



## The impact of in-hospital complications on the long-term functional outcome of trauma patients: A multicenter study



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### ABSTRACT

**Background:** The long-term consequences of in-hospital complications remain largely unknown. We sought to study the effect of complications on the long-term functional outcome of trauma patients.

**Methods:** Patients with an Injury Severity Score  $\geq 9$  admitted to 3, level I trauma centers between 2015 and 2017 were contacted 6 to 12 months postinjury and administered a validated trauma quality-of-life survey, assessing for the presence of any functional limitation. Functional limitation was defined as the inability to perform independently one or more activities of daily living (eg, driving, walking on flat surfaces/upstairs, dressing). Medical records and the trauma registry were reviewed systematically for all patient and injury variables. The occurrence of predefined in-hospital complications (eg, pneumonia, surgical site infection) was recorded. The impact of in-hospital complications on functional limitation was assessed using multivariate logistic regression models.

**Results:** Of 1,709 patients, 1,022 completed the study. The mean age was 58 y, 56% were male, 94% had blunt trauma, and the mean Injury Severity Score was 15. A total of 168 patients (16.4%) had a minimum of 1 in-hospital complication and reported significantly more functional limitations in most activities of daily living at 6 to 12 months, compared with those without complications. In multivariable analyses adjusting for confounders, the occurrence of complications was associated with a greater likelihood of functional limitation 6 to 12 months postinjury (odds ratio = 1.82, 95% confidence interval 1.22–2.69,  $P = .003$ ).

**Conclusion:** Trauma patients with in-hospital complications have a worse long-term functional outcome. In addition to prevention of primary complications, more rehabilitation resources should be made available to trauma patients who survive complications.

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### Introduction

During the past few decades, research on the quality of trauma care has focused for the most part on short-term outcomes, such as 30-day mortality and in-hospital complications.<sup>1–3</sup> More recently, there has been an increased awareness and recognition of the

importance of collecting long-term, patient-centered and patient-reported outcomes, including quality of life, ability to return to one's job, and mental health,<sup>1–3</sup> for trauma survivors.<sup>4,5</sup>

Recently, Gabbe et al<sup>4</sup> reported longitudinal, long-term functional and quality-of-life patient outcomes and suggested that less than a quarter of trauma survivors have complete functional recovery, and almost a third fail to return to work or study 24 months after their injury.<sup>5</sup> Our multi-institutional, research, Functional Outcomes and Recovery after Trauma Emergencies group has been collecting long-term, patient-reported outcomes since 2015 and similarly demonstrated that a substantial proportion of trauma survivors have functional limitations and post-traumatic stress

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disorder at 6 and 12 months post-injury, and half have not yet returned to work.<sup>6</sup>

It remains unclear how much of an impact a patient's hospital course has on their long-term recovery after trauma in comparison with injury severity or comorbidities.<sup>4–12</sup> Specifically, the impact of in-hospital complications on long-term functional limitations (FL) in the trauma patient remains largely unknown. In this study of trauma patients, we sought to examine the impact of in-hospital complications on the occurrence of FL 6 to 12 months postinjury.

## Methods

### Patient population

We reviewed patients with an Injury Severity Score  $\geq 9$  admitted to 3 level I trauma centers between 2015 and 2017.

### Recruitment and data collection

All patients received pamphlets with details about the Functional Outcomes and Recovery after Trauma Emergencies project and letters informing them that they would be contacted by a trained member of the research team via telephone numbers extracted from the electronic medical records a minimum of 10 d before data collection.

Interviews were performed using structured telephone surveys in English or Spanish between 6 and 12 months after injury. Patients who did not complete the survey or who spoke a language other than English or Spanish were excluded. Up to 6 phone calls were attempted before excluding the patient as nonrespondent.

