

Hand Surgery Transfers to Level 1 Center: Variables Affecting Transfer Method and Diagnostic Accuracy

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Background: We hypothesize that some costly patient transfers to a level 1 trauma center for hand specialist management may be unnecessary. This analysis evaluates transfer cost effectiveness and whether time of consult, transfer distance, diagnosis at time of transfer, and provider level influence diagnostic accuracy and transport method.

Methods: Two hundred and sixty-five patients transferred to a suburban level 1 trauma center for hand surgeon evaluation between 2014 and 2019 were evaluated for patient and injury characteristics, time of consult, transfer distance, provider level, transport method, treatment cost, and diagnostic accuracy.

Results: The average patient age was 36.2 years, and 80.3% were men. 21% of transfers had inaccurate pre-transfer diagnoses, and certain pre-transfer diagnoses correlated with an increased likelihood of inaccuracy, including flexor tenosynovitis and vascular injury. Patients with a language barrier had a greater likelihood of being transferred with an inaccurate diagnosis ($P < 0.05$). Compared with ground transport, air ambulance was associated with a higher cost of treatment (\$225,679 versus \$133,887, $P < 0.00001$). Of all transfers, 14 (5%) were discharged from the emergency department (ED) without a procedure, 9 (3%) were admitted for observation, 73 (27%) had an ED procedure before discharge, and 166 (62%) received operative management.

Conclusions: Over 30% of transfers to a level 1 trauma center likely could have been managed at the transferring facility at a decreased cost. Certain diagnoses are associated with increased risk for diagnostic error and unnecessarily urgent transport. Providers can use this information to consider transfer patterns and to educate transferring providers. (*Plast Reconstr Surg Glob Open* 2020;8:e3279; doi: 10.1097/GOX.0000000000003279; Published online 22 December 2020.)

INTRODUCTION

Our level 1 trauma center receives many patients with upper extremity injuries transferred for higher level care by hand-surgery-trained specialists. Our institution strives to accept all patients appropriate for transfer and provide the needed level of care. However, hand surgeons at our institution have observed that not all transferred patients required urgent hand surgery evaluation and treatment. Many patients could have been managed at the referring facility or triaged to outpatient follow-up. These unnecessary or inappropriate transfers for a perceived need for a

higher level of care are not only financially burdensome to the patient and healthcare system, but also are inefficient.

Prior studies of upper extremity trauma transfers have demonstrated that 39% of transfers did not involve formal surgical intervention within the first 24 hours after transport, supporting the concept that many urgent transfers are not actually urgent.¹ Another study found that only 10% of upper extremity transfers required emergent surgery, and that 53% of transfers did not actually require evaluation by a hand surgeon.²

A few studies have evaluated potential risk factors for inappropriate transfers. These studies have confirmed that unsurprisingly, transfers involving “off-hours” and uninsured patients are more likely to be deemed inappropriate.³⁻⁵

Furthermore, method of transport may be unnecessarily costly. Ozer et al. found that 65% of helicopter transfers for a possible replant involved patients or injury characteristics that were prohibitive of replant.⁶ This is an important consideration, especially as the median air ambulance service cost soared to \$30,000 in 2017.^{7,8} These

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costs create a significant financial burden for patients that they are likely unaware of at the time of transfer.

This analysis seeks to build upon prior literature by determining which referring center, patient, and injury characteristics affect diagnostic accuracy, method of transport, and patient management. The authors also seek to analyze the cost effectiveness of certain transfers. We hypothesize that patient and provider factors can be identified that lead to unnecessary, costly transfers to a level 1 trauma center for hand specialist management.

METHODS

Data Collection

A retrospective review of transfer records from a single suburban level 1 trauma center was assessed from 2014 to 2019. During this time, 285 patients were transferred to our facility for hand surgeon evaluation. Twenty patients were excluded for incomplete records. The remaining 265 transfer records were assessed for patient and injury characteristics, day and time of consult, referring provider level, insurance at time of billing, cost of medical management at receiving facility, accuracy of pre-transfer diagnosis, and post-transfer patient management. Transfers occurring on weekends and between 6pm and 6am were considered “off hours.” Referring center level (1, 2, 3, or no trauma-level designation) and availability of hand or orthopedic specialty care was also noted. All accepted hand transfers were approved by the hand surgeon on call at our facility. Management was categorized as either discharge from the emergency department (ED) without any procedure, hospital admission without procedure, procedure performed in the ED, or formal surgical procedure in the operating room (OR). Some patients discharged from the ED were judged to be more appropriate for outpatient follow-up or outpatient surgery scheduling. Transfer method (ground or air), distance, and time between outside assessment and evaluation in our ED was also recorded.

