

# Delayed Diagnosis of Hand Injuries in Polytrauma Patients

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**Abstract:** Trauma patients are at high risk for delayed diagnosis of injuries, including those to the hand, with reports in the literature as high as 50%. As a result, patients may have prolonged disability and longer hospital stays with associated increased costs. Our objective was to elucidate risk factors for the delayed diagnosis of hand injuries.

A review was performed from 2000 through 2009, assessing for age, sex, blood alcohol level, Glasgow Coma Score (GCS), Injury Severity Score (ISS), mechanism, injury type, length of stay, and timing of hand injury diagnosis.

In this study, 36,568 patients were identified; 738 meeting criteria; 21.7% of patients had delayed diagnoses with 91.3% of patients diagnosed by the day after admission. Delayed diagnoses were more than 2 times higher for severely injured patients. Patients with delayed diagnoses had a lower GCS and a higher ISS and length of hospitalization.

With a decreased GCS and elevated ISS, patients are at risk for delayed diagnoses of hand injuries. A focused tertiary survey is mandatory, particularly in patients with an altered mental status or with multiple injuries.

**Key Words:** hand injuries, trauma patients, delayed diagnosis, missed injuries (*Ann Plast Surg* 2012;69: 442–445)

Hand injuries represent 5% to 10% of emergency department visits in the United States,<sup>1</sup> most commonly affecting patients from 5 to 14 years.<sup>2</sup> Further, of all skeletal injuries sustained in trauma, metacarpal and phalangeal fractures are the most common.<sup>3</sup> These injuries may occur in isolation or as part of the constellation of injuries defining the polytrauma patient.<sup>4</sup> Because of their frequent occurrence,<sup>5</sup> the costs of treating upper extremity disorders in the United States have been estimated at over \$18 billion a year.<sup>6</sup> Indirect economic effects of hand injuries are also significant as they are responsible for 19% of lost-time injuries and 9% of worker compensation cases.<sup>7</sup>

The complex presentation of polytrauma patients can make immediate assessment of hand injuries difficult. The fact that hand injuries may be fatal in only the rarest situations may also lead to an abbreviated or deferred initial evaluation. Even with a robust hand evaluation at the time of presentation, it is known that hand injuries can be missed.<sup>8–10</sup> Although most injuries can be easily diagnosed based on radiographs,<sup>11–13</sup> if no suspicion for injury exists, these essential diagnostic studies may be omitted in the initial workup.

Trauma patients are at a particularly high risk for delayed diagnosis of concomitant injuries, including hand injuries, with reports in the literature as high as 50%.<sup>14</sup> A previous study by Houshian et al<sup>15</sup> describe an average of 1.3 missed injuries per patient. Not

surprisingly, head injury, Glasgow Coma Score (GCS) of 8 or less, a greater Injury Severity Score (ISS), and childhood have been implicated as risk factors for missed injuries in polytrauma patients.<sup>16–21</sup> If diagnosis is delayed, patients may have a prolonged period of disability<sup>8</sup> and longer hospital stays associated with increased costs.<sup>15</sup> Additionally, delayed diagnosis of these injuries may require surgical intervention that may not have been required had the diagnosis been made promptly.<sup>8</sup> If not accurately and expeditiously diagnosed, treated, and rehabilitated, these injuries may result in an irreversible functional impairment.<sup>22,23</sup>

No studies have focused specifically on the risk factors associated with delayed diagnosis of hand injuries in the trauma patient population at a Level 1 Trauma Center.

## METHODS

A retrospective review of prospectively collected data from the Lehigh Valley Health Network Trauma Registry was performed on all admitted trauma patients from January 1, 2000, through December 31, 2009. Patients with an isolated or conspicuous hand injury were omitted from the study. Distal radius fractures were omitted from the study as well, as these are not evaluated and treated by plastic surgeons in our health network. Patients were assessed for age, sex, blood alcohol level, GCS, ISS, mechanism, injury type, and length of stay (LOS). Timing of hand injury diagnosis (date of hand surgery consultation, imaging study documenting the injury, or documentation in the chart) related to admission date (measured in days) was noted. ISS scores were categorized into mild (<10), moderate,<sup>10–15</sup> and severe ( $\geq 16$ ) for statistical analysis. The likelihood of a delayed hand injury diagnosis was examined adjusting for age, GCS, ISS, alcohol use, and sex. In this study, we use the term “delayed” rather than “missed,” as inclusion in this study required an eventual diagnosis. A multivariate logistic regression model was used to determine the likelihood of independent variables to contribute to a “delayed diagnosis” of hand injuries. All analyses were performed using SPSS 15.0 (SPSS Inc, Chicago, IL).  $\alpha$  was set at 0.05 with a 95% confidence interval (CI).

