Implementing a Novel Guideline to Prevent Hospital-Acquired Pressure Ulcers in a Trauma Population: A Patient-Safety Approach

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BACKGROUND: The development of hospital-acquired pressure ulcers (HAPUs) is a common complication associated with immobilization and prolonged hospitalization in trauma patients. Our semi-annual Trauma Quality Improvement Program report identified HAPUs as an outlier complication. We used a hospital-wide initiative to reduce the incidence of HAPUs among our trauma patient population. Our study aimed to determine whether the implemented measures would decrease HAPUs incidence rates.

STUDY DESIGN: We reviewed adult trauma patients during a 3-year period. The novel care-based platform and preventive measures for reducing HAPUs included the following components: pressure-reducing beds; improved and protocolized nutritional support; mandatory 2-hour change of posture; turning clocks; early surgical intervention; spot checks by our wound care nurse; and education to patients and caregivers. Paired-sample *t*-test and chi-square analyses were used, with significance defined as $p < 0.05$.

RESULTS: A total of 9,755 patients were admitted to our trauma services in the study period. Of these, HAPUs developed in 89 patients (mean age 57.9 years and 48 [54%] were female). The Injury Severity Score ranged from 1 to 75, with a mean of 20 in patients with HAPUs compared with 8 in patients without HAPUs during the same study period. The incidence of HAPUs at our institution was initially 1.36%, which decreased to 0.98% in year 2 and to 0.39% in year 3 ($p = 0.002$).

CONCLUSIONS: The novel 7-step care-based process changes, acquisition of specialized equipment, and educational initiatives implemented were associated with a significant decrease in the incidence rates of HAPUs. (J Am Coll Surg 2018;226:1122−1127. © 2018 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

Pressure-induced skin and soft-tissue injuries are some of the most common problems encountered in hospitalized patients and those in long-term institutional care, and contributes significantly to morbidity and mortality.[1] Estimates indicate that 1 to 3 million people in the US develop pressure ulcers each year.[2] An estimated 2.5 million pressure ulcers are treated each year in acute care facilities in the US alone, and 60,000 die from pressure ulcer complications each year.[3] According to The National Pressure Ulcer Advisory Panel, the national incidence of pressure ulcers ranges from 2.3% to 23.9% in long-term care, 0% to 17% in home care, and 0% to 6% in rehabilitative care. However, the national overall incidence rate of pressure injuries ranges from 0.4% to 38% of inpatients per year.[4,5]

The Healthcare Cost and Utilization Project report estimated that the average cost of treating pressure injuries is $37,800 per patient.[6] Several studies have reported that mortality rates are as high as 60% for patients with pressure injuries within 1 year of hospital discharge.[7,8] Prevention of pressure ulcers is one of the greatest healthcare

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Table 1. Staging of Pressure Injuries

Stage	Description
1	Nonblanchable erythema of intact skin
2	Partial-thickness skin loss with exposed dermis
3	Full-thickness skin loss with adipose tissue visible
4	Full-thickness skin and tissue loss with visible or palpable fascia, muscle, tendon, ligament, cartilage, or bone
Unstageable pressure injury	Obscured full-thickness skin and tissue loss by sloughing or eschar
Deep-tissue pressure injury	Intact or non-intact skin with localized area of persistent nonblanchable deep red, maroon, purple discoloration or epidermal separation revealing a dark wound bed or blood filled blister

challenges to reducing patient harm.[9] In 2008, the Centers for Medicare and Medicaid Services announced it would no longer pay for additional costs incurred related to hospital-acquired pressure ulcers (HAPUs). Pressure ulcer treatment is costly and resource intensive, and appropriate identification and modification of risk factors can minimize or prevent the development of pressure ulcers through the use of evidence-based clinical practices. However, some pressure ulcers are unavoidable.

In 2016, the National Pressure Ulcer Advisory Panel changed the terminology from *pressure ulcer* to *pressure injury* to eliminate the confusion between intact skin and open ulcer injuries during their Staging Consensus Conference.[4] The current definition of pressure injury is "… localized damage to the skin and/or underlying soft tissue usually over a bony prominence or related to a medical or other device. The injury can present as intact skin or an open ulcer and may be painful. The injury occurs as a result of intense and/or prolonged pressure or pressure in combination with shear. The tolerance of soft tissue for pressure and shear may also be affected by microclimate, nutrition, perfusion, co-morbidities and condition of the soft tissue."[10] Staging of pressure injuries was revamped, and is described in Table 1.

