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A Preoperative Cognitive Screening Test Predicts Increased Length of Stay in a Frail Population: A Retrospective Case–Control Study

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Abstract

[Further content provided as per the original document]
BACKGROUND: Frailty is associated with adverse perioperative outcomes including major morbidity, mortality, and increased length of stay. We sought to elucidate the role that a preoperatively assessed Mini-Cog can play in assessing the risk of adverse perioperative outcomes in a population at high risk of frailty.

METHODS: In this retrospective case–control study, patients who were >60 years of age, nonambulatory, or had >5 documented medications were preoperatively assessed for handgrip strength, walking speed, and Mini-Cog score. The Emory University Clinical Data Warehouse was then used to extract this information and other perioperative data elements and outcomes data.

RESULTS: Data were available for 1132 patients undergoing a wide variety of surgical procedures. For the subset of 747 patients with data for observed-to-expected length of stay, an abnormal Mini-Cog was associated with an increased odds of observed-to-expected >1 (odds ratio, 1.52; 95% CI, 1.05–2.19; P = .025). There was no association of abnormal Mini-Cog with intensive care unit length of stay >3 days (P = .182) discharge to home with self-care (P = .873) or risk of readmission (P = .104). Decreased baseline hemoglobin was associated with increased risk of 2 of the 4 outcomes studied.

CONCLUSIONS: In a high-risk pool of patients, Mini-Cog may not be sensitive enough to detect significant differences for most adverse outcomes. Further work is needed to assess whether cognitive screens with greater resolution are of value in this context and to compare tools for assessing overall frailty status.

In the United States, the percentage of the population >65 years of age has been increasing rapidly since 2011, when the oldest baby boomers turned 65. Concomitantly, surgical practice patterns have evolved to prioritize the maximization of disease management over the potential risks of surgery in the elderly. The large and increasing proportion of surgical procedures performed on this aging population of patients has made it incumbent on the anesthetic and surgical community to improve risk stratification. Therefore, we continue to seek additional factors that may predict a patient’s perioperative risk for major adverse events. Frailty, in particular, has become an area of increased interest. There is no universal definition of frailty because assessments of frailty range from the very simple (number of outpatient medications) to the relatively complex (scored clock-drawing test). There is consensus that frailty, as measured by any number of these metrics, is associated with adverse perioperative outcomes including major morbidity, mortality, and increased length of stay. Recent work has focused on differentiating the roles that physical deconditioning and cognitive impairment play in predicting adverse events and suggests that cognitive impairment may play a significant role in risk stratification, though the evidence is mixed.

In the present work, we sought to further elucidate the role that a well-established cognitive screening tool, the Mini-Cog, can play in assessing the risk of adverse perioperative outcomes in a high-risk population. The Mini-Cog is a well-established dementia screening tool that consists of clock drawing and 3-word recall, with a sensitivity of 76%–99% and a specificity of 89%–96% for identifying dementia in the primary care setting. High risk of frailty was defined as taking >5 medications or >60 years of age or nonambulatory. We hypothesized that there would be significant differences in the primary outcome of observed-
to-expected length of stay and secondary outcomes including intensive care unit length of stay, readmission, and discharge disposition based on Mini-Cog performance.

**METHODS**

Ethical approval from the Emory University Institutional Review Board (IRB00099566) was obtained before data acquisition and analysis. This manuscript was prepared in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology checklist for the improved reporting of observational studies.11

**Design**

This was retrospective case–control study that used a convenience sampling method.

**Inclusion/Exclusion Criteria**

Inclusion criteria were patients who were >60 years of age or had >5 prescribed medications or were nonambulatory presenting for elective noncardiac surgical procedures performed under general anesthesia from May 27, 2015, to November 28, 2016, at Emory University Hospital (Clifton campus or Midtown campus, Atlanta, GA) who were evaluated in the Anesthesia Preoperative Clinic and admitted postoperatively.