Statistical analysis: Descriptive analysis was performed to determine average patient characteristics, management strategies, and diagnostic accuracy associated with each transfer diagnosis. Chi-square analysis was performed for categorical variables, and analysis of variance used for continuous variables, to determine which independent variables were associated with management strategies, air versus ground transport, and diagnostic accuracy.

RESULTS

The average age of the patient was 36.2 ± 20.6 years, and 80.3% were men. An estimated 44 (16.6%) patients had a documented language barrier requiring an interpreter. Of the patients scheduled for transfer, 113 (42.6%) were transferred on a weekend, and 136 (51.3%) transfers occurred between 6pm and 6am; transfer of these patients were categorized as “off hours” transfers. Nineteen (7.2%) patients were transferred from another level 1 facility, 40 (15.1%) from a level 2, 7 (2.6%) from a level 3, and 199 (75.1%) from a facility without a trauma-level designation. Totally, 12 (4.5%) patients were transferred with the work-up primarily performed by a physician’s assistant, and 197

patients (74.3%) were transferred from facilities reporting availability of hand or orthopedic specialty services. Availability of orthopedic or hand specialty care from the referring facility was not associated with diagnostic accuracy (Table 1). Based on the available records, it could not be discerned how many patients were seen by a subspecialist before transfer.

Forty-six (17.4%) patients were transferred by air. We found that mean time for air transport was 5.5 hours (range, 2–12 hours) and also 5.5 hours (range, 1–24 hours) for ground transport, but a longer mean air transfer distance mostly accounts for this similarity. Mean air transfer distance was 166 miles (range, 19.5–333 miles), versus 63.5 miles (range, 4.6–471.0 miles) for ground transport. Longer interfacility distance and amputation as a pre-transfer diagnosis were associated with increased utilization of air transport ($P < 0.05$). Air transport was more likely to be associated with an OR procedure ($P < 0.05$). Compared with ground transport, air transport was also found to be associated with a higher cost of medical care, excluding the price of transport (\$225,679 versus \$133,887, $P < 0.00001$).

Patient diagnoses on transfer and diagnostic accuracy associated with each transfer diagnosis are listed in Table 2. Of all transports, 213 (80.4%) had a pre-transfer diagnosis consistent with diagnosis on arrival. However, vascular injury, flexor tenosynovitis, fracture, and septic arthritis were most likely to carry an inaccurate diagnosis (42%, 56%, 59%, and 67% diagnostic accuracy, respectively).

An estimated 14 (5.3%) patients were managed with discharge from the ED without a procedure, 9 (3.4%) were hospitalized without a procedure, 74 (27.9%) were

Table 1. Patient Demographics and Potential Variables Associated with Diagnostic Inaccuracy during Transfer

Variable (no. patients)	% Patients	P*
Diagnosis during transfer		0.25
Patient age		0.65
Patient gender		0.22
Woman (52)	19.7%	
Man (213)	80.3%	
“On hours” versus “off hours”		0.25
“On Hours,” 6am–6pm (129)	48.7%	
“Off Hours” (136)	51.3%	
Weekday (152)	57.4%	
Weekend (113)	42.6%	
Referring provider level		0.71
Physician assistant (12)	4.5%	
Physician (253)	95.5%	
Referring center specialist availability		0.41
Yes (197)	74.3%	
No (68)	25.7%	
Referring center level		0.012
1 (19)	7.2%	
2 (40)	15.1%	
3 (7)	2.6%	
No trauma designation (199)	75.1%	
Language barrier		0.02
Requiring a translator (44)	16.6%	
Insurance		0.072
Private (98)	37.0%	
Medicaid (81)	30.6%	
Workers’ compensation (50)	18.9%	
Medicare (26)	9.8%	
Uninsured (10)	3.8%	

* P value to determine the possible association of variable with diagnostic inaccuracy, calculated using chi-square or analysis of variance.

managed with an ED procedure, and 168 (63.4%) were managed with an OR procedure. Transport from a level I trauma center was most likely to be associated with an OR procedure ($P < 0.001$). Decreasing referring center trauma level was associated with an increased risk of diagnostic inaccuracy ($P < 0.05$).

Insurance was made up of 37.0% private, 30.6% state Medicaid, 18.9% workers' compensation, 9.8% Medicare, and 3.8% uninsured. Type of insurance was not associated with an increased risk of diagnostic accuracy; however, our data include insurance status at the time of billing, not upon transfer.