Performance and quality improvement is at the core of all trauma programs. Our institution uses the Trauma Quality Improvement Program to identify opportunities for improvement. Our Trauma Quality Improvement Program risk-adjusted model showed we were in the bottom half of Trauma Centers for HAPUs as did our National Trauma Database analysis. To address this, we initiated and implemented a hospital-wide, care-based platform and preventive measures to reduce HAPUs and improve our patient's outcomes. Our study main objective was to determine whether the measures we implemented would reduce the incidence rate of HAPUs in our trauma population. We predicted that these implemented measures should decrease the incidence rate of HAPUs among our trauma patients.

METHODS

Our prospective intervention targeted measuring the effects of the change and compared the result with a review of our prospectively collected dataset for adult trauma patients, defined as older than 15 years old, in the period from 2014 through 2016 using our institution's Trauma Registry. Our hospital is a designated Florida Department of Health Level I adult and pediatric trauma center. Study population included all adult trauma patients with stage 2 or higher pressure ulcer admitted during the study period. Paired-sample *t*-test and chi-square analyses were used, with significance defined as $p < 0.05$. We evaluated the effects of implementing a novel structural care-based platform and preventive measures on reducing HAPUs incidence rates in our trauma patients. Strategies and measures implemented were the following: use of pressure-reducing beds; improved and protocolized nutritional support; mandatory patient repositioning every 2 hours; clocks for determining the patient repositioning times; early surgical intervention; spot checks by experienced wound care nurse; and education of patients and care providers.

Demographic and outcomes variables were collected and compared between the different groups based on calendar year. Paired-sample *t*-test and chi-square analyses were used, with significance defined as $p < 0.05$.

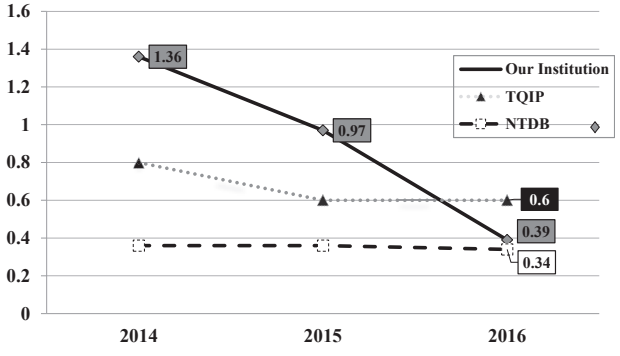

Figure 1. Pressure ulcer stage 2 or higher incidence rate by year comparing Trauma Quality and Improvement Program (TQIP) vs National Trauma Database (NTDB) vs our institution 2014 through 2016.

Table 2. Pressure Ulcerations Staging and Location 2014 Through 2016

Variable	2014, n	2015, n	2016, n	p Value
Patient with hospital-acquired pressure ulcer	42	34	13	<0.05
Pressure ulcer staging				NS
II	41	29	12	
III	1	5	1	
IV	0	0	0	
Pressure ulcer location				NS
Sacral	22	18	8	
Buttocks	9	10	3	
Heal	6	4	0	
Gluteal	5	2	2	

RESULTS

Our study included all trauma patients older than 15 years old admitted during the study. A total of 9,755 patients were admitted to our trauma services in the period from 2014 through 2016. In 89 of these patients, stage 2 or higher HAPUs developed during the same study. In 2014, HAPUs developed in 42 of 3,054 (1.38%) admissions. In 2015, HAPUs developed in 34 of 3,455 (0.98%) admissions. In 2016, HAPUs developed in 13 of 3,246 (0.40%) admissions, a significant decreased compared with 2014 and 2015 ($p < 0.002$, chi-square), as shown in Figure 1. The mean age of patients with pressure ulcers was 57.9 years; 53.9% were female and 46.1% were male. The Injury Severity Score (ISS) in trauma patients with HAPUs ranged from 1 to 75, with a mean of 20, compared with ISS of 8 in trauma patients without HAPUs during the same study period. Mean ISS was 19 in 2014, sixteen in 2015, and increased significantly in 2016 to 24 ($p < 0.05$) in trauma patients with HAPUs, and mean ISS in trauma patients without HAPUs did not change significantly, and was 8 in 2014, nine in 2015, and 8 in 2016 ($p > 0.05$). Pressure ulceration characterization by stage and location for the 89 patients with pressure ulcers are described in Table 2. Spinal cord injuries increased from zero to 8% among patients with HAPUs and remained at a constant rate of 0.8% for patients without HAPUs from 2014 through 2016 ($p > 0.05$). Mortality rates did not change significantly and were 2.4% (1 of 41) in year one, 9.7% (3 of 31) in year 2, and 0% (0 of 13) in year 3 ($p > 0.05$), as shown in Table 3.