The interview consisted of an initial screening, verbal consent, and a comprehensive survey that collected patient-centered data focused on their recovery after injury. Specifically, the survey included domains on work, occupation, and insurance status; education level, residential status; and postdischarge contacts with health care, as well as a trauma quality-of-life instrument. The interview lasted approximately 15 min and was administered to patients or their health care proxies. A more detailed description of our methodology can be found in our earlier study.<sup>6</sup>

### In-hospital complications

The medical records of patients with in-hospital complications reported by the respective hospitals' trauma registries were reviewed by trained members of the research team to confirm the occurrence of the complication and action taken by the care team in response to the complication (eg, pharmacologic intervention, endotracheal intubation, radiologic procedures) and then to classify its severity using the Clavien-Dindo classification system.<sup>13</sup> For patients with multiple complications, we accounted for all complications but designated the greatest severity complication as the principal complication. If patients had multiple complications with the same severity, trained members reviewed the electronic medical record to select the complication that impacted most negatively the patient outcome.

### Primary outcome: FL

We studied whether the occurrence of an in-hospital complication correlated with the presence of a minimum of 1 FL in the 6- to 12-month postinjury period. FL was defined as the inability to perform independently one or more activities of daily living, as screened for by the trauma quality-of-life instrument. These activities included driving, walking upstairs, walking on flat

surfaces, dressing, bathing or showering, eating, going to the bathroom, and cooking or preparing meals.

### Study variables

Variables on demographics or socioeconomic status (eg, age, sex, race or ethnicity, education level, insurance status, comorbidities); injury mechanism, type, and severity (eg, ISS, work relatedness, head injury, torso injury, extremities injury, injury mechanism); and outcome (eg, intensive care unit [ICU] admission, ventilator dependent, hospital duration of stay, complication, discharge disposition) were extracted systematically from the trauma registries of each participating hospital.

### Statistical analysis

Descriptive statistics were calculated. Categorical variables were presented as absolute values, and percentages and continuous variables were presented as either mean (standard deviation) or median (interquartile range) based on the distribution of the data. We used  $\chi^2$  tests or the Fisher exact test to compare categorical variables. Based on the distribution, Wilcoxon rank-sum tests or *t* tests were used to compare continuous variables.

Multivariable adjusted logistic regression models were constructed to assess the independent impact of any in-hospital complication, infectious complication, or noninfectious complication on the occurrence of FL. The models adjusted for demographics or socioeconomic status (age, sex, race/ethnicity, education level, insurance status, comorbidities) and injury mechanism, type, and severity (ISS, work relatedness, head injury, torso injury, extremities injury, injury mechanism).

Statistical analyses were performed using the STATA 14.0 (StataCorp, College Station, TX) statistical software package.

### Ethical oversight

This study was approved by the institutional review boards of all participating hospitals.

## Results

### Study population

Out of 1,709 eligible patients, 1,022 (60%) patients were included (Fig. 1). The mean age of the patient population was 58 (21.9) y, 56% were male, 94% had blunt trauma, and the mean ISS was 14.5 (7.4).

### Occurrence of in-hospital complications

A total of 168 (16.4%) patients had a minimum of 1 in-hospital complication. Among patients with complications, almost a third

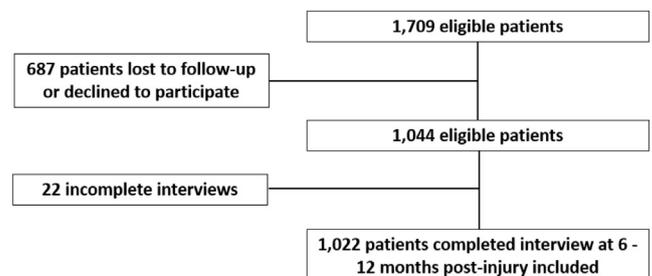


Fig 1. Flowchart of population selection.