CONCLUSIONS

Patient transfer for specialty care is essential for many conditions involving the upper extremity. Making the distinction between conditions requiring urgent transfer to a higher level of care and those that can be managed in a lower acuity facility or in the outpatient setting may relieve the healthcare system and patient from unnecessary financial burden. Understanding characteristics associated with inaccurate diagnoses or unnecessary transfers is critical to improving the efficiency of our transfer system.

Previous studies have demonstrated that uninsured patients are unfortunately associated with unnecessary risk of transfer.³⁻⁵ Friebe et al. demonstrated this pattern and also that nonbusiness hours were associated with "inappropriate transfers." Similarly, Petkovic et al. reviewed all hand transfers to their tertiary care center over 1 year and found that "second shift" was significantly associated with inappropriate transfers.⁹ Conversely, we did not find that "off hours" were associated with unnecessary transfer. This lack of an association of either insurance or "off hours" with unnecessary transfers supports the concept that many unnecessary transfers are simply related to diagnostic inaccuracy.

Specialist evaluation at a referring hospital has not been shown to deter transfer of patients, suggesting that

the lack of resources (rather than clinical knowledge) may also be a significant factor in the decision to transfer in some cases.⁹ When looking at this variable, we also found that specialist availability did not affect likelihood of transfer. This may mean that specialists are not readily available at certain centers or do not consistently take call for hand emergencies.

We found that a language barrier requiring an interpreter was associated with diagnostic inaccuracy on transfer. This may be because translation services are not available at all facilities. Alternatively, patients with a language barrier may be more likely to have their care unnecessarily escalated to avoid difficult conversations requiring time and cost associated with translators.^{10,11} Previous studies have shown that non-English-speaking patients, even with the use of an interpreter, are more likely to have their comments ignored or misunderstood.¹² Translator services through phone encounters are associated with decreased patient satisfaction compared with video encounters, although both are rated inferiorly to the use of an in-person translator.¹³

Our analysis demonstrates that certain pre-transfer diagnoses are more commonly inaccurate, and that approximately 21% of patients had an inaccurate pre-transfer diagnosis. The transfer diagnoses most associated with inaccuracy were vascular injury requiring repair, flexor tenosynovitis, and fracture. Our findings are consistent with a recent study by Ortiz et al, which describes diagnostic inaccuracy in 33% of transfers, and higher diagnostic inaccuracy with infection and dysvascularity.¹⁴ These inaccuracies may be due to inexperience of the referring provider or assigning a more "urgent" diagnosis to relieve the referring center of a patient for which no specialist is willing to care. If the true explanation for this phenomenon is a lack of clinical knowledge or exposure, assisting referring providers with the diagnosis of these conditions can save a patient from an unnecessary transfer. Sharing photographs or radiographs between referring and accepting providers may help more accurately diagnose a patient's condition and determine the urgency of transfer. In the authors' experience, several "partial amputations" or infectious conditions can be triaged by photographs. For example, a photograph of a partial amputation might assist the consulting physician in describing how a wound can be appropriately dressed or closed before referral to an outpatient center, rather than resulting in an urgent transfer. Similarly, the referring physician can more confidently convey the urgency of the patient's condition. Additionally, our analysis demonstrated that a number of dislocations were inappropriately transferred as "fractures" without a reduction attempt at the referring facility; shared radiographs via sources such as Care Everywhere within Epic (Epic Systems Corporation, Verona, Wis.) and clearer communication between providers would have resulted in more timely care and decreased cost to the patient.

A few illustrative cases shown in Figures 1 and 2 demonstrate transfers in which exchange of photographs may have prevented an unnecessarily expensive transfer. Figure 1 illustrates a case of Raynaud's disease in

Table 2. Transfer Diagnosis and Diagnostic Accuracy

Transfer Diagnosis	Total	# Accurate (%)	# Inaccurate (%)
Amputation	47	47 (100%)	0
Blast	5	5 (100%)	0
Compartment syndrome	2	1 (50%)	1 (50%)
Crush injury	3	3 (100%)	0
Deep infection	11	7 (63.6%)	4 (36.4%)
Degloving injury	5	3 (60%)	2 (40%)
Dislocation	7	7 (100%)	0
Dog bite	2	2 (100%)	0
Flexor tenosynovitis	18	10 (55.6%)	8 (44.4%)
Foreign body	2	2 (100%)	0
Fracture	22	13 (59.1%)	9 (40.9%)
Gunshot wound	5	5 (100%)	0
Injection injury	1	1 (100%)	0
Laceration	21	14 (66.7%)	7 (33.3%)
Necrosis	1	0	1 (100%)
Necrotizing infection	4	4 (100%)	0
Nerve injury	1	1 (100%)	0
Partial amputation	82	71 (86.6%)	11 (13.4%)
Perilunate dislocation	1	1 (100%)	0
Septic arthritis	3	2 (66.7%)	1 (33.3%)
Superficial infection	4	4 (100%)	0
Tendon injury	6	5 (83.3%)	1 (16.7%)
Vascular injury	12	5 (41.7%)	7 (58.3%)



Fig. 1. Bilateral hands of a middle-aged woman with Raynaud's disease who was transferred for a vascular injury.



