Published in final edited form as:

J Hand Surg Am. 2017 August ; 42(8): 610–617.e2. doi:10.1016/j.jhsa.2017.04.004.

Effect of policy change on the use of long-distance transport and follow-up care for patients with traumatic finger amputations

Michael T. Nolte, BS¹, Melissa J. Shauver, MPH², Kevin C. Chung, MD, MS³, and Aviram M. Giladi, MD, MS⁴

¹University of Michigan Medical School, Ann Arbor, MI, USA

²Clinical Research Coordinator, Department of Surgery, Section of Plastic Surgery, University of Michigan Medical School, Ann Arbor, MI, USA

³Professor of Surgery, Section of Plastic Surgery, Assistant Dean for Faculty Affairs, University of Michigan Medical School, Ann Arbor, MI, USA

⁴Resident, Department of Surgery, Section of Plastic Surgery, University of Michigan Medical School, Ann Arbor, MI, USA

Abstract

Purpose—In January 2006, the American College of Emergency Physicians (ACEP) released updated guidelines for air transfer. Digit amputation and near-amputation were no longer an indication for this costly service. We analyzed the effect of this update on the use of air transport and associated care outcomes for finger amputation patients, and examined factors involved in providing follow-up care for these patients.

Methods—A retrospective chart review identified all patients treated for traumatic finger amputation between 1995 and 2012 at a major hand trauma referral center. Analysis of available outcome measures was conducted using multiple logistic and linear regression models. Analysis of factors affecting frequency of return visits was performed via negative binomial regression.

Results—724 patients with isolated traumatic finger amputations were identified. 267 (37%) were transferred from an outside hospital. Patients injured after 2006 were less likely to be transferred via air, with a decrease from 29.5% pre-2006 to 14.9% post-2006. There was no difference in likelihood of replantation success, length of hospital stay, or number of return visits pre- versus post-2006. Patients transferred via helicopter after 2006 were more likely to be under 20 years of age and injured in a winter month. Following successful replantation, work-relatedness was associated with a higher number of return visits, whereas increasing age and transfer from >100 miles away were associated with fewer.

Corresponding author and reprint requests sent to: Aviram M. Giladi, MD, MS, Section of Plastic Surgery, The University of Michigan Health System, 1500 E. Medical Center Drive, 2130 Taubman Center, SPC 5340, Ann Arbor, MI 48109-5340, Phone: 734-936-5885, Fax: 734-763-5354, aviram@med.umich.edu.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Conclusions—After the ACEP policy update, decreased use of emergency air transport to a hand trauma referral center for patients with traumatic finger amputations did not adversely affect care delivery and outcomes. These changes may be successfully implemented on a center-by-center basis to reduce costs without detriment to patient care; however, coordination of follow-up care for long-distance transport patients may require special focus when designing policy around referral centers.

Level of Evidence—Therapeutic, Level IV

Keywords

amputation; helicopter; policy change; transfer; transport

Introduction

Time constraints may limit successful revascularization for traumatic hand injuries with vascular compromise.^{1,2} Therefore, emergency physicians and hand surgeons strive to ensure efficient and timely transfer to a tertiary care center equipped to perform revascularization, when indicated. One such option is to use emergency air services. Emergency air services are available for patients with a finger amputation in at least fourteen different countries, and are supported by over thirty private air transport organizations.³ However, this transfer modality can carry an enormous cost.⁴ In 2010, it was estimated that transfer via helicopter cost \$6000 more than a transfer via traditional ground ambulance.⁵ Therefore, this service has been frequently cited as overused and unnecessary, especially in regard to hand injuries resulting in finger amputation.^{6–9} In 2006, these suggestions were reflected in the release of the Official Guidelines for Air Medical Dispatch, published by the American College of Emergency Physicians (ACEP).¹⁰ This updated statement provided greater detail and specific indications for the use of air transport, and stated that the amputation or near-amputation of a finger or thumb is not an indication for transfer via this service.¹¹ The protocol applied to both adult and pediatric populations.