**Data Collection**

Patients coming to the Anesthesia Preoperative Clinic at both campuses were screened and assessed by 2 study team members (S.H. and P.D.). Assessors were not present or available daily; data were collected on an ad hoc basis on days that the study team was present in the Anesthesia Preoperative Clinic for data collection. Patients who were >60 years of age, nonambulatory, or had >5 documented medications were assessed further for markers of frailty. A small number of patients were screened and assessed more than once due to multiple visits to the Anesthesia Preoperative Clinic. Some patients also had >1 procedure performed after assessment; for these patients, the surgery with the highest complexity as measured by the American Society of Anesthesiologists (ASA) Relative Value Guide base units was used in the analysis.

Handgrip strength measurements were taken with a Jamar hand-held hydraulic dynamometer (Sammons Preston Rolyan, Bolingbrook, IL) using a protocolized instruction set and measured only by these 2 assessors. The Mini-Cog assessment was administered per the protocol developed by the Alzheimer’s Association (Chicago, IL)9 and scored as follows: 0 or 2 points depending on the accuracy of the clock draw, and 1 point for each recalled word. Clock draw was scored as abnormal if ≥1 of 6 protocolized errors were noted after standard instructions were given.12 Walking speed was also measured as a single trial of a fixed 5 m span hand-timed via stopwatch. These items were recorded in the patient’s electronic medical record. Also recorded were measures of perioperative risk used in the American College of Surgeons–National Surgical Quality Improvement Program risk calculator.

The Emory University Clinical Data Warehouse was then queried on a retrospective basis to count the number of patients who were seen in the Anesthesia Preoperative Clinic, the
number of patients meeting age or prescription screening criteria, and the number of patients for whom frailty data were recorded. Additional information was extracted retrospectively for outcomes and independent variables as outlined below.

**Primary and Secondary Outcomes**

The primary outcome was based on the ratio of observed-to-expected length of stay. The expected length of stay was calculated by Vizient (Vizient Inc, Irving, TX) using a multivariable model specifically developed for each admission diagnosis-related group code. These expected lengths of stay are part of a package of metrics obtained by Emory Healthcare for operations, quality, and research purposes. Vizient ratio of observed-to-expected length of stay was then binomially categorized as above expected (>1.0) or below expected (≤1.0).

Secondary outcomes included intensive care unit length of stay for patients admitted to an intensive care unit at any point during their encounter. Intensive care unit length of stay was binomially categorized using 2 cutoffs: 3 or 7 days. Other secondary outcomes included readmission to any Emory Healthcare system hospital within 30 days of discharge (readmissions) and discharge disposition comparing home/self-care to all other discharge dispositions (discharge disposition). The number of patients with 30-day mortality was very low, preventing meaningful analysis.

**Exposure Independent Variable**

The independent variable of interest in this study was the preoperatively assessed Mini-Cog, using a score of ≤2 as the criteria for an abnormal result. This corresponds to either an abnormal clock draw, failure to recall ≥2 words, or both. A cutoff of 3 has also been used; a sensitivity analysis using this cutoff did not materially affect the findings (not shown).

**Other Independent Variables**

Other independent variables used in the analysis were age, gender, height, weight, outpatient prescription count >5, hemoglobin within 60 days of procedure, grip strength, walking speed, ASA physical status score, surgical case complexity as measured by the ASA-Relative Value Guide, and surgical case length. Surgical case length was defined as the span of time between surgery start and surgery stop, as recorded in the patient record by intraoperative staff. Some numeric variables (weight and surgical case length) were scaled (log-normalized) to aid in linear regression analysis. Grip strength was binomially categorized as frail or not frail on the basis of previously published cutoffs based on gender and body mass index. Walking speed was binomially categorized as frail or not frail on the basis of the previously published cutoff of 0.9 m/s.

**Univariable Statistical Methods**

Statistical analysis was performed in R v3.3.2 (R Core Team, Vienna, Austria) using the RStudio platform v1.1.423 (R Studio Team, Boston, MA). Demographic characteristics were compared, between those with an abnormal Mini-Cog and those with normal Mini-Cog, using \( \chi^2 \) for surgical specialty; Wilcoxon rank-sum test for age, body mass index, surgical case length, and hemoglobin; and Fisher exact test for gender, >5 prescriptions, grip
strength, walking speed, ASA physical status score, Vizient ratio of observed-to-expected length of stay >1, intensive care unit length of stay at both cutoffs, intensive care unit admissions, readmissions, and discharges to home with self-care. Normality was assessed via visual assessment of normalized quantile–quantile plots and, in borderline cases, using a Shapiro–Wilk test.

