The Significance of Preoperative Impaired Sensorium on Surgical Outcomes in Nonemergent General Surgical Operations

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IMPORANCE With an aging population, preoperative assessment of the frail older adult requires evaluation beyond simply accounting for chronic diseases. Impaired cognition is a recognized characteristic of the frail older adult.

OBJECTIVE To examine the effect of preoperative impaired sensorium (IS) on general surgical outcomes.

DESIGN, SETTING, AND PARTICIPANTS Retrospective cohort study using data between January 2005 and December 2010 at academic and community hospitals participating in the American College of Surgeons National Surgical Quality Improvement Program. Patients undergoing nonemergent general surgical operations were studied. Multivariable logistic regression involving 45 preoperative patient-level risk factors and comorbidities was used to calculate the conditional probability of having IS. Patients having and not having preoperative IS were matched on their propensity scores using a 1:1 greedy matching technique. Propensity score matching resulted in almost all (n = 1765) patients with IS uniquely matching to a patient without IS, resulting in a cohort size of 3530. Complication rates between patients with and without IS were compared.

MAIN OUTCOMES AND MEASURES Rates of postoperative complications and death following nonemergent general surgical operations.

RESULTS In total, 294 037 patients were studied, of whom 1771 (0.6%) had preoperative IS. Patients with IS were older and had more significant preoperative risk factors and comorbidities. As a result, unadjusted analysis found that 22 of 23 postoperative complications were significantly more likely to occur in patients with IS. Within the matched cohort, rates of postoperative pneumonia, ventilator dependence, progressive renal insufficiency, urinary tract infection, stroke, venous thromboembolism, and postoperative death continued to be significantly (P < .05) elevated in patients with IS.

CONCLUSIONS AND RELEVANCE Impaired sensorium significantly increases postoperative morbidity and mortality independent of other preoperative risk factors and comorbidities following nonemergent general surgical operations. Incorporation of impaired cognitive function into routine preoperative risk assessment and decision making could be an important addition to traditional risk assessment strategies.

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Aging populations, with increased rates of comorbid conditions, will likely have higher rates of postoperative adverse events.\(^1\)\(^-\)\(^4\) Reducing postsurgical complications and death should be a priority to all practicing surgeons. To date, no single available risk assessment tool ideally predicts postsurgical complications, likely secondary to multiple unmeasured or unrecognized preoperative risk factors.

Few studies have attempted to identify risk factors for adverse postoperative outcomes besides the commonly recognized presence of chronic or acute comorbid conditions (eg, coronary artery disease or renal impairment). Quantification of frailty by assessment of cognition, function, and mobility has shown promise in the preoperative identification of older adults at high risk of adverse surgical outcomes.\(^5\)\(^-\)\(^9\) However, cognitive impairment is poorly studied in the surgical literature and to date is not part of any routinely performed preoperative risk assessment tool. As a result, little is known about the effects of preoperative impaired sensorium (IS) and postoperative outcomes.

Sensorium in the medical dictionary is defined as the state of an individual’s consciousness or mental awareness. Patients with IS develop acute mental status changes in the context of their current illness, and although they are acutely confused, they respond to verbal or tactile stimuli. While it is reasonable to assume that preoperative conditions accompanied by IS will lead to a higher rate of postsurgical complications and death, this relationship is largely unknown.

In this study, we used the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database. Our study examined the effect of the presence of preoperative IS on postoperative morbidity, mortality, and length of stay in patients undergoing major nonemergent general surgical operations.

### Methods

This study used a deidentified data set, and no institutional review board approval was needed. Similarly, no informed consent was obtained.

### Data Source

Data for this study were obtained from the ACS NSQIP. This database assesses preoperative risk factors, operative data, and 30-day postoperative outcomes for sampled patients undergoing major surgery at participating hospitals.\(^9\)

### Patients

The ACS NSQIP database was used to select patients who had major nonemergent general surgical operations between January 2005 and December 2010. Patients included in the analysis were identified by *Current Procedural Terminology* (CPT) codes used to select patients whose procedure warrants more than an overnight stay. Patients were excluded if their operation was coded as missing or as an emergency case (because emergent surgical operations are not discretionary) or if there was missing information for sex, age, or preoperative length of stay. Excluded from the analysis were all cases considered an emergency case by the ACS NSQIP user guide, defined as follows: “Yes if the surgeon and anesthesiologist report the case as emergent. An emergency case is usually performed as soon as possible and no later than 12 hours after the patient has been admitted to the hospital or after the onset of related preoperative symptomatology.”\(^10\) The CPT codes with an overall frequency of 10 or less in the matched cohort were also excluded.