Despite these updates to the written guidelines, it is unclear whether real changes in the use of this costly service for finger amputations have occurred. It is estimated that up to one-third of all transfers via emergency air services do not adhere, in one or more ways, to the current transfer and triage guidelines.¹² Furthermore, if these guidelines were to be successfully administered in a particular region, it is unknown how they would affect care delivery and outcomes. Issues surrounding patient transfer are important because efforts to understand the value and quality of regionalized care, in which a central hospital is responsible for providing a specialized service to the surrounding area, is an area of interest for clinicians, hospital administrators, and healthcare purchasers.^{13–15} This is especially true considering the Affordable Care Act and a growing emphasis on cost savings as well as high-quality care delivery.^{16,17}

By compiling a database of all patients treated for traumatic finger amputations at a single tertiary care center over a 16-year period, spanning 8 years before the 2006 protocol update to 8 years afterwards, our aim was to determine if such guideline changes can result in decreased use of emergency air transportation, and if so, what effect these changes have on

outcomes. We also analyzed factors that influenced the continued use of emergency air transport after the 2006 guideline change. Lastly, we evaluated factors related to long-term follow-up for these patients, especially as related to long-distance transport. In analyzing a single major referral center that provides a specialized service for a large region, we aimed to discern how these changes may impact the quality of care on a center-by-center basis, and to identify factors that may affect post-discharge follow-up for patients transferred to a specialized care center.

Materials and Methods

Patient Database

A retrospective chart review was performed to identify all patients treated for traumatic finger amputation between 1995 and 2012 at a major hand trauma referral center. An initial screen was performed using ICD-9 codes specific to finger amputations. Because CPT codes are often inadequate to reflect the details of the patient encounter and surgery performed, as well as the success of the revascularization, we reviewed the medical record for each patient identified by ICD-9 code. Inclusion criteria for this study were all patients with amputations distal to the metacarpophalangeal (MCP) joint of any digit, including the thumb, regardless of age. Patients with non-traumatic amputations were excluded from the study. In addition, patients described as having a “tip laceration” or “deep laceration” not resulting in amputation or need for revascularization were excluded from the study. If the patient had a major injury, such as an open long-bone fracture or vascular compromise of the extremity proximal to the MCP joint, or any other condition that influenced the method of transfer, they were excluded. We did not exclude bony or soft tissue injuries at or distal to the metacarpophalangeal joints, whether in the amputated digit(s) or other digits.

Comprehensive demographic information was collected for each patient. Data unique to the traumatic episode included age at time of injury, work-relatedness, method of transfer and transfer distance (when available), ischemia time from injury to presentation at the tertiary care center, season of year, and pre- versus post-2006. Transfer distance was calculated in miles using a straight-line calculation between the outside hospital and the destination trauma center. Summer season was identified based on the 3 months (June, July, August) with the highest average temperature in the region of interest. The winter season was similarly identified as December, January, and February. Injuries were identified as “post-2006” if they occurred after January 31, 2006, as the updated guidelines were published in January 2006. Injuries identified as “pre-2006” occurred on January 31, 2006 or earlier. The outcomes collected included success of revascularization, length of hospital stay, number of re-operations, number of follow-up visits, and post-operative complication percentage for 6 months following the initial injury. Neither hand function scores nor patient satisfaction measures were available. Analysis of return visits was performed separately for patients with successful replantation and patients with a revision amputation, in an effort to avoid confounding from the difference in procedure complexity and need for follow-up. There were no other substantial changes to care protocols or hand trauma management guidelines at our institution during the period of study. This study and the collection of data were approved by an institutional review board.

Statistical Analysis

A multivariable logistic regression model was developed to assess factors affecting whether a patient was transferred via emergency air services. Independent variables include sex, age, work-relatedness, transfer distance, type of injury (avulsion, blast, and sharp), pre vs. post-2006, and season. Fisher's exact test was used to compare relevant categorical measures before and after 2006. These included the proportion of patients who underwent a replantation attempt and the proportion of replantation attempts that were successful. An unpaired t-test was used to compare linear values before and after 2006. These included length of hospital stay, number of reoperations, number of return visits, and number of complications. Logistic regression was used to assess factors affecting whether a patient was transferred via emergency air services after 2006 (versus before 2006). These models included patient age, transfer distance, injury type, season of the year, work-relatedness of the injury, and smoking status. Lastly, negative binomial regression was used to assess factors that affect the number of return visits. Statistical significance for all tests was established at $p < 0.05$.

Published replantation success rates in the United States range from 50% to 85%.^{18–20} We consider the difference of 35% between the high end of this range and the low end of this range as an indicator of clinically significant difference in digit amputation care quality – indicating that if a center had a 35% change in replantation success rate that would reflect a clinically significant difference. Based on this conservative estimate, a power analysis for this study design indicates that with alpha 0.05, Beta 0.2 (Power 0.8), and a sampling ratio of 1 (no change in clinical volume), we would need 25 patients in each group to identify a significant difference in the proportion of replantation attempts that were successful pre- versus post-2006.