**Table 1**  
Comparison of patients with and without in-hospital complication(s)

Demographics	Total (N = 1,022)	No complication (n = 854)	Complication (n = 168)	P value
Age (y), mean (SD)	59.9 (21.9)	58.2 (21.9)	59.9 (22.1)	.343
Sex, male	571 (55.9)	461 (54.0)	110 (65.5)	<b>.006</b>
Race*				.462
White	712 (75.0)	593 (74.2)	119 (78.8)	
Black or African American	141 (14.8)	123 (15.4)	18 (11.9)	
Other	97 (10.2)	83 (10.4)	14 (9.3)	
Education, high school or lower <sup>†</sup>	504 (50.2)	411 (48.9)	93 (56.7)	.066
Insurance, private <sup>‡</sup>	457 (54.0)	373 (52.9)	84 (59.2)	.173
Number of comorbidities <sup>‡</sup>				.864
0	189 (21.9)	158 (21.7)	31 (22.9)	
1	250 (29.0)	215 (29.6)	35 (25.9)	
2	246 (28.5)	206 (28.3)	40 (29.6)	
3 +	177 (20.5)	148 (20.4)	29 (21.5)	
Injury characteristics				
Injury Severity Score, mean (SD)	14.5 (7.4)	13.7 (6.7)	18.4 (9.2)	< <b>.001</b>
Work relatedness <sup>†</sup>	46 (4.7)	41 (5.0)	5 (3.1)	.301
Head injuries (AIS ≥ 2)	379 (37.1)	297 (34.8)	82 (48.8)	<b>.001</b>
Torso injuries (AIS ≥ 2)	292 (28.6)	230 (26.9)	62 (36.9)	<b>.009</b>
Extremities injuries (AIS ≥ 2)	590 (57.7)	502 (58.8)	88 (52.4)	.125
Injury mechanism, blunt	956 (93.5)	799 (93.6)	157 (93.5)	.727
Outcome				
ICU admission	384 (37.6)	268 (31.4)	116 (69.1)	< <b>.001</b>
Ventilator dependent	133 (13.0)	67 (7.9)	66 (39.3)	< <b>.001</b>
Functional limitation	362 (35.4)	277 (32.4)	85 (50.6)	< <b>.001</b>
Duration of hospital stay (days), median (IQR)	5 (3–8)	4 (3–6)	10 (6–19)	< <b>.001</b>
Discharge disposition				< <b>.001</b>
Home	303 (29.7)	282 (33.0)	21 (12.5)	
Home with health services	164 (16.1)	148 (17.3)	16 (9.5)	
Rehabilitation facility	397 (38.9)	303 (35.5)	94 (56.0)	
Nursing home/skilled nursing facility	126 (12.3)	102 (11.9)	24 (14.3)	
Other	32 (3.1)	19 (2.2)	13 (7.7)	

P value greater than or equal to .05 is in bold.

IQR, interquartile range.

\* Missing < 10%.

† Missing < 5%.

‡ Missing < 20%

(32.1%) had 2 or more complications. Compared with patients with no complication, patients with in-hospital complications were more often male (65.5% vs 54.0%,  $P = .006$ ), had a greater ISS (mean ISS 18.4 vs 13.7,  $P < .001$ ), and more often had a traumatic brain injury (48.8% vs 34.8%,  $P = .001$ ) or a torso injury (36.9% vs 26.9%,  $P = .009$ ; Table 1).

Table 2 describes the nature of the complications. From a severity perspective, grade II complications were the most common (57.7%). Of the 1,568 patients with a complication, the most common complication was pneumonia, occurring in 32 patients. Psychologic complications (eg, delirium, substance withdrawal, agitation) and hematologic complications (eg, deep vein thrombosis, pulmonary embolism, bleeding) were also common, occurring in 23 and 17 patients, respectively. A total of 19 patients (11.3%) had unplanned admissions to the ICU owing to complications, 11 (6.6%) required reoperation, and 15 (9.0%) were readmitted to the hospital within 30 d of discharge.

Patients with in-hospital complications were more often admitted to the ICU (69.1% vs 31.4%,  $P < .001$ ), required mechanical ventilation more frequently (39.3% versus 7.9,  $P < .001$ ), had greater hospital duration of stay (median 10 vs 4 d,  $P < .001$ ), and were more often discharged to a rehabilitation (33.0% vs 12.5%,  $P < .001$ ) or long-term/nursing facility (17.3% vs 9.5%,  $P < .001$ ).