### Table 1

<table>
<thead>
<tr>
<th>CPT Code</th>
<th>Description</th>
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### Definition of IS

The ACS NSQIP defines IS as follows: “...if the patient is acutely confused and/or delirious and responds to verbal and/or mild tactile stimulation. Patients are noted to have developed an impaired sensorium if they have mental status changes and/or delirium in the context of their current illness. Patients with chronic or long-standing mental status changes secondary to chronic mental illness or chronic dementing illnesses (ie, multi-infarct dementia, senile dementia of Alzheimer’s type) are not included. This assessment of the patient’s mental status is within 48 hours prior to the surgical procedure.”\(^11\) A study\(^11\) of the interrater reliability of the ACS NSQIP database found that the reporting of IS had greater than 97% interrater agreement between what was reported by the surgical clinical nurse reviewers at the participating sites and an independent auditor of the data.

### Definitions of Outcomes of Interest

Postoperative outcomes of interest were complications occurring within 30 days of the index operation, return to the operating room (OR) within 30 days, postsurgical length of stay, and 30-day mortality. Postoperative complications included 23 individual complications collected in the ACS NSQIP.

### Statistical Analysis

Missing observations for comorbidities and preoperative risk factors were assessed. Because it is assumed that values tend to be missing for patients without major adverse health issues, missing values for functional status were changed to “independent” and the remaining 28 comorbidities to “no.” A random normal imputation method was used to populate missing observations for 9 laboratory values and for total operative time. These random variables were generated to approximate a range of values typically seen in healthy individuals. The rationale for this approach was based on findings that missing preoperative laboratory values tend to occur more frequently in healthy patients.\(^12\) Missing observations for anesthesia technique were replaced with a randomly selected value. The preoperative laboratory variables had the most missing data, with rates ranging from 7% for hematocrit to 32% for serum albumin level. The nonlaboratory variables were complete, with missing rates of less than 0.01%.

Baseline patient characteristics were compared for the total cohort and for the 1:1 propensity-matched samples between patients with and without IS using standardized
differences.\textsuperscript{13,14} It is recommended that standardized differences rather than \textit{P} values from statistical tests (eg, \textit{χ}² test or \textit{t} test) should be used because of the large differences in sample sizes that often occur when comparing results from the total cohort vs the 1:1 propensity-matched samples and their resultant effects on \textit{P} values. A standardized difference of 0.1 or less is generally regarded as indicating a negligible difference in the mean or prevalence of a covariate between the 2 groups of interest. A logistic regression was performed using the entire nonemergent general surgical inpatient cohort to calculate the conditional probability of having IS using 45 covariates. A greedy matching technique was used to perform a 1:1 matching: one patient with IS was matched to one patient without IS according to the conditional probability values. For the outcome analyses of the total cohort of patients, \textit{χ}² test was used for categorical outcomes, and independent samples \textit{t} test was used for continuous outcomes comparing patients with and without IS. Patients were not matched on International Classification of Diseases, Ninth Revision (ICD-9), diagnosis codes because of the great variety of postoperative diagnoses (the highest frequency of ICD-9 code was only 4\% of the entire patient population).

All analyses were performed using statistical software (SAS, version 9.3; SAS Institute Inc). \textit{P} < .05 was considered statistically significant.

### Results

In total, 294 037 patients who underwent elective major general surgical operations between 2005 and 2010 were studied. Of these patients, 1771 (0.6\%) had preoperative IS. The top 10 most commonly performed general surgical operations and postprocedure ICD-9 codes among the 1:1 propensity-matched samples are listed in Table 2 and in eTable 1 in the Supplement. The top 10 operations and ICD-9 codes were well balanced between the IS and non-IS propensity-matched samples.
Characteristics of all patients with and without IS are summarized on the left in eTable 2 in the Supplement. The frequency of medical comorbidities or other risk factors was higher in the IS sample than in the non-IS sample for all 29 preoperative conditions collected in the database, with only chemotherapy and radiation therapy for malignancy and current smoker showing small differences (standardized difference, ≤0.10) between the 2 groups. Patients with IS were older (mean age, 67.3 vs 57.5 years) and were less likely to be independent in their activities of daily living (26.7% vs 93.4%). Patients with IS were more likely to have abnormal preoperative laboratory values for all 9 laboratory tests performed. Patients with IS spent more time in the hospital before surgery (9.8 vs 1.4 days) and had shorter operative time (100.6 vs 133.6 minutes) but had operations of equivalent mean complexity (mean work relative value units, 17.8 for both groups). The mean (SD) standardized difference exceeded 0.10 (functional status, with a standardized difference of 0.132). The mean (SD) standardized difference for the 45 variables was 0.0320 (0.0265). While patients were not matched on the presence or absence of ventilator dependence in the 48 hours before surgery, 11.8% of patients with IS had ventilator dependence compared with 10.3% of patients without IS following 1:1 matching as described above.