Results

Factors Influencing Transfer via Helicopter

A total of 724 total patients with isolated traumatic finger amputations were identified, and 267 (37%) were transferred from an outside hospital. Of those transferred, a total of 64 (24.0%) were via helicopter (Table 1). Prior to 2006, 29.5% of transfers occurred via helicopter, whereas 14.9% of transfers after 2006 occurred via helicopter. A multivariable logistic regression model demonstrated that, of all transferred patients, those with injuries after 2006 were significantly less likely to be transferred by helicopter (OR=0.24, 95% CI: 0.01 – 0.71, $p < 0.05$) (Table 2). In addition, patients in each transfer distance category greater than 50 miles were significantly more likely to be transferred by helicopter. Of note, patient age, sex, mechanism of injury, season of year, and work-relatedness of the injury had no statistically significant effect on whether the patient was transferred via helicopter.

Comparison of Outcomes Measures

Comparative analysis pre- versus post-2006 was performed for both patients transferred via helicopter and all transferred patients. There was no statistically significant difference in the proportion of replantation attempts that were successful, length of hospital stay, and number of return visits between pre- and post-2006 for either patient category (Table 3). The number

of reoperations ($p<0.05$) and the complication rate ($p<0.05$) were both significantly lower for patients transferred post-2006 via helicopter in comparison to patients transferred pre-2006 via helicopter. There was no statistically significant difference for these outcomes measures in the category containing all transferred patients. In addition, there was no significant difference in replantation attempt percentage or transfer distance for either group of patients.

Ischemia time from injury to presentation was available for 265 patients. Of those, 64 underwent attempted replantation with 41 successful procedures. The mean ischemia time for patients who experienced a replantation attempt did not significantly differ from those who did not undergo replantation (Table 4). Similarly, the mean ischemia time for patients with a successful replantation did not significantly differ from those who had an unsuccessful replantation (Table 4). Logistic regression models were used to see if, in the sub-group with available data, ischemia time predicted replantation attempt or replantation success. For both, the results were not significant (OR=0.99, 95% CI: 0.87 – 1.15, $p=0.95$ for attempt, OR=1.13, 95% CI: 0.77 – 1.65, $p=0.55$ for success). There was also no difference in mean ischemia time from pre-2006 to post-2006, for both the all-transferred patients group and for the helicopter transfer-only group (Table 3). Additional regression results are included in Appendix 1–3.

Continued Use of Transfer via Helicopter After 2006

Despite release of the new ACEP guidelines, 15 (14.9%) patients were transferred via emergency air transport after 2006. Injury to a patient age 20 years or less (OR 22.24, 95% CI: 4.90 – 100.88, $p<0.05$) and injury during a winter month (OR=23.20, 95% CI: 2.34 – 230.39, $p<0.05$) were associated with an increased likelihood for the use of this service after 2006 (Table 5). Positive smoking status (OR=0.23, 95% CI: 0.06 – 0.82, $p<0.05$) and a work-related injury (OR=0.11, 95% CI: 0.03 – 0.39, $p<0.05$) were both associated with a decreased likelihood for the use of emergency air transport after 2006. There was no significant association between transfer distance or injury type and the continued use of this service.

Follow-Up Care

Method of transport alone was not predictive of number of return visits. For patients who underwent successful replantation, both patient age (IRR=0.92, 95% CI: 0.86 – 0.98, $p<0.05$) and transfer distance of greater than 100 miles (IRR=0.24, 95% CI: 0.08 – 0.75, $p<0.05$) were inversely associated with the number of return visits (Table 6). In addition, work-relatedness was directly associated with the number of return visits (IRR=1.81, 95% CI: 1.04 – 3.15, $p<0.05$). Of note, there was no correlation between presence of complications or transfer distance less than 50 miles with the number of return visits. Patient age and transfer further than 100 miles were inversely correlated, and work-relatedness of injury directly correlated, with number of return visits when analyzed amongst all patients, both replantation and revisions combined (Appendix 4). However, these significant correlations were no longer present when analyzing patients who underwent a revision amputation alone (Appendix 5).