#### Occurrence of in-hospital complication versus long-term FL

Patients with in-hospital complications had a greater likelihood of FL compared with patients without in-hospital complications (50.6% vs 32.4%,  $P < .001$ ). Specifically, they were more likely to need help with driving (20.8% vs 12.9%,  $P = .007$ ), walking upstairs

(31% vs 16.7%,  $P < .001$ ), walking on flat surfaces (25% vs 13.7%,  $P < .001$ ), bathing or showering (20.8% vs 11.7%,  $P = .001$ ), eating (6% vs 2.6%,  $P = .022$ ), going to the bathroom (13.7% vs 5.2%,  $P < .001$ ), and cooking or preparing meals (19.6% vs 9.6%,  $P < .001$ ; Fig. 2).

After adjusting for demographics or socioeconomic status, injury characteristics, and hospital outcomes, the occurrence of one or more in-hospital complication independently increased the odds of long-term FL in trauma patients (odds ratio = 1.82, 95% confidence interval 1.22–2.69,  $P = .003$ ). The occurrence of infectious complications in particular most negatively affected the functional recovery (odds ratio = 2.44, 95% confidence interval 1.37–4.35,  $P = .002$ ).

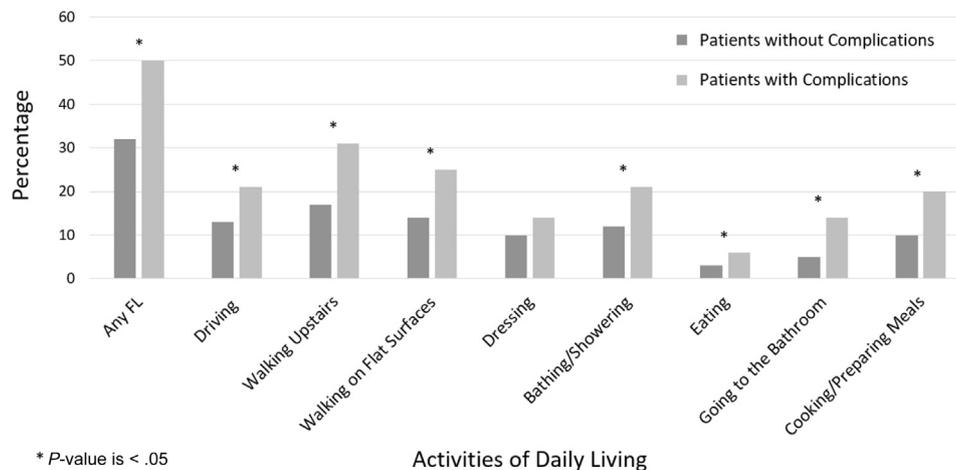
#### Discussion

In this study, we have shown that the subset of trauma patients who sustain complications during their initial hospital stay have worse long-term post-injury functional recovery. These findings suggest that most complications, even when they resolve during or shortly after the hospitalization, can have a long-lasting effect on the quality of life of trauma survivors. Therefore, efforts should be made to not only prevent complications when possible but also to mitigate their consequences, potentially by increasing the rehabilitation resources for patients with complicated hospital courses.

Our study adds to the existing literature in other fields, suggesting that hospital-acquired adverse events not only prolong the duration of a hospital stay and increase medical cost, but also significantly affect patient's long-term recovery.<sup>14–22</sup> In 2001, Holbrook et al<sup>18</sup> suggested that major inpatient complications in trauma patients leads to worse quality of life for many months after the injury. In that study, the occurrence of infectious complications

