In previous studies of elective total knee replacement[2] and elective colon resection,[3] we have adopted an alternative approach to comparative effectiveness and efficiency. Instead of examining the effect of specific drugs or surgical methods, we examined adverse surgical outcomes as objective measures of suboptimal performance among hospitals and then examined inefficiency among those hospitals that met quality standards. From these studies, reference hospitals were identified that met objective criteria for cost effectiveness. The analysis of optimally performing hospitals and then comparing them with suboptimal ones can support a systems approach to improving health care effectiveness and efficiency. Reference hospitals that meet quality and cost standards can serve as the basis for implementing episode-based, prospective payment initiatives.

Elective peripheral vascular surgery is a high-volume, high-cost area in which quality outcomes are of great benefit to patients, but complications of care may result in severe morbidity and excessive costs. Elective peripheral vascular surgery was one of the areas for study and improvement in the Surgical Infection Prevention Project and the Surgical Care Improvement Project.[4] High rates of tobacco use, suboptimal treatment of hypertension, epidemic hyperlipidemia and obesity, and aging of the population will ensure that the cost and quality of surgical interventions for occlusive peripheral vascular disease will remain important concerns for clinicians, patients, payers, and policy makers. We used a national sample to evaluate variations in the cost effectiveness of peripheral vascular surgical care.

Methods

We studied elective carotid endarterectomy, aortofemoral bypass/aortic aneurysm repair, and femoral-distal arterial bypass from 2002 to 2005 from the National Inpatient Sample of the Healthcare Cost and Utilization project. Only elective surgeries performed within 2 days of admission to hospitals with 20 cases or more for the study period were included in the analysis. Costs were derived from total billed charges and hospital-specific cost-to-charge ratios. Predicted costs were adjusted to regional wage indexes of the location. All analyses were performed using SAS software (version 9.1.3; SAS Institute, Cary, NC). Refinement of the final analytic database used a previously described screening process[5] to eliminate poor coding hospitals, so that only hospitals with accurate coding would be used to derive and standardize quality and cost models.

Each study patient for each surgical procedure was classified as routine (ie, good outcome) or as an adverse outcome (AO) case. An AO was defined as either a postoperative death or a postoperative length-of-stay (poLOS) outlier. The risk-adjusted poLOS outliers for each surgery were identified using a linear regression prediction model based on cases without coded complications. This linear regression model was designed with independent variables of clinical risk factors likely to be associated with increased poLOS, and included progressively increasing age and a panel of comorbid clinical conditions (eg, chronic renal failure, chronic lung disease, and so forth). Observed poLOS for patients without complications became the dependent variable in the linear model to define the predicted values to be used for the analysis of subsequent differences.

Modified Average Moving Range (XmR) control charts were used to identify outliers as described previously.[5] Predicted poLOS for each patient was multiplied by a constant to equalize total predicted values to observed poLOS for each hospital. Cases were temporally sequenced. The absolute difference of observed poLOS for each case was determined from its preceding case. The moving average of all absolute differences was determined, and the upper control limit was determined by multiplying the moving average by 2.66 to give the upper control limit of 3 σ. Cases exceeding the 3 σ threshold were considered outliers and were removed from the case sequence. Then, a new upper control limit was calculated and any new outliers were determined. The process was repeated until no outliers were obtained for the final control limit and all cases exceeding the final control limit were considered poLOS outliers.

Logistic regression models were developed to predict the probability of death and the probability of poLOS outliers for live discharges. Observed deaths and observed poLOS outliers for each hospital were compared with corresponding predicted values for each hospital after predicted rates were adjusted so that observed and predicted rates were equal for the entire study population.[2,3] A hospital was classified as having suboptimal quality if its observed AO rate exceeded its predicted rate by more than 2.56 standard deviations ($P < .005$). Hospitals with suboptimal quality were removed from the analytic database that subsequently was used to develop cost models.

Routine cases for each procedure were used to develop linear regression models with cost as the dependent variable and comorbid risk factors as the independent variables. Predicted costs were subtracted from observed costs after predicted costs were adjusted so that total observed and predicted costs were equal for the entire study population. A hospital was classified as inefficient if its average observed cost exceeded the predicted cost of 3.29 or more standard deviations ($P < .0005$).[2,3] Hospitals with suboptimal efficiency were removed from the analytic database so that remaining reference hospitals all met both quality and efficiency standards. The reference group for each surgery was used to recalibrate predictive models to define risk-adjusted targets for effective and efficient care for each procedure. After quality and cost parameters were indexed to only reference hospitals, the patient-level cost of AOs were evaluated.

Results

The comparative effectiveness of all hospitals for all surgeries studied is summarized in Table 1, and comparative