Discussion

Following the 2006 ACEP guideline update, patients with finger amputation injuries were significantly less likely to be transferred via emergency air services, with a substantial relative decrease in the use of this service from 29.5% of all transferred patients pre-2006 to 14.9% post-2006. In addition, these changes were accomplished without loss of clinical volume or ability to delivery emergency surgical care. These findings suggest that adopting this guideline to decrease the use of a costly service, while maintaining clinical volumes and quality, is an attainable goal for individual care centers.

Despite the decreased use of helicopter transport, there was no worsening of available outcome measures in comparing pre-2006 versus post-2006. There was also no significant difference in the distance traveled for all patients transferred pre- versus post-2006, suggesting that the reduction in transfer via helicopter was not simply attributable to serving fewer patients from further outside facilities. In addition, our results suggest that the consistency in outcome measures was independent of ischemia time. Although there are many factors that may influence the outcome measures analyzed in this study, these data suggest that reducing the use of emergency air transport in favor of ground ambulance without adversely affecting patient care is an attainable goal. This single-center study could benefit from a larger sample and increased statistical power, but these data accumulated over a 16-year period should be encouraging to care centers adopting similar protocol changes.

It must be noted that the use of helicopter transfer did continue after 2006. This finding may reflect that full implementation of a guideline can take several years. It also may shed light on scenarios for which this service may still be warranted, despite explicit guidelines against it. For example, replantation for a younger patient is likely more cost-effective than the same procedure in an elderly patient.²¹ It is therefore understandable for emergency physicians and hand surgeons to be less concerned with incurring a costly transfer if the potential benefit to the patient is greater. However, with further understanding as to how transfer timing and method affects outcomes, this utilization for younger patients may also be found to be unnecessary. Patients who smoke were less likely to be transferred via helicopter. An underlying reason for this is unclear, but may stimulate future investigation regarding disparities in care delivery following finger amputation. The findings regarding work-relatedness may reflect complexities of care coverage, and a decreased willingness of certain payers to reimburse for the costly service.²² Lastly, the increased likelihood for air transfer for an injury in the winter months likely reflects the decreased safety of ground transportation on Midwestern winter roads as compared to summer months.⁹ This final point is actually addressed in the guidelines, which state that air transfer is appropriate when replantation is indicated and ground transport is unavailable. Lastly, our findings regarding mechanism of injury and outcomes of care were consistent with previous literature, adding validity to our database and analytical models.^{23–26}

Our findings support prior reports that younger patients are likely to attend more follow-up appointments.^{27,28} In addition, we found that patients who experienced a work-related finger amputation were likely to come for more return visits. However, the further a patient was transferred (greater than 100 miles), the fewer appointments they were likely to attend

regardless of how they were transferred to our center at time of injury. Of note, the factors mentioned above were not associated with number of return visits for patients following revision amputation. As the complexity of a surgical intervention increases, the variability in extent of follow-up care and number of return visits also increases.²⁹ A focus on complex procedures like finger replantation may have high yield for future efforts to understand factors affecting follow-up after long-distance transfers for complex care.

The statistical analysis in this study is limited by small sample size. This is especially true for the comparison of care outcome measures following replantation attempt, for which we were under-powered according to our power analysis, and for our findings that there were no adverse changes in available measures over the 16-year period. Replantation care quality data, including the likelihood of success, were included nonetheless, as each additional successful replantation is clinically meaningful. In regards to the generalizability of these data, one must consider that the institution in this study is the primary replant referral center for a large Midwestern state, in addition to drawing from parts of surrounding states. The case volume represented at this institution is consistent with the actual volume seen at similar referral centers, and although some of the subgroups in this study have limited data, this is a true representation of clinical care delivery for a regional replantation center. In light of this volume, confidence intervals for odds ratios calculated by logistic regression modeling are wide, indicating that these estimates are somewhat imprecise. We have chosen to include these data nonetheless in order to stimulate the development of hypotheses for future research

A particularly interesting finding was that reoperation and complication rates both decreased after 2006 for patients transferred via helicopter. Data from this analysis encompassed a 16-year period. Although the approach to finger amputations has not substantially changed over this time, it is likely that surgical outcomes have generally improved owing to strides forward in perioperative care, infection control, and patient management. This is consistent with similar surgical case series that have spanned several years.^{30,31} In addition, we did not control for number of amputated digits or severity/level of finger injury with each patient. Although we have no reason to believe that the diversity of injury types would have changed substantially year to year, this also may have contributed to these findings if the case mix was not balanced. Another possibility is that patients have increasingly sought follow-up care close to home, and therefore complications did not present as frequently to our tertiary care center. Despite these possible contributing factors, they are unlikely to mask all underlying deficits or adverse outcomes attributable to the reduction in emergency air transfer.