The incidence of postoperative complications by type of complication is summarized in Table 3. For the total cohort of unmatched patients (on the left in Table 3), almost all postoperative complications had a higher rate among the patients with IS than among the patients without IS. The exceptions were graft, prosthesis, or flap failure, for which there was no difference, and superficial surgical site infection, which was higher in the non-IS sample. Rates of return to the OR, mortality, and postoperative length of stay were higher among the IS sample. These differences were statistically significant (P < .001).

Following 1:1 propensity score matching, surgical site infection was less likely in patients without IS (4.9% vs 3.5%, P = .04), but pneumonia (9.2% vs 11.9%, P = .01), ventilator dependence (20.8% vs 28.5%, P < .001), progressive renal insufficiency (1.1% vs 2.2%, P = .009), urinary tract infection (6.5% vs 8.4%, P = .04), stroke or cerebrovascular accident with neurologic deficit (0.6% vs 1.5%, P = .005), and deep vein thrombosis or thrombophlebitis (2.7% vs 4.3%, P = .009) were all significantly more likely to occur in patients with IS (on the right in Table 3). Patients with IS also had a statistically significantly higher chance of dying within 30 days of the operative intervention (14.9% vs 20.4%, P < .001).

### Discussion

The data herein represent complication rates and short-term outcomes of nonemergent general surgical operations in a large patient sample with IS as defined by the ACS NSQIP data set. Patients with IS had significantly more baseline comorbidities, including sex, age, race/ethnicity, 29 comorbidities or preoperative risk factors, the percentage of patients with abnormal preoperative laboratory test results, preoperative length of stay, and operative time, were well balanced between the IS and non-IS samples. Only 1 of 45 variables (2.2%) had a standardized difference exceeding 0.10 (functional status, with a standardized difference of 0.132). The mean (SD) standardized difference for the 45 variables was 0.0320 (0.0265). While patients were not matched on the presence or absence of ventilator dependence in the 48 hours before surgery, 11.8% of patients with IS had ventilator dependence compared with 10.3% of patients without IS following 1:1 matching as described above.

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The combined higher incidence of these adverse events, chronic organic brain impairments (psychiatric or dementia) reflect alterations in neurotransmitters, which predispose patients to postoperative brain dysfunction or delirium. Patients with IS are more likely to require urinary catheterization, resulting in higher rates of urinary tract infection. The combined higher incidence of these adverse postoperative events could lead to increased risk of postoperative mortality.

The preoperative variable of IS used in this study is unique to the ACS NSQIP data set. Delirium is the closest clinical variable able to describe IS. Delirium is defined as an acute change or fluctuation in mental status, disorganized thinking, and attention or an altered level of consciousness. Gerontologists have developed validated medical record review methods to diagnose hospitalized patients with delirium that search for keywords in the medical record such as disorientation, inattention, agitation, and mental status change. This validated clinical medical record review strategy is similar to the methods described to quantify IS in the ACS NSQIP data set. Delirium is a common and deleterious complication in postoperative older adults. The presence of delirium in the preoperative and postoperative settings is related to increased complications, longer length of stay, and 30-day and 6-month mortality. To date, minimal literature addresses the presence of acute preoperative brain dysfunction on postoperative outcomes.