### Multivariable Statistical Methods

Multivariable logistic regression was performed to examine the association between the same independent variables and the following 5 dependent variables: (1) readmissions; (2) discharge disposition; (3) categorized Vizient ratio of observed-to-expected length of stay; (4) categorized intensive care unit length of stay (3-day cutoff); and (5) categorized intensive care unit length of stay (7-day cutoff). Initial regression analyses included all independent variables. Backwards model selection was then performed for each of the models, removing variables, one at a time, failing to contribute significantly to the explanatory power of the model, as signified by $P$ value above $\alpha_{\text{crit}} = .2$. For the intensive care unit length of stay (7-day cutoff), Hosmer–Lemeshow testing indicated that removal of walking speed, although above $\alpha_{\text{crit}}$ the prespecified $\alpha_{\text{crit}}$, resulted in evidence of poor model fit; therefore, this variable was retained in the final model. For categorical variables with >2 factors, $P$ values were reported for the overall variable using a Wald-type test.

### Sample Size/Power

Power analysis revealed that to detect a 40% difference in such heterogeneous data (estimated SD as 50% of mean), 199 charts would need to be examined (for a CI of 95% with $\beta = .8$). However, as noted, this is a retrospective study of data collected using convenience sampling from May 27, 2015, to November 28, 2016. No specific sample size was targeted.

### RESULTS

Demographic information for the complete cohort of cases used in the analysis is shown in the Table, and a flow diagram outlining exclusions is shown in Figure 1. Data from 1132 patients were analyzed in the multiple variable regressions analyzing readmissions and discharge disposition. Only 747 patients from this sample had data available related to Vizient expected length of stay. Only 157 patients were admitted to the intensive care unit. As seen in the Table, there were significant differences in underlying patient characteristics between those who had abnormal versus normal Mini-Cog results. Patients with abnormal Mini-Cog were slightly older, with lower grip strength, slower walking speed, and slightly lower baseline hemoglobin values. These patients were assigned higher ASA physical status scores, and while surgical cases in these patients were shorter, there were no significant differences in any of the outcomes of interest on a single variable basis.

### Primary Outcome

For the primary outcome of the Vizient ratio of observed-to-expected length of stay, 207 of 572 patients (36.2%) with normal Mini-Cog stayed longer than expected (ratio of observed-to-expected length of stay >1) versus 76 of 175 patients (41.7%) with an abnormal Mini-
After adjusting for other variables presented in Figure 2A, the most parsimonious multiple variable logistic regression model demonstrated that there was an independent association between abnormal Mini-Cog score and increased observed-to-expected length of stay (Figure 2A; odds ratio, 1.52 [95% CI, 1.05–2.19]; $P = .025$). Other predictors of increased ratio of observed-to-expected length of stay in length of stay included increasing surgical case complexity (ASA-Relative Value Guide base units, $P = .042$) and increasing surgical case length ($P < .001$).

Secondary Outcomes

On multivariable logistic regression, there was no evidence for an association of abnormal Mini-Cog with readmission (Figure 2B; $P = .104$) nor was there association of abnormal Mini-Cog with odds of discharge to home with self-care (Figure 2C; $P = .873$). As seen in Figure 2B, the significant factors associated with readmission were preoperative hemoglobin ($P = .006$), increasing surgical case length ($P < .001$), and surgical specialty ($P = .020$ for the overall variable). Figure 2C demonstrates that the significant factors associated with discharge to home with self-care were younger age ($P < .001$), male gender ($P = .029$), increased baseline hemoglobin ($P = .003$), lower ASA physical status score ($P < .001$ for the overall variable), decreasing surgical case complexity ($P < .001$) and length ($P < .001$), and surgical specialty ($P < .001$).

For the secondary outcome of intensive care unit length of stay among those admitted to the intensive care unit, there was no significant association between abnormal Mini-Cog and intensive care unit length of stay using a 3-day cutoff for binomial categorization (Figure 3A); however, using a cutoff of 7 days, there appeared to be an association of abnormal Mini-Cog with a reduced odds of intensive care unit admission >7 days (Figure 3B).