As previously mentioned, the guidelines offer an exception for the use of air transfer when replantation of a digit is indicated and ground transport is unavailable. Although it is unclear how this would influence our findings, it is unlikely that the availability of ground transfer changed considerably after the year 2006. Finally, distance from outside hospital and the tertiary care center was used in our analysis of return visits and follow-up care. While a more appropriate measure may have been the distance between the patient's home and the care center, or the site of injury and care center, these distances could not be calculated due

to the lack of comprehensive billing records from patients in our database from the 1990s. These may be points of interest for future prospective studies.

Our findings suggest that the ACEP guideline may be successfully implemented on a center-by-center basis to reduce costs without reduction in clinical volume or clear worsening in patient care outcomes. Patient groups who continue to have disproportionately high rates of helicopter transfer after the guideline change, especially patients under 20 years old, warrant more thorough evaluation, either to reduce this overuse or consider exceptions to the guidelines. Lastly, work-relatedness, patient age, and transfer distance had a significant impact on the number of return visits for patients with successful replantation, suggesting that funding status and travel distance are important in understanding how to provide high-quality healthcare for patients transferred long distances to a regional referral center. Future studies should address whether the ACEP policy changes have been effective on a national level. Such research may also help guide future protocol changes aimed at reducing costs and improving patient outcomes.

Acknowledgments

Research reported in this publication was supported by the National Institute of Arthritis and Musculoskeletal and Skin Diseases of the National Institutes of Health under Award Number 2 K24-AR053120-06 (to Dr. Kevin C. Chung). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

References

1. Lin CH, Aydyn N, Lin YT, Hsu CT, Lin CH, Yeh JT. Hand and Finger Replantation After Prolonged Ischemia (More Than 24 Hours). *Ann Plast Surg*. Mar; 2010 64(3):286–290. [PubMed: 20179474]
2. O'Brien BM, Miller GD. Digital reattachment and revascularization. *J Bone Joint Surg Am*. Jun; 1973 55(4):714–724. [PubMed: 4283743]
3. Wigman LD, van Lieshout EM, de Ronde G, Patka P, Schipper IB. Trauma-related dispatch criteria for Helicopter Emergency Medical Services in Europe. *Injury*. May; 2011 42(5):525–533. [PubMed: 20381803]
4. Gearhart PA, Wuerz R, Localio AR. Cost-effectiveness analysis of helicopter EMS for trauma patients. *Ann Emerg Med*. Oct; 1997 30(4):500–506. [PubMed: 9326865]
5. Medicare Ambulance Services. [Accessed 6/23/14, 2014] 2011. <https://www.medicare.gov/coverage/ambulance-services.html>
6. Friebe I, Isaacs J, Mallu S, Kurdin A, Mounasamy V, Dhindsa H. Evaluation of appropriateness of patient transfers for hand and microsurgery to a level I trauma center. *Hand*. Dec; 2013 8(4):417–421. [PubMed: 24426959]
7. Amis B, Friedrich J. Differences in treatment of digital amputation injuries based on community transfer versus tertiary initial presentation. *Hand*. Sep; 2012 7(3):259–262. [PubMed: 23997728]
8. Bauer AS, Blazar PE, Earp BE, Louie DL, Pallin DJ. Characteristics of emergency department transfers for hand surgery consultation. *Hand*. Mar; 2013 8(1):12–16. [PubMed: 24426887]
9. Ozer K, Kramer W, Gillani S, Williams A, Smith W. Replantation versus revision of amputated fingers in patients air-transported to a level I trauma center. *J Hand Surg Am*. Jun; 2010 35(6):936–940. [PubMed: 20488629]
10. Guidelines for Air Medical Dispatch: Policy Resource and Education Paper. American College of Emergency Physicians; Approved January 2006
11. EMS Committee. Appropriate utilization of air medical transport in the out-of-hospital setting. *Ann Emerg Med*. Sep.1999 34(3):420. [PubMed: 10459108]