Fig. 2. Left index finger paronychia infection, transferred as a case of purulent flexor tenosynovitis.

middle-aged woman who was transferred by ground ambulance during off-hours for a vascular injury without a history of trauma. After improving in our ED with warming, she was discharged from the ED with instructions to perform warm water soaks and to take nifedipine, and to follow up as an outpatient. [Figure 2](#) demonstrates a young man with a paronychia infection, who was transferred for flexor tenosynovitis by ground ambulance for 35 miles during off-hours. This patient was managed with a bedside paronychia decompression from a junior resident before being discharged from our ED. Both cases emphasize the opportunity for better communication, where exchange

of a clinical photograph and counseling from the specialty provider might have changed the diagnosis, improved patient care, and lessened the patient's financial burden.

Use of telehealth has been explored in the field of upper extremity surgery.¹⁵ The application of telemedicine technology as applied to emergent hand consultation has been proved to decrease the number of unnecessary transfers and transfer costs. According to Tripod et al.¹⁶ after implementation of a telemedicine system for emergent hand consultation between rural hospitals and a centralized university system, unnecessary transfers decreased by 20% and transport costs decreased by 17% in a 1-year period.

Transferring a patient to an outside facility invokes under-appreciated consequences for patients. In our series, 68 (26%) of patients were transferred >100 miles, which causes challenges for transportation home following discharge and follow-up care. Treating patients locally, when appropriate, decreases the travel, time, and financial burden for often a socioeconomically disadvantaged group.¹⁷ If a patient is to be transferred, the referring provider should consider the economic burden of air ambulance, which can cost as much as 10 times the cost of ground transport.⁸ For example, of the 46 patients transferred by air, 4 patients in particular incurred transfer costs that exceeded the cost of their injury management at our facility ([Table 3](#)).^{7,8} All patients shown in [Table 2](#) were managed by a junior resident with a bedside procedure, which likely could have been appropriately conducted by another on-call specialist at the referring facility, or by staff in the ED. The use of air ambulance in these cases did not change patient management or outcome, but amounts to financial burden for the patient and unnecessary stress for families, who are unable to travel with the patient. In contrast, transport by private vehicle is an affordable option that should not change outcomes for most hand injuries, and that allows family to travel with the patient.

There are limitations to this analysis. This single center suburban experience may not mimic experiences throughout the United States. However, the authors believe that the regional transfer patterns and long distances traveled are common at many hand surgical emergency accepting facilities. While the data were carefully reviewed by the authors, inherent errors in data entry and variability in outside documentation on review of patient records may have affected results similar to all retrospective reviews. Specialist availability was analyzed at the time of data analysis; any changes between then and the original time of transfer would not be reflected in our data.

In conclusion, the authors encourage healthcare providers to consider their own transfer patterns, and how

Table 3. Case Examples of Transport Cost Exceeding Injury Management Costs*

Off-hours	Insurance	Transfer Distance (miles)	Transfer Method	Diagnosis on Transfer	Diagnosis on Arrival	Management	Cost of Management
No	Medicare	138	Air	Partial amputation	Laceration	Bedside procedure	\$12,139
No	Uninsured	52	Air	Partial amputation	Partial amputation	Bedside procedure	\$12,750
Yes	Uninsured	57	Air	Amputation	Amputation	Bedside procedure	\$5,162
Yes	Private	258	Air	Partial amputation	Partial amputation	Bedside procedure	\$17,274

*Based on cost estimate of mean air transport > \$30,000.^{7,8}

more effective communication might reduce unnecessary transfers, improve patient care, and preserve medical resources. Appreciation of the costs associated with ground and air ambulance should encourage providers to carefully assess the benefit and burden of each method before transferring a patient. Additionally, we urge accepting and referring providers, EDs, and health care systems to consider the advantages of telemedicine to aid in the assessment and treatment of hand emergencies for better quality patient care and an improved value of care.

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