



Management of Extremity Injuries by Residents: Can We improve Quality and Efficiency through a Simple Checklist?

¹Kamran S Hamid MD, MPH, ²Benedict U Nwachukwu MD, MBA, ³Bret A Nicks MD, MHA, ⁴Sayon Dutta MD, MPH, ⁵Eben A Carroll MD

ABSTRACT

Introduction: Variation in practice among resident physicians is a barrier to providing consistent, high-quality care to patients with musculoskeletal injuries.

Materials and methods: A multidisciplinary group at an academic center developed a checklist for managing suspected extremity injuries in adults. Simulation testing was conducted in which 17 Emergency Medicine residents were randomized by year of training into cohorts of 8 “checklist” residents and 9 “no checklist” residents. Each resident performed 2 case simulations and was evaluated based on adherence to 12 predefined critical process measures.

Results: Usage of the checklist resulted in a decrease in delay of care events (8.3 vs 27.3%, $p < 0.01$) and decrease in potential medical errors (5.7 vs 22.2%, $p < 0.01$). All levels of training demonstrated improvements, and first-year residents using the checklist performed significantly better than third-year residents without the checklist, demonstrating decrease in delay of care events (8.3 vs 26.4%, $p < 0.05$) and decrease in potential medical errors (5.6 vs 18.1%, $p < 0.05$).

Conclusion: Implementation of a simple checklist can reduce delays in care and potential medical errors in the management of extremity injuries by resident physicians.

Keywords: Checklist, Cost, Education, Efficiency, Emergency medicine, Extremity, Fracture, Injury, Orthopaedics, Quality, Throughput, Value.

Hamid KS, Nwachukwu BU, Nicks BA, Dutta S, Carroll EA. Management of Extremity Injuries by Residents: Can We improve Quality and Efficiency through a Simple Checklist? *The Duke Orthop J* 2016;6(1):7-11.

Source of support: Nil

¹Fellow, ²Resident, ^{3,5}Associate Professor, ⁴Instructor

¹Department of Orthopaedic Surgery, Duke University Medical Center, Durham, North Carolina, USA

²Department of Orthopaedic Surgery, Hospital for Special Surgery, New York, USA

³Department of Emergency Medicine, Wake Forest Baptist Medical Center, Winston-Salem, North Carolina, USA

⁴Department of Emergency Medicine, Massachusetts General Hospital, Boston, Massachusetts, USA

⁵Department of Orthopaedic Surgery, Wake Forest Baptist Medical Center, Winston-Salem, North Carolina, USA

Corresponding Author: Kamran S Hamid, Fellow, Department of Orthopaedic Surgery, Duke University Medical Center 4709 Creekstone Drive, Durham, North Carolina-27703, USA, Phone: +2149243280, e-mail: kamranhamid@gmail.com

Conflict of interest: None.

IRB statement: This simulation was undertaken as part of an institutional quality improvement project and was granted Institutional Review Board exemption.

INTRODUCTION

Extremity injuries are common and result in an estimated 8 million visits to US emergency departments (EDs) per year.^{1,2} There is an abundance of literature focused on diagnosis, classification, prognosis, and treatment options for these injuries, but there is a dearth of investigation on the delivery of care for this subset of injuries. The interface between ED physicians and orthopaedic surgeons is currently an unexplored area of health care delivery science. There exists a rich potential to improve outcomes by analyzing variations in practice patterns and standardizing protocols to treat musculoskeletal injury. Specifically, variation in care delivery by trainees is an area ripe for study.

Medical centers often target improvement of discrete quality metrics linked to reimbursement (e.g., “never pay” events, readmissions) with unintentional de-emphasis of overall systems of care.³ Systems engineering approaches may result in decreased preventable harms and improved patient value (health outcomes per dollar spent).⁴⁻⁷ To our knowledge, there has been no previous study evaluating the value of care delivered by residents to patients with extremity injuries that present to the ED.