12. Tiamfook-Morgan TO, Kociszewski C, Browne C, Barclay D, Wedel SK, Thomas SH. Helicopter scene response: regional variation in compliance with air medical triage guidelines. *Prehosp Emerg Care*. Oct-Dec;2008 12(4):443–450. [PubMed: 18924007]
13. Petersen LA, Normand ST, Leape LL, McNeil BJ. Regionalization and the underuse of angiography in the veterans affairs health care system as compared with a fee-for-service system. *New Engl J Med*. May 29; 2003 348(22):2209–2217. [PubMed: 12773649]
14. Chappidi MR, Kates M, Stimson CJ, Johnson MH, Pierorazio PM, Bivalacqua TJ. Causes, timing, hospital costs and perioperative outcomes of index vs nonindex hospital readmissions after radical cystectomy: implications for regionalization of care. *J Urol*. 2017 Feb 28; 197(2):296–301. [PubMed: 27545575]
15. Warner CJ, Roddy SP, Chang BB, Kreienberg PB, Sternbach Y, Taggart JB, Ozsvath KJ, Stain SC, Darling RC III. Regionalization of Emergent Vascular Surgery for Patients With Ruptured AAA Improves Outcomes. *Ann Surg*. 2016 Sep 1; 264(3):538–43. [PubMed: 27433898]
16. Orynich CA, Casamassimo PS, Seale NS, Reggiardo P, Litch CS. The Affordable Care Act and health insurance exchanges: effects on the pediatric dental benefit. *Pediatr Dent*. Jan-Feb;2015 37(1):23–29. [PubMed: 25685969]
17. Hoffmann SM. Health insurance exchanges under the Patient Protection and Affordable Care Act: regulatory and design challenges. *J Am Coll Radiol : JACR*. Dec; 2012 9(12):881–886. [PubMed: 23206645]
18. Morrison WA, McCombe D. Digital replantation. *Hand Clinics*. 2007 Feb 28; 23(1):1–2. [PubMed: 17478248]
19. Kleinart HE, Jablon M, Tsai TM. An overview of replantation and results of 347 replants in 245 patients. *J Trauma Acute Care Surg*. 1980 May 1; 20(5):390–8.
20. Tamai S. Digit replantation. Analysis of 163 replantations in an 11 year period. *Clin Plast Surg*. 1978 Apr; 5(2):195–209. [PubMed: 679604]
21. Sears ED, Shin R, Prosser LA, Chung KC. Economic analysis of revision amputation and replantation treatment of finger amputation injuries. *Plast Reconstr Surg*. Apr; 2014 133(4):827–840. [PubMed: 24352209]
22. Cameron P, Dziukas L, Hadj A, Clark P, Hooper S. Major trauma in Australia: a regional analysis. *J Trauma*. Sep; 1995 39(3):545–552. [PubMed: 7473922]
23. Urbaniak JR, Evans JP, Bright DS. Microvascular management of ring avulsion injuries. *J Hand Surg Am*. Jan; 1981 6(1):25–30. [PubMed: 7204914]
24. Sears ED, Chung KC. Replantation of finger avulsion injuries: a systematic review of survival and functional outcomes. *J Hand Surg Am*. Apr; 2011 36(4):686–694. [PubMed: 21463730]
25. Tark KC, Kim YW, Lee YH, Lew JD. Replantation and revascularization of hands: clinical analysis and functional results of 261 cases. *J Hand Surg Am*. Jan; 1989 14(1):17–27. [PubMed: 2723364]
26. Waikakul S, Sakkarnkosol S, Vanadurongwan V, Un-nanuntana A. Results of 1018 digital replantations in 552 patients. *Injury*. Jan; 2000 31(1):33–40.
27. Cypress BK. Characteristics of Physician Visits for Back Symptoms - a National Perspective. *Am J Public Health*. 1983; 73(4):389–395. [PubMed: 6219588]
28. Alessandrini EA, Lavelle JM, Grenfell SM, Jacobstein CR, Shaw KN. Return visits to a pediatric emergency department. *Pediatr Emerg Care*. Mar; 2004 20(3):166–171. [PubMed: 15094574]
29. Joshi AB, Gill GS, Smith PL. Outcome in patients lost to follow-up. *J Arthroplasty*. Feb; 2003 18(2):149–153. [PubMed: 12629603]
30. Bratzler DW, Hunt DR. The surgical infection prevention and surgical care improvement projects: national initiatives to improve outcomes for patients having surgery. *Clin Infect Dis*. 2006 Aug 1; 43(3):322–30. [PubMed: 16804848]
31. Jarnagin WR, Gonen M, Fong Y, DeMatteo RP, Ben-Porat L, Little S, Corvera C, Weber S, Blumgart LH. Improvement in perioperative outcome after hepatic resection: analysis of 1,803 consecutive cases over the past decade. *Ann Surg*. 2002 Oct 1; 236(4):397–407. [PubMed: 12368667]