DISCUSSION

In this study, the Mini-Cog assessment was explored as a marker for cognitive frailty and, thus, of adverse perioperative outcomes in high-risk surgical patients. This was a single-center, retrospective, case–control study, examining a pragmatic sample of surgical case types. High-risk patients were defined as patients >60 years of age, prescribed ≥5 medications, or those who were nonambulatory. In the studied population of patients at high risk of frailty, there was significant independent association between abnormal preoperative Mini-Cog status for the primary outcome of observed-to-expected length of stay, as assessed via multiple variable logistic regression. There was no significant association of abnormal preoperative Mini-Cog status with intensive care unit length of stay (comparing those admitted for >3 days versus those admitted for <3 days), discharge to home with self-care, or risk of readmission. The finding of reduced odds of intensive care unit admission >7 days associated with abnormal Mini-Cog is interesting and may be driven by several factors: (1) spurious result due to small number of events; (2) unmeasured confounding differences between populations admitted to the intensive care unit with normal versus abnormal Mini-Cog; (3) closer attention paid to those at highest risk for cognitive frailty; and (4) other causes for termination of intensive care unit–level care besides safe discharge to a lower level of care (viz mortality, hospice, and comfort care measures).
As mentioned, the Mini-Cog is a well-established dementia screening tool that consists of clock drawing and 3-word recall. It has a high degree of sensitivity and specificity for identifying dementia in the primary care setting.\textsuperscript{10} Given the validity of the Mini-Cog test in detecting cognitive impairment, it was reasonable to explore its role as a marker for frailty in high-risk patients undergoing a variety of surgical procedures. However, we found that in this population of patients carrying traditional risk factors for frailty such as being $>60$ years of age, taking several medications, and being nonambulatory, the Mini-Cog was not able to further stratify risk of adverse perioperative outcomes. Interestingly, the Mini-Cog was associated with lower walking speed, lower grip strength, and lower baseline hemoglobin values in this surgical population, suggesting that several physiological markers of frailty are coincident and a single marker may be sufficient.

Despite the lack of consensus on a universal definition of frailty, adverse perioperative outcomes are well understood to be associated with frailty, including major morbidity, mortality, and increased length of stay.\textsuperscript{3,5,14,19-23} Many methods for measuring frailty have been used in the literature, ranging from single surrogate measurements such as gait speed\textsuperscript{24} to more complex frailty scales that provide a numerical frailty “score” based on functional status, comorbidities, and many other factors.\textsuperscript{19} Most of these definitions have primarily measured frailty based on physical factors with minimal to no focus on cognitive factors. However, several studies have suggested that cognitive impairment plays a significant role in risk stratification before surgery.\textsuperscript{6,7,25-28} Robinson et al\textsuperscript{26} similarly used an abnormal Mini-Cog test (defined as a score of $\leq 3$) as a marker of cognitive impairment in patients $\geq 65$ years of age undergoing planned elective operations requiring postoperative intensive care unit admission. They found a significantly higher incidence of delirium, longer hospital stays, higher rates of discharge institutionalization, and higher 6-month mortality.\textsuperscript{26} Heng et al\textsuperscript{7} found that among hospitalized patients $\geq 70$ years of age with orthopedic fractures, an abnormal Mini-Cog (score $<3$) was predictive of an increased risk of in-hospital complications, delirium, and mortality at 1-year postfracture. Jha et al\textsuperscript{27} found that they were better able to predict 12-month mortality rates in patients with advanced heart failure undergoing cardiac transplants by assessing cognitive frailty (via the Montreal Cognitive Assessment) in addition to physical frailty. Finally, Makhani et al\textsuperscript{29} found that by combining frailty and cognitive assessment scores, they were better able to identify patients at high risk of diminished overall survival after surgery.

