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## Surgeon variation in operating times and charges for emergency general surgery



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### ABSTRACT

**Background:** Patients and hospitals face significant financial burdens from emergency general surgeries (EGSs), which have been termed a public health crisis in the United States. We evaluated hospitalization charges, operating charges, and variations in operating time by surgeon volume for three common EGS procedures.

**Methods:** Using Maryland's Health Services Cost Review Commission database, we performed a retrospective study of laparoscopic appendectomies, laparoscopic cholecystectomies, and open bowel resections performed by general surgeons among adult patients from July 2012 to September 2014. We compared operating charges to total hospitalization charges and quantified variations in operating time for each procedure. We then divided patients into quartiles based on their surgeon's procedure-specific case volume and used hierarchical linear regressions to calculate differences in both operating time and charges between quartiles.

**Results:** We identified 3194 appendectomies, 4143 cholecystectomies, and 1478 bowel resections. Operating charges accounted for one-quarter (26.9%) of total hospitalization charges and widespread variation existed in operating time (appendectomies: median 79 min [interquartile range 66-100 min], cholecystectomies: 96 min [76-125 min], bowel resections: 155 min [117-209 min]). After adjustment, low-volume surgeons relative to high-volume surgeons did not operate statistically longer for appendectomies (+1%, 95% confidence interval [CI]: -2% to 5%) but operated +16% (95% CI: 12%-20%) longer for cholecystectomies (+14 min) and +40% (95% CI: 30%-50%) longer for bowel resections (+59 min). Adjusted median operating charges from low-volume surgeons relative to high-volume surgeons were \$554 (26.7%), \$621 (22.0%), and \$1801 (47.0%) greater for appendectomies, cholecystectomies, and bowel resections, respectively.

**Conclusions:** Operating charges contributed substantially to total EGS hospitalization charges, where low-volume surgeons operated longer and had higher operative charges relative to high-volume surgeons. Reducing variations in operating times and charges represents an opportunity to alleviate the financial burden from EGS procedures.

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## Introduction

Patients and hospitals face significant financial burdens associated with emergency general surgeries (EGS).<sup>1</sup> In 2010, there were 2.6 million hospitalizations for EGS procedures in the United States (US), resulting in a total national health-care cost of \$28.4 billion.<sup>2</sup> The increasing and rapidly aging US population suggests that the prevalence and associated charges of EGS procedures will continue growing.<sup>1,2</sup> Furthermore, although the regionalization of acute critical care, which now includes EGS procedures, has been associated with lower mortality and complications, some studies suggest that it may be associated with increased costs, especially when patients require an intensive unit care stay.<sup>3</sup>

Operating time contributes largely to the total hospitalization charge.<sup>4</sup> Several quality improvement initiatives have subsequently used individualized physician feedback to reduce both the average operating charges and the underlying surgeon variation of these charges after elective surgical procedures.<sup>5,6</sup> However, there remains little understanding regarding surgeon variation in operating time and the subsequent implications for hospitalization charges after nonelective and acute operations, such as EGS procedures. Characterizing this variation and its contribution to hospitalization charges can inform quality improvement initiatives that seek to reduce the financial burden of EGS procedures for patients, hospitals, and the national health-care system.

In this study, we used Maryland's Health Services Cost Review Commission (HSCRC) database to (1) evaluate operating charges and their contribution to overall total hospitalization charges, (2) assess the variation in operating times for each procedure, and (3) determine the associations between patient, surgeon, and hospital characteristics with operating time. We hypothesized that there would be large variations in operating times for each EGS procedure and that low-volume surgeons would be associated with higher operating times and subsequent charges.

## Methods

### Study population and variables

We used Maryland's all-payer claims database, the HSCRC, to analyze three common EGS procedures that contribute to the majority of the national burden of operative EGS in the US, including procedures, deaths, complications, and inpatient costs: laparoscopic appendectomies, laparoscopic cholecystectomies, and open small or large bowel resections.<sup>1</sup> This database captures all surgical patients, including those who undergo either same-day outpatient surgery and those admitted to the hospital, within the state's 62 hospitals between July 1, 2012 and September 30, 2014.<sup>7</sup> We identified procedures using International Classification of Diseases-9-Schedule Modification (ICD-9-CM) codes: laparoscopic appendectomy (47.01), laparoscopic cholecystectomy (51.23, 51.24), open and other partial excision of large intestine (45.7×), and other excision of small intestine (45.6×). For bowel resections, we excluded laparoscopic-to-open conversions by

the conversion code (V64.41). Finally, we used the National Provider Identifier with Medicare's Physician Compare database<sup>8</sup> to obtain each surgeon's primary reported specialty and obtained hospital characteristics from the American Hospital Association.<sup>9</sup> The Johns Hopkins Institutional Review Board exempted this study.

The data set consisted of patients aged 20 y or older, admitted urgently or emergently or through the emergency department if admission type was unknown, with a principal procedure of one of the included ICD-9-CM codes that was performed on day 0 or 1 of admission. We excluded patients who experienced trauma (ICD-9-CM diagnosis codes 800×-950×). We also removed hospitalizations with operating times of less than 20 min, determined a priori, likely to be coding errors. Finally, to remove outlier hospitalizations, we dropped the top and bottom 5th-percentile of patients with regards to total hospitalization charges for each of the three EGS procedures, as these would likely capture hospitalizations with a disproportionate amount of charges due to tasks not directly related to the actual operation.

Patient factors included age at admission (20-44, 45-64, 65+), gender, race and ethnicity (non-Hispanic white, non-Hispanic black, Hispanic race, and other/unknown), payer (private, Medicare, Medicaid, and self-pay), and Elixhauser score (0-1, 2-4, 5+) to capture patient comorbidities significantly associated with in-hospital mortality.<sup>10,11</sup> Hospital factors included beds ( $\leq 200$ , 201-400,  $>401$ ), region (urban, rural), and teaching affiliation (teaching, nonteaching, unknown). We identified the presence of at least one of eight common EGS complications using previously published ICD-9-CM codes<sup>12</sup>: pulmonary failure, pneumonia, myocardial infarction, deep vein thrombosis/pulmonary embolism, acute renal failure, hemorrhage, surgical site infection, and gastrointestinal bleed.

### Outcomes and statistical analysis

We analyzed operating time (min), operating charges (USD), and surgeon volume during the study period. Maryland's all-payer rate-setting system standardizes charges across the state, and its HSCRC database includes unique variables for each of the following: operating time, operating charges, and total hospitalization charges. The operating time represents the duration for which the patient is under anesthesia—from the time after anesthesia has been administered to the end of anesthesia.<sup>13</sup> The operating charge includes medical center fees associated with the operating room in addition to medical and surgical supplies used for the procedure.<sup>13</sup> We first determined the median hospitalization charge and the corresponding interquartile range ([IQR], 25th-75th-percentile) for each procedure, and then calculated the average proportion of these charges that were due to operating charges. Next, we assessed variation in operating times for each procedure by determining the median operating time and IQR.

For each procedure, we ordered all patients by their surgeon's procedure-specific volume and then divided them equally into quartiles. The bottom quartile represents patients who were operated on by surgeons with the lowest procedure-volumes during our study period and the top quartile represents

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