## RESULTS

The database consisted of 36,568 patients; 2736 with hand injuries. After excluding patients with an obvious diagnosis of or mechanism for hand injury, 738 patients were identified. The average age was 45.59 years (range, 2–98 years), average LOS was 6.95 days (range, 1–70 days), average time of diagnosis of hand injury was 0.51 days (range, 0–15 days), average ISS was 13.84 (range, 1–75), average blood alcohol level was 50.17 (range, 0–459), and average GCS was 13.89 (range, 3–15) (Table 1). Overall, 21.7% of patients had a delayed diagnosis (diagnosis at least 1 day after the date of admission) with 91.3% of patients diagnosed by the day after admission. All hand injuries in our study population were diagnosed by day 15 (Table 2).

A statistically significant difference in the mean GCS, ISS, and LOS was noted in patients with a delayed diagnosis and those without a delayed diagnosis. The mean GCS for patients with delayed diagnosis was 12.95 (4.03), whereas patients with diagnosis the day of admission had a mean GCS of 14.16 (2.70) ( $P < 0.001$ ). Patients with delayed diagnosis had a mean ISS of 17.57 (10.86) versus 12.81 (8.77) for those diagnosed the day of admission ( $P < 0.001$ ). Patients

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**TABLE 1.** Demographics of Hand Injury Population

Demographic	N	Mean (SD)	Minimum	Maximum
Age, y	738	45.6 (23.0)	2	98
LOS	738	6.95 (8.65)	1	70
Diagnosis of injury (no. hospital day)	738	0.51 (1.60)	0	15
ISS	738	13.8 (9.5)	1	75
ETOH	424	50.2 (89.2)	0	459
GCS	691	13.9 (3.1)	3	15

with delayed diagnosis had a mean LOS of 10.41 (11.02) days, whereas those diagnosed at the time of admission had a mean LOS of 5.99 (7.60) days ( $P < 0.001$ ). Although not statistically significant, patients who had a delayed diagnosis were also older (47.84 vs 44.96) with a higher blood alcohol level (57.73 vs 47.50) on admission (Table 3).

The age-adjusted likelihood of a delayed hand injury diagnosis was more than 2 times higher for severely injured patients than mildly injured patients [odds ratio (OR), 2.01; 95% CI, 1.14–3.55] ( $P = 0.015$ ). There was no statistical difference between moderately and mildly injured patients (OR, 1.89; 95% CI, 0.999–3.575) ( $P = 0.050$ ). For every point decrease in GCS and year increase in age, odds of a delayed diagnosis increased by 7% and 2%, respectively [OR, 0.934; 95% CI, 0.877–0.995 ( $P = 0.035$ ) and 1.02 95% CI, 1.01–1.03 ( $P = 0.001$ ), respectively]. Furthermore, there was no difference between men and women or alcohol use with regard to the likelihood of delayed diagnosis (Table 4).

There were 348 patients with a mild ISS, 137 with a moderate ISS, and 253 with a severe ISS (total  $n = 738$ ). For patients with a delayed diagnosis ( $n = 160$ ), 50 were mildly injured, 33 were moderately injured, and 77 were severely injured. The delayed diagnosis rate increased in a stepwise fashion as the ISS category increased: 14.4%, 24.1%, and 30.4% ( $P < 0.001$ ) (Table 5).

Metacarpal and phalangeal fractures were the most common injuries overall (46.9% and 25.8%, respectively). Furthermore, delayed diagnoses were most commonly associated with phalangeal and metacarpal fractures (28.4% and 25.4%, respectively;  $P = 0.001$ ) (Table 6). Motor vehicle collisions (MVCs) were the most common mechanism of injury followed by falls (60.0% and 26.7%, respectively). Moreover, MVCs and falls were the mechanisms for which the greatest proportions of diagnoses were delayed (24.8% and 16.2%, respectively;  $P = 0.036$ ) (Table 7).