Appendix 1. Factors affecting length of hospital stay

Variable	Coefficient	p	95% Confidence Interval	
Injury Type				
Avulsion	-0.74	0.12	-1.69	0.20
Blast	2.22	<0.05 *	0.32	4.11
Sharp	0.29	0.49	-0.54	1.13
Crush	Reference	-	-	-
Other				
Transfer	-0.15	0.70	-0.87	0.58
Work-Related	0.42	0.26	-0.30	1.14

* Indicates statistical significance of $p < 0.05$

Appendix 2. Factors affecting likelihood for a successful replantation procedure

Variable	Odds Ratio	p	95% Confidence Interval	
Age ^A	0.97	0.26	0.91	1.03
Ischemia Time ^B	1.13	0.55	0.77	1.65
Smoker	0.97	0.67	0.39	2.04
Work-Related	1.72	0.85	0.43	3.22
Injury Type				
Avulsion	7.22	0.21	0.34	15.15
Blast	0.66	0.35	0.05	2.86
Sharp	28.32	<0.05 *	1.50	53.45
Crush	Reference	-	-	-
Transfer Method				
Helicopter	0.48	0.97	0.15	1.89
Ground	1.13	0.96	0.27	3.45
Self	Reference	-	-	-

^A OR, CI, and p calculated for each 1 year increase in age

^B OR, CI, and p calculated for each 1 hour increase in ischemia time

* Indicates statistical significance of $p < 0.05$

Appendix 3. Factors affecting likelihood of a replantation attempt

Variable	Odds	Ratio	p	95% Confidence Interval
Age ^A	1.00	0.75	0.97	1.02
Ischemia Time ^B	0.99	0.95	0.87	1.15
Smoker	0.73	0.87	0.36	1.78

Variable	Odds	Ratio	p	95% Confidence Interval
Work-Related	1.33	0.61	0.85	2.02
Injury Type				
Avulsion	0.65	0.54	0.16	2.59
Blast	0.32	<0.05*	0.07	0.75
Sharp	1.49	0.87	0.58	2.96
Crush	Reference	-	-	-
Transfer Method				
Helicopter	0.74	0.72	0.14	4.00
Ground	1.38	0.67	0.31	6.12
Self	Reference	-	-	-

^AOR, CI, and p calculated for each 1 year increase in age

^BOR, CI, and p calculated for each 1 hour increase in ischemia time

* Indicates statistical significance of p<0.05

Appendix 4. Factors affecting the number of return visits following traumatic finger amputations, all patients

Variable	IRR	p	95% Confidence Interval	
Age	0.98	<0.05*	0.96	1.00
Work-Related	1.38	<0.05*	1.13	1.67
Complication (Y/N)	1.11	0.30	0.91	1.34
Transfer <50 miles	1.35	0.10	0.94	1.95
Transfer >100 miles	0.60	<0.05*	0.41	0.88

* Indicates statistical significance of p<0.05

Appendix 5. Factors affecting the number of return visits for patients with revision amputation following traumatic finger amputation

Variable	IRR	p	95% Confidence Interval	
Age	0.99	0.53	0.97	1.01
Work-Related	1.20	0.08	0.98	1.47
Complication (Y/N)	0.98	0.83	0.80	1.20
Transfer <50 miles	1.13	0.54	0.77	1.65
Transfer >100 miles	0.72	0.12	0.48	1.08

Table 1

Cohort breakdown by transfer method and study time period.

Category	Pre-2006	Post-2006	Total
All Patients	n=377	n=348	n=724
All Transfers	n=166	n=101	n=267
Transfer Method			
Helicopter	n=49 (29.5%)	n=15 (14.9%)	n=64 (24.0%)
Ground Ambulance	n=92 (55.4%)	n=77 (76.2%)	n=169 (63.3%)
Self	n=25 (15.1%)	n=9 (8.9%)	n=34 (12.7%)

Established deadline for Pre-versus Post-2006 is January 31, 2006.

Table 2

Factors affecting the likelihood for transfer via helicopter of a patient with isolated traumatic finger amputation.