Psychiatric diagnosis in general is a risk factor for postoperative adverse events. Chronic organic brain impairments (psychiatric or dementia) reflect alterations in neurotransmitters, which predispose patients to postoperative brain dysfunction or delirium. Patients with IS may also have developed

### Table 3. Postoperative Complications by IS Status for General Nonemergent Inpatient Procedures Among 294 037 Patients in the Total Cohort and 3530 Patients in the Matched Samples

<table>
<thead>
<tr>
<th>Postoperative Complication</th>
<th>Total Cohort, No. (%)</th>
<th>Matched Samples, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-IS (n = 292 266)</td>
<td>IS (n = 1771)</td>
</tr>
<tr>
<td>Superficial SSI</td>
<td>13 735 (4.7)</td>
<td>62 (3.5)</td>
</tr>
<tr>
<td>Deep incisional SSI</td>
<td>3411 (1.2)</td>
<td>36 (2.0)</td>
</tr>
<tr>
<td>Organ-space SSI</td>
<td>7185 (2.5)</td>
<td>69 (3.9)</td>
</tr>
<tr>
<td>Wound disruption</td>
<td>2645 (0.9)</td>
<td>37 (2.1)</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>6313 (2.2)</td>
<td>211 (11.9)</td>
</tr>
<tr>
<td>Unplanned intubation</td>
<td>5383 (1.8)</td>
<td>173 (9.8)</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>1497 (0.5)</td>
<td>24 (1.4)</td>
</tr>
<tr>
<td>Ventilator dependence</td>
<td>6655 (2.3)</td>
<td>505 (28.5)</td>
</tr>
<tr>
<td>Progressive renal insufficiency</td>
<td>1488 (0.5)</td>
<td>38 (2.1)</td>
</tr>
<tr>
<td>Acute renal failure</td>
<td>1403 (0.5)</td>
<td>65 (3.7)</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>7240 (2.5)</td>
<td>149 (8.4)</td>
</tr>
<tr>
<td>Stroke or cerebrovascular accident with neurologic deficit</td>
<td>569 (0.2)</td>
<td>27 (1.5)</td>
</tr>
<tr>
<td>Coma &gt;24 h</td>
<td>217 (0.1)</td>
<td>21 (1.2)</td>
</tr>
<tr>
<td>Cardiac arrest requiring CPR</td>
<td>1270 (0.4)</td>
<td>60 (3.4)</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>961 (0.3)</td>
<td>19 (1.1)</td>
</tr>
<tr>
<td>Bleeding transfusion</td>
<td>5345 (1.8)</td>
<td>110 (6.2)</td>
</tr>
<tr>
<td>Graft, prosthesis, or flap failure</td>
<td>292 (0.1)</td>
<td>1 (0.1)</td>
</tr>
<tr>
<td>Deep vein thrombosis or thrombophlebitis</td>
<td>2906 (1.0)</td>
<td>76 (4.3)</td>
</tr>
<tr>
<td>Sepsis</td>
<td>9900 (3.4)</td>
<td>178 (10.1)</td>
</tr>
<tr>
<td>Septic shock</td>
<td>4567 (1.6)</td>
<td>179 (10.1)</td>
</tr>
<tr>
<td>Return to OR</td>
<td>15 619 (5.3)</td>
<td>347 (19.6)</td>
</tr>
<tr>
<td>Death within 30 d of operation</td>
<td>4798 (1.6)</td>
<td>36 (2.0)</td>
</tr>
</tbody>
</table>

Abbreviations: CPR, cardiopulmonary resuscitation; IS, impaired sensorium; OR, operating room; SSI, surgical site infection.

- The mean (SD) overall lengths of stay in the total cohort were 6.5 (10.6) days for patients without IS and 21.8 (22.5) days for patients with IS (P < .001). The mean (SD) overall lengths of stay in the matched samples were 20.6 (30.3) days for patients without IS and 21.8 (22.6) days for patients with IS (P = .17).
- McNemar χ² test of association for categorical covariates and t test for continuous outcomes.
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mental status changes in the context of their surgical illness. The underlying surgical or medical problems could have contributed to the change in preoperative mental status. As a result, IS may also be a marker of decreased reserve to tolerate the underlying disease process, reflecting a more frail state, which can lead to increased risk of postoperative complications and mortality.

The preoperative IS variable is likely distinct from the clinical entity of impaired cognition or dementia. Dementia represents a chronic global loss of cognitive or brain function and phenotypically manifests as the loss of memory, executive function, and attention. In contrast, IS (similar to delirium) is acute in onset and fluctuates over short periods. Impaired sen- sorium by its definition is an acute dysfunction of the brain. In contrast, dementia represents chronic cognitive impairment. Dementia in older adults is related to an increased incidence of adverse health care events, including morbidity (pneumonia, febrile episodes, and feeding problems), as well as high 6-month mortality. Determining the contribution of a possible acute mental status change in addition to a chronic brain dysfunction can be almost impossible, especially under the circumstances of an emergent operation. Selecting elective surgical procedures should help delineate the individual contributions of acute vs chronic mental impairment to preoperative changes in mental status.