## DISCUSSION

Previous authors note that a lack of admission radiographs (46.3% to 53.8% of delayed diagnoses) and misinterpretation of studies (15%–34.9% of delayed diagnoses) are common causes of missed extremity injuries.<sup>11–13,15,17</sup> Neighboring injuries, interrupted

**TABLE 2.** Day of Hand Injury Diagnosis

Day	Frequency	Percent	Cumulative Percent
0	578	78.3	78.3
1	96	13.0	91.3
2	29	3.9	95.3
3	9	1.2	96.5
4+	26	3.6	100.0
Total	738	100.0	

**TABLE 3.** Group Comparisons

Independent Variables	Delayed Diagnosis [Mean (SD)]		P
	Yes, n = 160	No, n = 578	
Age, y	47.8 (21.9)	45.0 (23.2)	0.160
GCS*	13.0 (4.0)	14.2 (2.7)	<0.001
ETOH†	57.7 (92.5)	47.5 (88.0)	0.300
ISS	17.6 (10.9)	12.8 (8.8)	<0.001
LOS	10.4 (11.0)	5.99 (7.6)	<0.001

\*GCS  $n = 156$  and  $535$  for delayed diagnosis, yes and no, respectively.

†ETOH  $n = 111$  and  $313$  for delayed diagnosis, yes and no, respectively.

diagnoses, and insufficient x-rays were also found to be contributing factors.<sup>15,17</sup> Although any of these factors may independently contribute to a delay in diagnosis, often a combination of circumstances are responsible.<sup>14</sup>

At our Level 1 Trauma Center, 78.3% of patients with hand injuries were diagnosed on the day of admission, with 91.3% diagnosed by the following day. This suggests that the secondary and tertiary surveys are capable of leading to an expeditious hand injury diagnosis in most cases, regardless of age, GCS, blood alcohol level, ISS, type of injury, or mechanism for injury. A landmark study by Enderson and colleagues<sup>24</sup> reported finding additional injuries in 9% (50% of these were of the extremity) of the trauma population through tertiary survey, with others supporting the efficacy of the tertiary survey.<sup>25–28</sup>

Injury or intoxication causing impaired mental status is often noted to delay the diagnosis of traumatic injuries, by virtue of the associated unreliable clinical examination.<sup>29</sup> In this study, patients with a decreased GCS, elevated ISS, and elevated blood alcohol levels were noted to have delayed diagnosis. However, only GCS and ISS levels were found to be statistically significant. That a patient with a decreased GCS would be less able to communicate an occult injury is intuitive and consistent with previous studies.<sup>13,30</sup> The ISS levels [described here as mild (<10), moderate, 10–15 and severe ( $\geq 16$ )] correlate with the relative severity of injury to multiple body systems.<sup>31</sup> As such, an elevated ISS indicates that the clinicians associated with emergency care of the patient may potentially be focused on more severe (ie, life-threatening) injuries. Rather innocuous clinical findings associated with an underlying hand injury may then be easily missed.

Length of hospitalization was also noted to be longer in the subset of patients with a delayed diagnosis of hand injuries [10.41 vs

**TABLE 4.** Logistic Regression Model ( $P < 0.001$ ) for Delayed Hand Injury Diagnosis

Delayed Hand Injury Diagnosis	P	Adjusted OR	95% CI for Adjusted OR	
Intercept	0.004			
GCS	0.035	0.934	0.877	0.995
Age, y	0.001	1.02	1.01	1.03
Severely injured	0.015	2.01	1.14	3.55
Moderately injured	0.050	1.89	0.999	3.58
Mildly injured		1.0 (reference)		
Alcohol use	0.058	1.61	0.985	2.62
No alcohol use		1.0 (reference)		
Female	0.057	1.61	0.985	2.63
Male		1.0 (reference)		

**TABLE 5.** Delayed Diagnosis by ISS Category Crosstabulation ( $P < 0.001$ )

Injury Severity Score Category	Delayed Diagnosis [n (%)]		Total [n (%)]
	Yes	No	
Mild	50 (14.4)	298 (85.6)	348 (47.2)
Moderate	33 (24.1)	104 (75.9)	137 (18.6)
Severe	77 (30.4)	176 (69.6)	253 (34.3)

5.99 days ( $P < 0.001$ )]. This is likely the result of concomitant injuries, requiring prolonged treatment and subsequent recovery—consistent with the higher ISS scores in patients with delayed diagnosis. A similar relationship between missed injuries and length of hospital stay has been noted elsewhere.<sup>17</sup>

Obvious and isolated hand injuries were excluded from our study. This allowed us to focus on injuries that may not be initially obvious to the trauma team on primary survey. Delayed diagnoses were most commonly associated with the phalanges (28.4% of all phalangeal fractures) and metacarpals (25.4% of all metacarpal fractures). The phalanges are the most distal, and among the most frequently injured, bones in the human body.<sup>3</sup> Their exposed position increases the likelihood of injury while, their relatively small size confounds efforts at detection during the initial assessment. A delayed diagnosis of metacarpal fractures may be the result of the rather protected nature of the metacarpal within the palm and the potential lack of obvious malalignment or deformity on initial evaluation.

