The financial impact of intraoperative adverse events in abdominal surgery

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Background. *Little evidence currently exists regarding the clinical or financial impact of intraoperative adverse events (iAEs). We sought to study the additional health care charges attributable to the occurrence of an iAE.*

Methods. *The administrative and ACS-NSQIP databases at our tertiary academic medical center were linked for all patients undergoing abdominal surgery (January 2007–October 2012). The ICD-9-CM-based Patient Safety Indicator "accidental puncture/laceration" was used to screen the linked database for potential iAEs. All iAEs were confirmed subsequently through standardized review of all flagged medical records. Multivariate analyses controlling for demographics, comorbidities/laboratory values, procedure type, and approach and complexity of surgery were performed to assess the increase in health care charges independently predicted by the occurrence of iAEs.*

Results. *Of 9,111 patients, 183 were confirmed to have iAEs. Patients in the iAE group had higher median total charges ($27,169 [IQR, 17,302–44,952] vs $13,312 [IQR, 8,586–22,012];* $P < .001$*), direct charges ($17,808 [IQR, 11,520–28,930] vs $8,738 [IQR, 5,686–14,227];* $P < .001$*) and indirect charges ($9,396 [IQR, 5,932–16,144] vs $4,568 [IQR, 2,887–7,824];* $P < .001$*) when compared with patients without iAEs. Multivariate analyses demonstrated that iAEs independently predict an increase in total hospitalization charges by 41% (95% CI, 30–52%;* $P < .001$*). Specifically, the direct, indirect, operating room, laboratory/radiology, and alimentation/medical therapy charges increased by 42, 39, 27, 54, and 48%, respectively (all* $P < .001$*).*

Conclusion. *In addition to the morbidity incurred by patients, the occurrence of an iAE is associated with major additional health care charges. In an era of value-based health care, understanding and preventing iAEs can lead to major cost savings alongside improvements in patient safety and surgical quality. (Surgery 2015;158:1382-8.)*

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THE COST OF HEALTH CARE is increasing in the United States and worldwide.[1] In the setting of constrained resources and an increased focus on patient safety, strategies aimed at improving the value of health care by improving quality while reducing cost are invaluable.[2,3] Complications of care are a major contributor to health care costs,[4] and postoperative complications or adverse events constitute a particularly costly subset of these events[5-7] with Medicare paying, on average, >$5,000 additional per patient to hospitals with a high rate of surgical complications compared with those with a low rate.[8]

Initiatives such as the National Surgical Quality Improvement Program (NSQIP) and subsequently the American College of Surgeons' (ACS)-NSQIP have reduced substantially the incidence of postoperative complications[9] and their associated costs.[10,11] For selected operative procedures, reducing ACS-NSQIP postoperative complication rates by 5% could result in $31 million per year in Medicare savings.[12]

Intraoperative adverse events (iAEs) are less well understood than postoperative adverse events, and

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their financial implications remain uncertain. We hypothesized that iAEs increase health care costs independently by requiring additional intraoperative resources to address them, triggering further care to monitor for or mitigate their effects postoperatively, and by potentially resulting in additional postoperative complications that prolong duration of stay, increasing costs further. In this study, we aimed to evaluate the independent effect of iAEs on total, direct, and indirect hospital charges, including charges resulting from additional intraoperative interventions, laboratory tests, radiological examinations, and medication or nutritional supplementation.

METHODS

Patient population. All ACS-NSQIP patients undergoing an abdominal operation under general anesthesia at our tertiary care academic medical center between January 2007 and October 2012 were included initially. The ACS-NSQIP methodology has been previously described and repeatedly validated.[13,14] In brief, predefined preoperative, intraoperative, and postoperative variables are collected systematically and prospectively by an independent nurse reviewer. Our institutional ACS-NSQIP database was then linked with its corresponding administrative and financial datasets. Patients with no available hospital charges data were excluded.

Definition and identification of iAEs. An "adverse event" was defined as "an injury caused by medical management rather than the underlying disease."[15] An iAE was defined as any inadvertent injury during the operation. We have previously described our 3-step methodology to identify and confirm the occurrence of iAEs[16,17]: we first linked our tertiary care academic medical center's institutional ACS-NSQIP database with its corresponding administrative database. The second step consisted of screening the linked database using the *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM)-based algorithm for the Agency for Healthcare Research and Quality 15th Patient Safety Indicator (PSI) to flag potential iAEs. PSI 15—Accidental Puncture or Laceration—was designed to screen administrative databases for technical injuries occurring during procedures, including but not limited to operative procedures. The positive predictive value of PSI 15 has been previously calculated to be between 85 and 91%.[18-20] The final step consisted of a systematic review of flagged medical records to confirm the occurrence of an iAE. Patients deemed to not have an iAE upon chart review were excluded.

Clinical variables and operative complexity. All ACS-NSQIP preoperative and intraoperative variables were included in the multivariable linear analysis models. As a proxy, operative complexity was assessed using each procedure's relative value unit (RVU; by the Centers for Medicare and Medicaid Services Resource Based Relative Value Scale) based on Current Procedural Terminology codes. The total RVU for each case was calculated as the sum of the RVUs of the individual procedures performed within that case. Despite their imperfections, RVUs have been shown previously to predict independently hospital costs[21] as well as intraoperative and postoperative complications.[22]

Financial variables. For this study, the linked ACS-NSQIP/administrative database was supplemented with patient-level hospital charges data from the internal accounting database. We used hospital charges, rather than costs. The financial variables included total charges as well as direct, indirect, operating room (OR), laboratory, radiology, nutrition, and medical therapy charges associated with each patient's admission.

Total charges equal the sum of variable direct, fixed direct, and indirect charges.[23] Direct charges reflect the value of health care resources associated with a particular interaction with the health care system (eg, a hospital admission to a surgical service), and may be variable (ie, vary with patient activity, such as medications, tests, consumable surgical equipment and supplies, and nursing expenses), or fixed (ie, do not vary with patient activity, such as large equipment, facilities, or salaries of office or administrative staff working within the patient's admitting service). Indirect charges represent hospital expenses that are not associated with either a patient or a hospital unit; they are associated with non–revenue-generating functions and allocated across clinical revenue-producing departments (eg, hospital-wide finance, information technology, and maintenance services).[23]

Statistical analysis. Statistical analyses were performed using SAS 9.3 (SAS Institute, Cary, NC). Categorical variables are presented as total counts and percentages, and continuous variables as median values and interquartile ranges (IQR), unless indicated otherwise. Chi-square tests were used to compare categorical variables and Mann–Whitney *U* tests were used to compare continuous variables between those with and without iAEs. Multivariable linear regression models were constructed to assess the independent impact of iAE(s) on total, direct, indirect, OR, laboratory, radiology, nutrition, and medical therapy charges after adjusting for demographics, preoperative comorbidities/laboratory