The desire for checklists as a centerpiece for systems of care in academic centers has gained attention through frequent citing of the airline industry’s high rate of success with checklists in executing complicated tasks not dissimilar to those in healthcare.⁸ The rapid increase in checklist usage may have been catalyzed by two seminal studies conducted in the past decade. In 2006, Pronovost et al⁹ published findings on a checklist-based intervention that resulted in a significant reduction in catheter-related bloodstream infections in a Michigan hospital intensive care unit (ICU) patients as part of the keystone initiative. The checklist intervention was found to have substantial cost savings in addition to improved safety.¹⁰ In 2009, Gawande’s group demonstrated significant decreases in surgery-related mortality and complications due to

implementation of the World Health Organization’s safe surgery checklist in a multitude of varied medical centers across the globe.¹¹ Additionally, Gawande’s book “The Checklist Manifesto” has revealed the potency of checklists to a broader audience.¹²

Checklists have earned widespread popularity in health care though it is unknown what proportions of these instruments have undergone rigorous scientific validation prior to implementation. Use of nonvalidated checklists may have no effect on care or potentially result in worse value for patients. Emergency department physicians are inundated with algorithms, protocols, and checklists, which can result in “checklist fatigue” and decreased overall compliance.¹³ Implementation of an additional checklist tool must be done cautiously so as to enhance the workflow of ED physicians, not become another burden.

While there are many cultural and operational barriers to the uptake of a checklist for extremity injuries that present to the ED, our first priority is to ensure that the proposed checklist has been constructed in a scientific fashion and undergone appropriate vetting prior to implementation including simulation.^{8,14-17} We hypothesized that a scientifically developed, parsimonious checklist for evaluation and treatment of patients with extremity injuries presenting to the ED can reduce potential medical errors and delay in care events when utilized by residents. To evaluate the efficacy of this checklist in achieving our goals, we carried out a randomized simulation study utilizing ED resident physicians in a simulated ED environment.

MATERIALS AND METHODS

Checklist Development

The checklist was developed through a literature review of evidence-based processes deemed critical in the management of patients with extremity injuries. A multidisciplinary group consisting of emergency medicine physicians, orthopaedic surgeons, internal medicine specialists, musculoskeletal radiologists, trauma surgeons, and nurses convened via a modified Delphi Method arrived at the critical process steps deemed imperative for inclusion in our institution’s extremity injury checklist. Taking into account parsimony and the institution’s sociopolitical environment, a checklist was drafted utilizing previously described methodology and using a “checklist for checklists” as a guide.^{8,18} The “extremity injury checklist” underwent several revisions after trial runs in simulated scenarios with attending ED physicians and ancillary staff. A simple checklist tool with 12 critical process steps was refined for simulation pilot testing.

Randomized Simulation Study

All emergency medicine residents at our institution who were not currently working a shift or away were recruited to participate in two scenarios simulating management of extremity injuries in a mock ED room. The 17 available residents were stratified by postgraduate year (PGY) of training: 6 PGY-1 residents, 5 PGY-2 residents, and 6 PGY-3 residents. Within each year, the residents were randomly assigned to be in a “checklist” usage cohort or “no checklist” cohort (Flow Chart 1).

Due to rapid turnover of ED resident personnel and expansion of our health system to outside facility EDs, the study group aimed to develop an instrument that required no formal training. The checklist cohort was only given the checklist as a guide upon entering the simulation room and received no explicit instruction on its usage.

Participants interacted with the simulation team and were directly observed by two independent physician reviewers for adherence to the 12 predefined critical process measures (Table 1). Failure to adhere to critical process measures during the appropriate pause point or altogether was classified as a “delay in care event.” “Potential medical errors” were defined as failure to

Flow Chart 1: Recruitment and randomization of ED resident physician participants

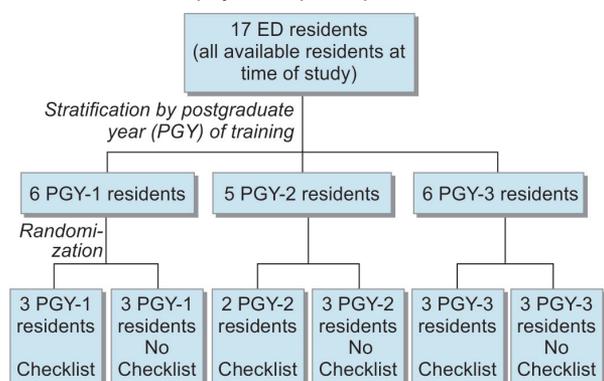


Table 1: Critical process measures

1. Secondary survey (including circumferential direct visualization of limb for open injury)
2. Evaluation of pulse
3. Identification of nonorthopaedic conditions
4. Appropriate plain film radiography
5. Administration of tetanus and evidence-based choice of antibiotics for open injury
6. Review of radiography by qualified individual
7. Collaboration with orthopaedic or hand consultant for operative conditions
8. Patient notified of condition and included in shared decision making
9. Adequate pain control measures
10. Review of feasibility of disposition prior to leaving the ED (e.g., appropriate placement of splint, able to use crutches, review postreduction x-rays for acceptable reduction of fracture or dislocation)
11. Medical optimization addressed prior to discharge
12. Disposition confirmed with discharging provider

address a critical process measure during the entire care cycle of the simulated patient. Should there have been disagreement between the two reviewers, a third reviewer would make the final decision though this arbitration process was never necessary.