**Table II**  
Details of in-hospital complications

	Patients with in-hospital complications (N = 168)
Number of total complications	
1	114 (67.9)
2	39 (23.2)
3	14 (8.3)
4	1 (0.6)
Type of principal complications	
Infectious complications	62 (36.9)
Pneumonia	32 (51.6)
Wound/surgical site infection	8 (12.9)
Urinary tract infection	16 (25.8)
Clostridium difficile infection	3 (4.8)
Sepsis	1 (1.6)
Other	2 (3.2)
Noninfectious complications	106 (63.1)
Pulmonary	12 (11.3)
Cardiac	10 (9.4)
Renal	4 (3.8)
Hematologic	17 (16.0)
Gastrointestinal	7 (6.60)
Neural	15 (14.2)
Psychologic	23 (21.7)
Other	18 (17.0)
Clavien-Dindo classification of principal complication	
Grade I	22 (13.1)
Grade II	97 (57.7)
Grade III	30 (17.9)
Grade IV	19 (11.3)
Unplanned reoperation	11 (6.6)
Unplanned admission to the ICU	19 (11.3)
Unplanned readmission	15 (8.9)



**Fig 2.** Comparison of functional limitations (activities of daily living) on occurrence of complication.

in particular was correlated with negative long-term quality of life and functional outcomes. A recent study by Naumann et al<sup>14</sup> suggested that surgical site infections after operative fixation of closed ankle fractures correlate with worse functional outcome. Similarly, Kopp et al<sup>15</sup> found that hospital-acquired pneumonia or post-operative wound infection in spinal cord injury was associated with greater long-term disability.

The persistent findings throughout the years highlight two needs: (1) the need to decrease the number of any preventable complications, and (2) the serious need to improve not only the quality but also the access of trauma patients to rehabilitation services, especially those with complex index hospitalizations with one or more complications. Policy efforts like the Hospital-Acquired

Condition Reduction Program from the Centers for Medicare and Medicaid aim to incentivize hospitals to invest in resources aimed at preventing hospital-acquired conditions.<sup>23</sup> This program was launched initially on the basis that hospital-acquired conditions increased medical costs, hospital durations of stay, and the risk of mortality.<sup>22</sup> Our findings suggest that such initiatives not only help in immediate value to patients within the same admission, but their positive impact can help more trauma patients recover their role in society and in earlier fashion. More importantly, we as trauma surgeons should dedicate more time and effort to advocate for policies and resources to increase access to early and intensive rehabilitation programs for our patients. Early intensive rehabilitation efforts have been shown to improve the functional outcome

of trauma patients. In 2018, Gray et al<sup>24</sup> showed that a comprehensive, integrated approach of rehabilitation program increased the functional recovery of the polytrauma patient. The value of intensive rehabilitation for these patients has been substantiated in multiple studies.<sup>25–27</sup> For example, Siddharthan et al<sup>26</sup> found that intensive rehabilitation therapy increased the functional ability for polytrauma veterans. In addition, Andelic et al<sup>27</sup> found that early comprehensive rehabilitation during the initial acute hospitalization resulted in better functional outcome.

It has been suggested that on average it takes 17 y for an evidence-based practice to disseminate and become the standard because of the knowledge-to-advocacy gap. As such, we call on trauma surgeons to not only provide the data, but also present the data to policy makers to affect change and improve the quality and access of trauma patients with complicated injuries and hospital courses to advanced rehabilitation services.

Our study has a few limitations. First, there is a potential selection bias. Despite our aggressive attempts to reach all patients, the response or interview rate was 60%, and the nonresponders could arguably be those who have even worse functional outcomes and disability. Second, as with all cohort studies, we cannot rule out the effect of unmeasured confounders in our findings, despite our diligent attempt in the multivariable models.

In conclusion, trauma patients with in-hospital complications have worse functional, long-term outcomes. In addition to the prevention of a primary complication when possible, more rehabilitation resources should be made available to the subgroup of trauma patients who survive in-hospital complications to mitigate the long-term, functional effect of these complications and improve the quality of life of the trauma survivors.

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### Conflict of interest/Disclosure

The authors declare no disclosures or conflicts of interest.

### Supplementary materials

Supplementary material associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.surg.2019.04.026>.

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