Motor vehicle collisions were the most frequent mechanism for injury in our patient population (60%) and most commonly associated with a delay in diagnosis (24.8% of all MVC). Motor vehicle collisions are capable of causing significant blunt force injury to occupants,<sup>32</sup> and may lead to diffuse, unrelated injuries which may force the clinician to defer full musculoskeletal examination until other life-threatening injuries may be addressed. On the basis of the proportion of trauma patients involved in MVC in our health network along with the inherent forces involved, it is not surprising that this is the prevailing mechanism associated with a delayed diagnosis.

Although MVCs are the most common cause for injury in patients younger than 45 years, falls are the most common cause among individuals older than 65 years.<sup>33</sup> Falls were the second most common mechanism of injury in our study. Because falls in the elderly may be associated with cognitive impairment and/or dementia,<sup>34</sup> this population of patients may not be able to readily communicate pain related to a hand injury.

A potential problem with comparing different studies quoting the rate of “missed” injuries is that the definition of “missed” injuries varies between studies. Although no consensus definition exists,<sup>35</sup> a missed injury has been described as an injury identified after the primary or secondary survey, or more than 24 hours after admission.<sup>36</sup>

**TABLE 6.** Delayed Diagnosis by Primary Injury Crosstabulation ( $P < 0.001$ )

Primary Injury Type	Delayed Diagnosis [n (%)]		Total [n (%)]
	Yes	No	
Phalangeal fracture	54 (28.4)	136 (71.6)	190 (25.7)
Metacarpal fracture	88 (25.4)	258 (74.6)	346 (46.9)
Carpal fracture	11 (11.3)	86 (88.7)	97 (13.1)
Other injury types	7 (6.7)	98 (93.3)	105 (14.2)

**TABLE 7.** Delayed Diagnosis by Mechanism of Injury Crosstabulation ( $P = 0.036$ )

Mechanism of Injury	Delayed Diagnosis [n (%)]		Total [n (%)]
	Yes	No	
MVC	110 (24.8)	333 (75.2)	443 (60)
Falls	32 (16.2)	165 (83.8)	197 (26.7)
Other injuries	18 (18.4)	80 (81.6)	98 (13.3)

In this study, we use the term “delayed,” rather than “missed,” as all patients had an eventual diagnosis of a hand injury. Missed injuries, as defined herein, would be those injuries to the hand that are diagnosed beyond the patient’s initial hospitalization. These types of injuries were not captured in this review.

A limitation of our study is the retrospective nature of the review. However, this is minimized by the fact that the data were taken from a prospectively collected database, for which data are entered throughout a patient’s hospitalization by a trained trauma registry nurse. We excluded conspicuous hand injuries to gain a greater understanding of our health system’s ability to detect occult hand injuries as well as the risk factors for a delayed diagnosis. We also excluded distal radius fractures, as orthopedic surgeons manage these particular injuries in our health network. We are unable to conclude if the patients in this study had negative functional outcomes or required additional surgical intervention because of a delay in diagnosis. Further studies should examine whether patients experiencing a delayed diagnosis indeed undergo surgical intervention that may not have been initially required.

This is the first study from a United States Level 1 Trauma Center to look specifically at the delayed diagnosis of hand injuries. As seen in previous studies,<sup>17,20</sup> an elevated ISS and decreased GCS were significant factors contributing to a delay in diagnosis. Hand injuries are particularly important, and although rarely life-threatening, can lead to a prolonged recovery, a delay in return to work or school,<sup>37</sup> and a diminished quality of life.<sup>38</sup> This has significant economic implications.<sup>6,7,37,39–42</sup> Most hand injuries, however, are not difficult to diagnosis based on a thorough history and physical examination combined with appropriate supporting imaging studies.<sup>43,44</sup>

**CONCLUSIONS**

With an increase in ISS and decreased GCS, trauma patients are increasingly at risk for delayed diagnosis of hand injuries with a concomitantly increased LOS. As a delayed diagnosis of hand injuries has significant physical and economic implications for patients, every effort should be made to expedite diagnosis in the polytrauma patient. A standardized evaluation of the trauma patient with a focused tertiary survey is mandatory, particularly in patients with an altered mental status or with multiple injuries. Further, special attention should be directed at the phalanges and metacarpals, specifically assessing for findings associated with an occult fracture. A delayed diagnosis of hand injuries may be unavoidable, however, particularly in patients with multiple traumatic injuries or an altered mental status.

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