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Are appendectomy outcomes in level I trauma centers as good as we think?

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ABSTRACT

Background: Designated trauma centers improve outcomes for severely injured patients. However, major trauma workload can disrupt other care pathways and some patient groups may compete ineffectively for resources with higher priority trauma cases. This study tested the hypothesis that treatment at a higher-level trauma center is an independent predictor for worse outcome after appendectomy.

Methods: An observational study was undertaken using an all-payer longitudinal data set (California State Inpatient Database 2007–2011). All patients with an ICD-90-CM diagnosis of "acute appendicitis" (International Classification of Diseases, Ninth Revision, Clinical Modification code 540) that subsequently underwent appendectomy were included. Patients transferred between hospitals were excluded to minimize selection bias. The outcome measures were days to the operating room, length of stay, unplanned 30-d readmission (to any hospital in California), and in-hospital mortality. Logistic and generalized linear regression models were used to adjust for patient- (age, sex, payer status, race, Charlson comorbidity index, weekend admission, and generalized peritonitis) and hospital-level (teaching status and bed size) factors.

Results: There were 119,601 patients treated in 278 individual hospitals. Patients in level I trauma centers (L1TCs) reached the operating room later (predicted mean difference 0.25 d [95% confidence interval 0.14–0.36]), stayed in hospital longer (0.83 d [0.36–1.31]), and had higher adjusted odds of generalized peritonitis (odds ratio 1.63 [95% confidence interval 1.13–2.36]) than those in nontrauma centers. There were no differences in mortality or unplanned 30-d readmissions to hospital; or between level II trauma centers and nontrauma centers across any of the measured outcomes.

Conclusions: Odds of generalized peritonitis are higher and hospital length of stay is longer in L1TCs, although we found no evidence that patients come to serious harm in such institutions. Further work is necessary to determine whether pressure for resources in L1TCs can explain these findings.

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Introduction

Regionalized trauma care has been shown to improve outcomes for major trauma patients. Many studies have shown that quality of care is higher [1–3] and that overall mortality is lower for severely injured patients at designated trauma centers [4–8]. There is also evidence that other surgical populations can benefit from treatment at a trauma center. For example, it has been reported that outcomes for patients with ruptured abdominal aortic aneurysms improve in new trauma centers [9,10].

However, trauma centers are often large regional hospitals that host multiple complex services and treat high patient volumes. The concentration of severely injured patients in these hospitals can impose a substantial resource burden on trauma centers [11–13]. This raises the possibility that other care pathways could be disrupted in these hospitals. For example, there is evidence from Europe that older adults with hip fractures may have worse outcomes when treated in trauma centers [14,15]. One possibility is that these patients compete ineffectively for resources with more urgent cases.

The impact of major trauma burden on other acute surgical services is particularly important in the United States. This is because the emerging specialty of acute care surgery may involve the sharing of resources (e.g., senior surgeons) between services caring for injured and emergency general surgical (EGS) patients. A small number of studies have found that acute care surgical services are associated with improved EGS outcomes [16–18]. However, it is unknown whether patients requiring EGS (e.g., appendectomy) are optimally treated in higher-level trauma centers.

The goal of this study was to compare outcomes in patients undergoing appendectomy in level I trauma centers (L1TCs), level II trauma centers (L2TCs), and nontrauma centers (NTCs). Our hypothesis was that undergoing appendectomy at a trauma center was an independent risk factor for worse outcomes.

Methods

Data source

The California State Inpatient Database (SID) is part of the Healthcare Cost and Utilization Project family of databases, which is managed by the Agency for Healthcare Research and Quality. It is an all-payer database that captures every inpatient discharge record from 98% of acute hospitals in California. Patients can be tracked longitudinally across hospital admissions (to any hospital in California) using a unique patient identifier. Linkage to the American Hospital Association (AHA) Annual Survey Database for each SID year (2007–2011) permitted analysis of hospital-level characteristics, including trauma center level.

Study population

Patients were included if they had a primary or secondary diagnosis of "acute appendicitis" (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM] code 540) within the SID 2007–2011 and underwent appendectomy (procedure code 470 [appendectomy]) during their admission. Patients with an alternative appendicitis diagnosis (006.8 [amebic appendicitis], 541 [appendicitis, unqualified], 542 [other appendicitis: chronic, recurrent, relapsing, subacute], and 543 [other diseases of appendix]) were not included. All hospital readmissions within 30 d of diagnosis were also extracted from the SID.

Patients that were transferred between hospitals were excluded to minimize selection bias.

Patient and hospital characteristics

Variables extracted from the SID were age, sex, race (white, black, Hispanic, and other), payment source (publicly-funded, private insurance, and self-paying), and admission during a weekend. Charlson comorbidity indices were generated using the CHARLSON module [19] in Stata.

ICD-9-CM codes were used to categorize patients with generalized peritonitis (540.0) and those undergoing laparoscopic appendectomy (470.1, 471.1). Annual appendectomy volumes were determined using unique hospital identifiers within the SID. The ICDPIC module in Stata [20] was used to identify patients with an injury severity score (ISS) $\geq$9 from ICD-9-CM codes, which facilitated calculation of annual trauma volumes.

Hospital characteristics from the linked AHA database were trauma center designation, teaching hospital status (defined as hosting a program recognized by the Accreditation Council for Graduate Medical Education), and hospital bed size. As this study was principally interested in higher-level trauma centers, trauma designation was recoded as "level I," "level II," and "NTCs" (including level III and IV centers). The AHA Annual Survey asks hospitals to declare their "certified" trauma center level but does not require verification by the American College of Surgeons [21]. As this variable was self-reported, a number of validation checks were undertaken. The combined SID-AHA data set was linked to an inventory of trauma center characteristics independently collated by the American Trauma Society as part of the Trauma Information Exchange Program [22]. Trauma center level mismatches were then identified and manually crosschecked against data held by the Office of Statewide Health Planning and Development [23,24]. The trauma center level was accurately recorded within the AHA for most L1TCs and L2TCs. As a result of the validation process, six hospitals were "downgraded": one L1TC to L2TC and five L2TCs to "NTCs." In many cases, these hospitals were affiliated with designated trauma centers (e.g., owned by the same organization), which could account for incorrect recording within the AHA. No hospitals in the data set were "upgraded."

Outcome measures

Outcomes were days to appendectomy, generalized peritonitis, length of stay (LOS), in-hospital mortality, and unplanned readmission to any hospital in California within 30 d. Time to appendectomy and LOS were only available in the SID