Strengths of this study include the use of study patients undergoing surgeries in a diverse range of subspecialties. The diversity among the types of surgeries makes the results of this study generalizable to most surgical patients with the exception of cardiac procedures, which were excluded in this study. There were several limitations to the study. Subtle sources of selection bias may have influenced the results due to patient enrollment not being consecutive or randomized. The retrospective nature of this study also bears inherent limitations. These include the lack of access to data regarding educational status, a potentially important confounder in neurocognitive assessments. In favor of our findings, the Mini-Cog appears to be less biased by low education status than, for example, the Mini-Mental State Examination.\textsuperscript{30} No adjustment of the type I error rate was performed, increasing the possibility that our findings were due to chance given that multiple comparisons were performed. Also, there was no postoperative cognitive assessment data.
available. This is important to assess as part of a potential causal chain resulting in increased length of stay.\textsuperscript{31}

The Vizient-calculated expected length of stay is based on a proprietary multiple variable analysis that is subject to change, which may affect reproducibility at other institutions or in future analysis. A major limitation to our finding of increased length of stay is that it is affected by a number of confounders not possible to include in the present analysis: hospital staffing, bed control, and payment classification.\textsuperscript{32} Balancing this, the Vizient methodology for calculating expected length of stay does incorporate some of these major confounders; the unique model for each admission diagnosis-related group may incorporate factors such as comorbidity status, admission source, discharge disposition, and proxies for socioeconomic status such as Medicaid payor.\textsuperscript{13} Although no difference was observed in readmission rate, these data are subject to the limitation that we cannot capture readmissions that occurred outside of the Emory Healthcare system. Finally, we note that discharge disposition with home care is often at the discretion of the attending surgeon. Some surgeons are known to avoid the use of home health services; these surgeon-level preferences and practice patterns were not accounted for in the present analysis.

It is possible that our “high-risk patient” inclusion criteria was too homogenous in terms of frailty. We speculate that, for this population, the Mini-Cog may not have been sensitive enough to detect significant differences in most adverse outcomes. Although Mini-Cog demonstrated discriminatory capacity for ratio of observed-to-expected length of stay, we hypothesize that cognitive screens with greater resolution may be required to discriminate other outcomes in a higher-risk pool. For example, a brief screening tool that samples a variety of cognitive-linguistic functions may provide a more comprehensive snapshot of brain function and capture subtle impairments that are likely to be associated with higher risk of cognitive frailty and adverse perioperative outcomes; a recently developed cognitive assessment tool for perioperative use captures some of these dimensions.\textsuperscript{33} Further studies will be required to assess this possibility.

That this rapidly and easily administered screening tool may contribute to understanding which patients are at risk for lengthier hospitalization is intriguing. Although the present work does demonstrate that Mini-Cog has some discriminatory capacity for an increased observed-to-expected length of stay even within a population pre-screened for high risk of frailty, it is only one of several other factors strongly associated (viz surgical case complexity and duration). Regardless, based on the currently available data from the broader literature, we conclude that frailty is an excellent predictor of which patients are more likely to suffer from adverse perioperative outcomes. However, there is not yet a universally accepted way to accurately measure frailty, and more research will be needed to identify new methods of measuring cognitive frailty. In addition, comparisons of the tools that have already shown to be good measures of frailty are needed.

**ACKNOWLEDGMENTS**

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REFERENCES


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KEY POINTS

• **Question:** In a population at high risk of frailty, does the Mini-Cog have discriminatory capability with regard to the risk of adverse perioperative outcomes?

• **Findings:** An abnormal Mini-Cog was associated with an increase in the observed-to-expected length of stay, but not with intensive care unit length of stay, risk of readmission, or discharge disposition. Decreased baseline hemoglobin was associated with increased risk of 2 of the 4 outcomes studied.