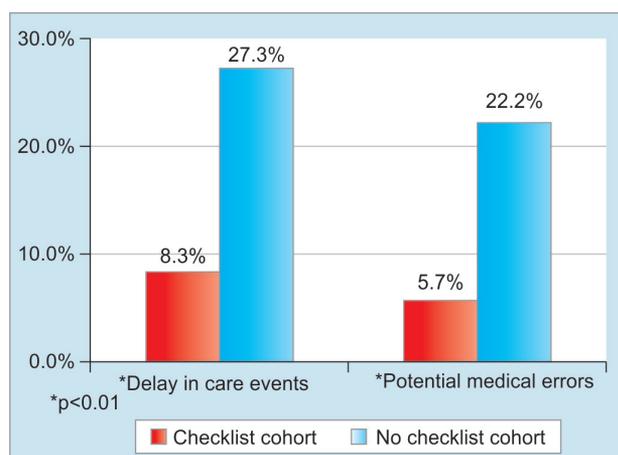
Percentages were used to summarize outcome rates with and without the checklist. The data analysis was performed with SAS version 9.2 software (SAS Institute Inc., Cary, NC, USA). All p -values were two-sided and $p < 0.05$ were considered significant.

RESULTS

Agreement between independent physician reviewers was excellent ($A = 1.00$) likely due to the discrete nature of the endpoints.

Usage of the checklist resulted in universally improved performance with a decrease in delay of care events (8.3 vs 27.3%, $p < 0.01$) and decrease in potential medical errors (5.7 vs 22.2%, $p < 0.01$) compared with those without the checklist (Graph 1). All levels of training demonstrated improvements in these metrics with no identifiable effect measure modification.

There were no significant differences in outcome measures with pairwise comparison of residents without checklists by year of training (e.g., "PGY-1 without checklist vs PGY-2 without checklist"). Additionally, pairwise comparison of residents with checklists by year of training demonstrated no significant differences (e.g., "PGY-1 with checklist vs PGY-2 with checklist"). However, second-year residents with the checklist showed trends in improvement over third-year residents without the checklist in decrease in delay of care events (10.4 vs 26.4%, $p = 0.07$) and decrease in potential medical errors (6.3 vs 26.4%, $p = 0.10$). First-year residents using the checklist performed significantly better than third-year residents without the checklist in decrease in delay of care events (8.3 vs 26.4%, $p < 0.05$) and decrease in potential medical errors (5.6 vs 18.1%, $p < 0.05$).



Graph 1: Association between usage of extremity injury management checklist and primary outcome measures; $*p < 0.01$

DISCUSSION

Despite increased focus on safety since the Institute of Medicine's landmark report "To Err is Human" in 1999, preventable patient harms throughout the US health care system remain unacceptably high.¹⁸⁻²² Orthopaedic surgeons and emergency medicine specialists are not immune to this phenomenon—the Patient Safety Committee of the American Academy of Orthopaedic Surgeons has found that medical errors remain a persistent threat to the safety of patients with musculoskeletal conditions and have thus called for quality assurance efforts and research in the field of preventable patient harms.²³ Efforts to move toward high-quality, expeditious care of patients presenting with extremity injuries to academic medical centers with resident and fellow physicians should be a priority. As described previously, checklists have enjoyed success in surgical and ICU settings but their implementation in the ED setting for musculoskeletal injuries has been surprisingly sparse considering their demonstrated potential efficacy. To our knowledge, this checklist represents the first attempt in the literature at developing a checklist-based system of care to manage orthopaedic injuries in the ED setting.