A prospective study by our group of postoperative complications in patients with preoperative cognitive dysfunction enrolled 168 individuals (mean age, 73 years) undergoing major elective operations in general, cardiothoracic, urologic, or vascular surgery. Forty-four percent of these patients had impaired cognition at baseline before surgery. The impaired cognition group (assessed by preoperative Mini-Cog test) had a higher incidence of 1 or more postoperative complications (eg, deep vein thrombosis, sepsis, and respiratory, renal, and infectious complications), a longer hospital stay, a higher readmission rate, and greater 6-month mortality. Impaired cognition continued to be a significant predictor of adverse postoperative events in multivariable analysis.

Major differences exist between these 2 studies performed by our group. The earlier one is a prospective study of mostly elderly individuals with a high incidence of chronically impaired cognition (dementia or acquired dysfunction in ≥2 domains of intellectual capacity), which was preoperatively determined by trained health care providers using an objective measure of cognition (the Mini-Cog test). The present data are from a large population-based study in which the IS variable was collected using the ACS NSQIP data set. By definition, patients in the present study had developed acute confusion in the context of their current illness unrelated to chronic mental illness or delirium. We believe that differentiating underlying reasons that lead to altered levels of preoperative consciousness may be more difficult than it appears. The present study may have included patients with acute (delirium) or chronic (dementia) mental status changes despite clear definitions of enrollment criteria and intentions not to mix the acute changes with chronic existing conditions. Despite marked differences in the methods and study populations, the outcomes of these 2 studies are similar. Patients with both acute and chronic mental status changes had a significant number of comorbidities at baseline, increasing the risk of postoperative adverse events.

Our study has several limitations. We used the definition of IS as defined in the ACS NSQIP user guide; categorizing patients into IS or non-IS groups was done by medical record abstracting and not by personal interviews. Delineating acute and chronic mental status changes can be a difficult task, even after personal interview of the patients. Similarly, measuring disease severity in the ACS NSQIP data set can be equally challenging. As a result, there is a small chance that IS in our study is a marker of disease severity as opposed to being a stand-alone geriatric syndrome. Some of these patients may have developed IS secondary to confusion as a marker of an early sign of sepsis in middle-aged and elderly individuals. Despite limiting our analysis to nonemergent operations, several procedures in this study can be categorized as semiurgent (eg, appendectomy, cholecystectomy). Furthermore, more than 10% of our cohort were ventilator dependent before surgery and were unlikely undergoing elective surgery. On the other hand, the fact that the IS sample spent almost 9 days on average in the hospital before surgery may indicate that most of these operations were truly nonemergent. It could also reflect a delay in diagnosing a surgical condition needing an earlier operation. Last, patient matching was done on total operative time and work relative value units but not on postprocedure ICD-9 codes for diagnosis. Similar operations (eg, colectomies) may have been performed for different disease processes carrying various risk of additional contribution to IS (eg, possible low-grade preoperative sepsis related to diverticulitis). Nevertheless, IS as defined in this study was still likely a combination of long preoperative hospital stay in a patient population with significantly decreased functional status, underlying medical and surgical diseases, and inherent difficulty of differentiating acute mental changes from chronic states, such as dementia.

Conclusions

In summary, general surgery patients with IS in ACS NSQIP hospitals have elevated risk of postoperative complications (pneumonia, ventilator dependence, urinary tract infection, progressive renal insufficiency, deep vein thrombosis, and stroke) and higher death rates than patients without IS, even after propensity score matching. While IS may develop in part owing to an underlying disease process, we believe it can also serve as a mediator of certain postoperative adverse events. The risk of some of these adverse events may be decreased via more aggressive postoperative interventions, including more intense pulmonary toilet and mobility, which can potentially translate into decreased postoperative morbidity, mortality rates, and length of stay. Based on our study, IS alone is an important predictor of adverse postoperative events in the general surgical population. New geriatric assessment tools should incorporate acute and chronic mental status changes to better risk-stratify elderly individuals before surgery.