Variable	Odds Ratio	p	95% Confidence Interval	
Age				
<20 years	1.27	0.70	0.37	4.36
21–30 years	0.26	0.09	0.06	1.22
31–40 years	Reference	-	-	-
41–50 years	1.01	0.98	0.35	2.95
51–60 years	0.58	0.39	0.16	2.04
>60 years	0.41	0.22	0.01	1.71
Transfer Distance				
<25 miles	0.45	0.20	0.05	1.69
25–50 miles	Reference	-	-	-
51–100 miles	12.27	<0.05 *	1.31	115.22
101–200 miles	13.36	<0.05 *	1.40	127.37
>200 miles	183.66	<0.05 *	10.36	3256.82
Injury Type				
Avulsion	0.75	0.63	0.23	2.42
Blast	3.32	0.19	0.55	20.17
Sharp	2.03	0.13	0.82	5.05
Crush	Reference	-	-	-
Season of Year				
Summer	0.28	0.05	0.08	1.01
Winter	1.40	0.43	0.61	3.18
Other				
Work-Related	1.29	0.62	0.48	3.47
Smoker	0.75	0.48	0.34	1.66
Post-2006 Revision	0.24	<0.05 *	0.01	0.71

* Indicates statistical significance of $p < 0.05$

Table 3

Comparison of key measures before and after 2006 ACEP protocol change.

Variable	Helicopter Transfers			All Transfers		
	Pre-2006	Post-2006	p	Pre-2006	Post-2006	p
Replantation Attempt Percentage	24.5% (n=12)	13.3% (n=2)	0.49	24.1% (n=40)	18.8% (n=19)	0.36
Replantation Success Percentage	66.7% (n=8)	50.0% (n=1)	1.00	75.0% (n=30)	63.2% (n=12)	0.37
Length of Hospital Stay	1.83	1.73	0.92	2.42	1.80	0.28
Number of Return Visits	4.65	4.53	0.91	4.53	3.94	0.24
Number of Reoperations	1.10	0.20	<0.05*	0.58	0.79	0.16
Complication Percentage	69.0%	30.8%	<0.05*	54.0%	57.6%	0.68
Transfer Distance (Miles)	67.54	90.08	0.14	69.56	70.26	0.93
Ischemia Time (Hours)	4.17	4.60	0.76	4.20	4.22	0.98

* Indicates statistical significance of p<0.05

Mean ischemia time (hours) from injury to ED presentation, by procedure type and outcome (n = 265 with available data).

Table 4

Replantation Attempt	Replantation Non-Attempt	Difference in Means	P-Value	95% Confidence Interval	
4.117	4.239	0.122	0.81	-0.900	1.143

Table 5

Replantation Success	Replantation Fail	Difference in Means	P-Value	95% Confidence Interval	
3.841	4.609	0.767	0.37	-0.933	2.468

Table 6

Factors affecting whether a patient was transferred via emergency air services after 2006 (versus before 2006).

Variable	Odds Ratio	p	95% Confidence Interval	
Age				
<20 years	22.24	<0.05 *	4.90	100.88
20 to 40 years	Reference	-	-	-
40 to 60 years	2.06	0.50	0.25	16.82
>60 years	5.03	0.21	0.70	36.15
Transfer Distance				
<50 miles	1.07	0.95	0.12	9.19
50–100 miles	Reference	-	-	-
100–200 miles	1.22	0.83	0.20	7.48
>200 miles	1.03	0.98	0.12	8.60
Injury Type				
Avulsion	3.57	0.12	0.72	17.81
Blast	0.92	0.94	0.11	7.51
Sharp	0.90	0.89	0.21	3.91
Crush	Reference	-	-	-
Season of Year				
Summer	0.44	0.16	0.14	1.38
Winter	23.20	<0.05 *	2.34	230.39
Other				
Work-Related	0.11	<0.05 *	0.03	0.39
Smoker	0.23	<0.05 *	0.06	0.82

* Indicates statistical significance of $p < 0.05$

Table 7

Factors affecting the number of return visits for patients with successful replantation following traumatic finger amputation.

Variable	IRR	p	95% Confidence Interval	
Age	0.92	<0.05 *	0.86	0.98
Work-Related (Y/N)	1.81	<0.05 *	1.04	3.15
Complication (Y/N)	1.56	0.07	0.97	2.52
Transfer <50 miles	2.79	0.06	0.94	8.31
Transfer >100 miles	0.24	<0.05 *	0.08	0.75

* Indicates statistical significance of $p < 0.05$