In addition to quality, efficiency of care is also a primary concern as the nation's emergency facilities are experiencing patient volumes in excess of current capacities—volumes that are projected to increase further with an aging population and increased access to care.²⁴⁻²⁸ Expedient management of extremity injury patients and decreased variation in practice not only improves ED throughput globally, it also results in decreased costs.²⁹ Improved quality outcomes with decreased costs result in increased patient-centric value. As US health care transitions from volume-based to value-based reimbursement models, value-enhancing initiatives, such as this will be highly rewarded.⁴⁻⁷ Institutions with trainees should develop systems of care where they provide similarly high value as other centers while still meeting the goal of education.

In this context, our findings of efficacy in simulation testing of an extremity injury checklist are a reassuring first step in developing a sophisticated system of care for patients with musculoskeletal conditions presenting to ED resident physicians. Randomization and high interobserver reliability are two strengths of this study contributing to its internal validity. Strengths of the instrument itself are its scientific development and ability to be translated into an effective tool without the need for formal training. Limitations of this study include inability to blind subjects or observers and resultant potential for information bias through differential misclassification, small sample size, as well as lack of previously validated outcome measures.

While the checklist was specifically developed for usage at an academic level 1 trauma center with trainees, it has minimal discriminatory features and likely

maintains generalizability to outside institutions making it ideal to function as the nucleus of a tele-orthopaedics program between understaffed EDs and tertiary care centers with full-time orthopaedic coverage. In order to serve as an adjunct to care as opposed to an additional layer of paperwork, the checklist is being implemented at our institution in two modes: (1) a large poster on the wall to be used as a reference and (2) as an easy-to-access mobile device app. Neither is part of the formal medical record and both are designed to engage nursing and ancillary staff in order to accelerate care rather than add to the physician's "checklist fatigue."

Gawande and Pronovost have led the charge for safety at the national level through development of checklist-based systems of care in operating rooms and ICUs. We believe that this checklist represents a successful first step for leading the charge at preventable patient harms for musculoskeletal injuries seen in an ED setting. After internal reporting of simulation results, the checklist has been adopted as the centerpiece of a formal quality improvement initiative targeting the ED management of patients with extremity injuries at our medical center. We anticipate our real-world results will support the findings of this simulation and validate the development of systems of care in this arena.

CONCLUSION

Implementation of a simple checklist, even without formal instruction, can reduce delays in care and potential medical errors in the management of extremity injuries by ED residents. Checklist usage improved performance at all levels of training in simulation and enabled first-year trainees to perform at a level higher than senior trainees without access to the checklist. This study represents the first attempt at creating a checklist-based system of care for resident physicians managing the orthopaedic trauma population. We anticipate implementation in a clinical setting will validate this methodology and allow adoption and refinement at other centers.

Practice Points

- Variation in practice among resident physicians remains a barrier to providing consistent, high-quality care.
- Implementation of checklists must be done so after scientific validation.
- A simple checklist can reduce delays in care and potential medical errors in the management of extremity injuries by residents.
- Checklist usage can reduce variation in practice by trainees.
- Well-designed checklists can be cost-effective teaching tools.