• **Meaning:** Even within a high-risk pool of patients, Mini-Cog may assist in assessing whether patients are at risk of increased length of stay but may not be sensitive enough to detect significant differences in other adverse outcomes.
**Figure 1.** 
Patient flow diagram. APC indicates Anesthesia Preoperative Clinic; ICU, intensive care unit; O:E, observed-to-expected.
Figure 2.
Multivariable logistic regression testing the association between independent variables of interest, including preoperatively assessed Mini-Cog, and odds of outcomes of interest. Note different scales for each panel. A, Odds of Vizient O:E ratio >1 (C-statistic, 0.626; Hosmer–Leshenow $g = 10; 0.966$). B, Odds of readmission (C-statistic, 0.714; Hosmer–Leshenow $g = 12; 0.628$). C, Odds of discharge to home with self-care (C-statistic, 0.794; Hosmer–Leshenow $g = 14; 0.515$). ASA-PS indicates American Society of Anesthesiologists physical status; O:E ratio, ratio of observed-to-expected length of stay; Onc, oncologic; Uro, urology.
Figure 3.
Multivariable logistic regression testing the association between independent variables of interest, including preoperatively assessed Mini-Cog, and odds of ICU admission for at least (A) 3 d (C-statistic, 0.692; Hosmer–Leshenow g = 8; 0.646) and (B) 7 d (C-statistic, 0.769; Hosmer–Leshenow g = 9; 0.454). ICU indicates intensive care unit; Onc, oncologic; Uro, urology.
### Table.
Comparison of Baseline Demographic Characteristics Between Patients With Normal and Abnormal Preoperative Mini-Cog Assessment

<table>
<thead>
<tr>
<th></th>
<th>Mini-Cog &gt;2</th>
<th>Mini-Cog ≤2</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td>N (patients)</td>
<td>866</td>
<td>266</td>
<td>...</td>
</tr>
<tr>
<td>Age (y), median (25th–75th quartile)</td>
<td>65 (58–71)</td>
<td>69 (62–75)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Males (%)</td>
<td>359 (41.5)</td>
<td>113 (42.5)</td>
<td>.777</td>
</tr>
<tr>
<td>Body mass index (kg/m²), median (25th–75th quartile)</td>
<td>28.9 (24.9–33.1)</td>
<td>28.3 (24.5–32.9)</td>
<td>.197</td>
</tr>
<tr>
<td>&gt;5 prescriptions</td>
<td>546 (63.0)</td>
<td>184 (69.2)</td>
<td>.079</td>
</tr>
<tr>
<td>Grip strength frail (%)</td>
<td>183 (21.1)</td>
<td>92 (34.6)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Walking speed frail (%)</td>
<td>46 (5.3)</td>
<td>41 (15.4)</td>
<td>&lt;.001</td>
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<tr>
<td>Hemoglobin (mg/dL)</td>
<td>13 (11.7–14)</td>
<td>12.6 (11.3–13.6)</td>
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</tr>
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<td>ASA-Relative Value Guide base units, median (25th–75th quartile)</td>
<td>7 (6–10)</td>
<td>7 (5–10)</td>
<td>.132</td>
</tr>
<tr>
<td>Surgical case length (min), median (25th–75th quartile)</td>
<td>136.5 (81.25–212)</td>
<td>113 (72–182.75)</td>
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<td>ASA classification</td>
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<tr>
<td>I/II</td>
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<td>50 (18.8)</td>
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<td>32 (12.0)</td>
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<td>Neurosurgery</td>
<td>141 (16.3)</td>
<td>49 (18.4)</td>
<td>...</td>
</tr>
<tr>
<td>Other</td>
<td>215 (24.8)</td>
<td>58 (21.8)</td>
<td>...</td>
</tr>
<tr>
<td>Outcomes</td>
<td></td>
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<tr>
<td>Vizient observed-to-expected length of stay &gt;1 (%)</td>
<td>207 (36.2)</td>
<td>73 (41.7)</td>
<td>.212</td>
</tr>
<tr>
<td>Intensive care unit patients (n)</td>
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<td>33</td>
<td>...</td>
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<tr>
<td>Intensive care unit length of stay &gt;3 d (%)</td>
<td>51 (41.1)</td>
<td>10 (30.3)</td>
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<td>Intensive care unit length of stay &gt;7 d (%)</td>
<td>25 (20.2)</td>
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<td>Readmissions (%)</td>
<td>64 (7.4)</td>
<td>28 (10.5)</td>
<td>.123</td>
</tr>
<tr>
<td>Discharged to home with self-care (%)</td>
<td>690 (79.7)</td>
<td>207 (77.8)</td>
<td>.545</td>
</tr>
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</table>

Abbreviation: ASA, American Society of Anesthesiologists.