REFERENCES

1. Lambers K, Ootes D, Ring D. Incidence of patients with lower extremity injuries presenting to US emergency departments by anatomic region, disease category, and age. *Clin Orthop Relat Res* 2012 Jan;470(1):284-290.
2. Ootes D, Lambers KT, Ring DC. The epidemiology of upper extremity injuries presenting to the emergency department in the United States. *Hand (N Y)* 2012 Mar;7(1):18-22.
3. Pronovost PJ, Bo-Linn GW. Preventing patient harms through systems of care. *JAMA* 2012 Aug 22;308(8):769-770.
4. Porter ME. Value-based health care delivery. *Ann Surg* 2008 Oct;248(4):503-509.
5. Porter ME. A strategy for health care reform—toward a value-based system. *N Engl J Med* 2009 Jul 9;361(2):109-112.
6. Porter ME. What is value in health care? *N Engl J Med* 2010 Dec;363(26):2477-2481.
7. Porter, ME.; Teisberg, EO. *Redefining health care: creating value-based competition on results*. Boston: Harvard Business Review Press; 2006.
8. Weiser TG, Haynes AB, Lashoer A, Dziekan G, Boorman DJ, Berry WR, Gawande AA. Perspectives in quality: designing the WHO Surgical Safety Checklist. *Int J Qual Health Care* 2010 Oct;22(5):365-370.
9. Pronovost P, Needham D, Berenholtz S, Sinopoli D, Chu H, Cosgrove S, Sexton B, Hyzy R, Welsh R, Roth G, et al. An intervention to decrease catheter-related bloodstream infections in the ICU. *N Engl J Med* 2006 Dec 28;355(26):2725-2732.
10. Study shows Keystone program achieved significant savings. *Healthcare Benchmarks Qual Improv* 2011 Nov;18(11):121-123.
11. Haynes AB, Weiser TG, Berry WR, Lipsitz SR, Breizat AH, Dellinger EP, Herbosa T, Joseph S, Kibatala PL, Lapitan MC, et al. A surgical safety checklist to reduce morbidity and mortality in a global population. *N Engl J Med* 2009 Jan 29;360(5):491-499.
12. Gawande, AA. *The checklist Manifesto*. New York: Metropolitan Books; 2009.
13. Thomassen O, Espeland A, Softeland E, Lossius HM, Heltne JK, Brattebo G. Implementation of checklists in health care; learning from high-reliability organisations. *Scand J Trauma Resusc Emerg Med* 2011 Oct 3;19:53.
14. Hales B, Terblanche M, Fowler R, Sibbald W. Development of medical checklists for improved quality of patient care. *Int J Qual Health Care* 2008 Feb;20(1):22-30.
15. Hales BM, Pronovost PJ. The checklist—a tool for error management and performance improvement. *J Crit Care* 2006 Sep;21(3):231-235.
16. Winters BD, Gurses AP, Lehmann H, Sexton JB, Rampersad CJ, Pronovost PJ. Clinical review: checklists—translating evidence into practice. *Crit Care* 2009;13(6):210.
17. Ziewacz JE, Arriaga AF, Bader AM, Berry WR, Edmondson L, Wong JM, Lipsitz SR, Hepner DL, Peyre S, Nelson S, et al. Crisis checklists for the operating room: development and pilot testing. *J Am Coll Surg* 2011 Aug;213(2):212-217.e10.
18. Landrigan CP, Parry GJ, Bones CB, Hackbarth AD, Goldmann DA, Sharek PJ. Temporal trends in rates of patient harm resulting from medical care. *N Engl J Med* 2010 Nov 25;363(22):2124-2134.
19. Kohn, LT.; Corrigan, JM.; Donaldson, MS, editors. *To err is human: building a safer health system*. Washington, DC: National Academies Press; 1999.

20. The IOM medical errors report: 5 years later, the journey continues. *Qual Lett Healthc Lead* 2005 Jan;17:2-10, 1.
21. Berman S. The AMA clinical quality improvement forum on addressing patient safety. *Jt Comm J Qual Improv* 2000 Jul;26(7):428-433.
22. Pronovost P, Wu AW, Dorman T, Morlock L. Building safety into ICU care. *J Crit Care* 2002 Jun;17(2):78-85.
23. Wong DA, Herndon JH, Canale ST, Brooks RL, Hunt TR, Epps HR, Fountain SS, Albanese SA, Johanson NA. Medical errors in orthopaedics: results of an AAOS member survey. *J Bone Joint Surg Am* 2009 Mar 1;91(3):547-557.
24. Halverson S, Malani PN, Newton DW, Habicht A, Vander Have K, Younger JG. Impact of hourly emergency department patient volume on blood culture contamination and diagnostic yield. *J Clin Microbiol* 2013 Jun;51(6):1721-1726.
25. Karaca Z, Wong HS, Mutter RL. Duration of patients' visits to the hospital emergency department. *BMC Emerg Med* 2012 Nov 6;12:15.
26. Keenum AJ, Rawlings LM, Odoi A, Wortley MG, Lamsen L, Jones L, Wallace LS. Tennessee emergency medicine workforce, 2009. *Tenn Med* 2013 Mar;106(3):41-43.
27. McCormick AP, Abubaker AO, Laskin DM, Gonzales MS, Garland S. Reducing the burden of dental patients on the busy hospital emergency department. *J Oral Maxillofac Surg* 2013 Mar;71(3):475-478.
28. Rasch EK, Gulley SP, Chan L. Use of emergency departments among working age adults with disabilities: a problem of access and service needs. *Health Serv Res* 2013 Aug;48(4):1334-1358.
29. Kaplan RS, Porter ME. How to solve the cost crisis in health care. *Harv Bus Rev* 2011 Sep;89(9):46-52, 54, 56-61 passim.