DISCUSSION

Skin protection and pressure ulcer prevention is an ongoing goal of the continuum of care. In 2016 compared with 2015, the mean ISS increased from 16 to 24, indicating that we cared for sicker patients, but our HAPU rates declined even more, validating the benefit of our pressure ulcer prevention program. Through re-evaluation and process adjustments, we have found that pressure injury events among our trauma patients decreased significantly, despite the increase in the severity of our patients' injuries. Our findings support our

Table 3. Demographic and Outcomes Variables for Patients with Hospital-Acquired Pressure Ulcers 2014 Through 2016

Variable	2014	2015	2016	p Value
Trauma admission, n	3,054	3,455	3,246	NS
Patient with HAPU, n	42	34	13	<0.05
Age, y, mean	59.1	63.7	50.9	NS
Female with HAPU, %	67	32.4	69	NS
Ethnicity, non-Hispanic, %	64	53	46	NS
Injury Severity Score, mean	19	16	24	<0.05
Spinal cord injury, n (%)				
HAPU	0 (0)	4 (12)	1 (8)	NS
Non-HAPU	25 (0.8)	29 (0.8)	25 (0.8)	NS
Incidence of HAPU, %	1.36	0.975	0.39	0.002
Mortality rate, n/N (%)	1/41 (2.4)	3/31 (9.7)	0/13 (0)	NS

HAPU, hospital-acquired pressure ulcer.

hypothesis that implementing preventative protocols would reduce the incidence rate of pressure ulcers. Our hospital initiative was to establish standards of care in an effort to reduce pressure ulcers in admitted patients. The hospital is part of a larger consortium of hospitals with a common Performance Improvement and Patient Safety committee that requires semiannual approved plans to address trauma center issues identified by our Trauma Quality and Improvement Program reports. Our findings show that with a team approach, adherence to best practice protocols, and appropriate resource use, continuous quality improvement can occur.

There were expenses to this process. Our action plan included hiring a full-time wound care coordinator to track pressure ulcers, deliver wound care, and educate staff about HAPUs. The wound care coordinator was responsible for rounding on patients, as well as conducting spot checks to be sure that the schedule of the turning clocks was being followed. Our institution took initiatives to purchase high-end mobility beds with pressure distributive mattresses (Hill Rom P500; Med Mart). These were placed in the trauma ICU rooms. In-service training was performed as well as educational training at the trauma multidisciplinary conferences on the importance of preventing HAPUs through the use of mobility beds. Training was also devoted to pressure ulcer prevention strategies by identifying patients at high risk for developing pressure ulcers and the need for a specialty bed in these cases. The beds are used to prevent complications associated with immobility, to prevent and reduce progression of pressure ulcers, and to have the capability of doing continuous lateral rotation therapy and percussion/vibration therapy.[11] A wound assessment/reassessment documentation tool and form was created as a tool for more precise wound documentation and daily follow-up using evidence-based examples.[12,13] The trauma medical director provided quarterly educational training to trauma surgeons, residents, and nurses on the importance of implemented measures, such as starting ideal goal-directed nutritional support as early as possible with regular measurement of nutritional parameters.[14] The nutrition team attended sign out rounds twice a week, as well as daily walk rounds with the trauma service. The turning clock was implemented in the same time period, where turning schedules were displayed inside each patient's room to remind nurses of the position the patient has to be placed accordingly.[15] A nursing buddy system was created in the ICU and documentation in writing was required on the wound assessment/reassessment documentation tool. Rounds were made by nursing unit leaders, the ICU director, and the wound care coordinator to confirm appropriate and timely turning positions and full execution of process changes. All nurses were educated on the turning schedules. On-the-spot education was given to nurses not compliant with the turning schedule. The turning tool part was made a part of the patient's medical record to enforce process changes and compliance. A staff member from the physical and occupational therapy services was available at daily sign out to facilitate early mobility.[16]

All staff were responsible for educating patients and their families on the benefits of early mobilization and frequent turning to reduce the risk of pressure ulcers and improve patient outcomes.[17]

Xakellis and colleagues[18] examined the efficacy of an intensive pressure ulcer prevention protocol to decrease the incidence of ulcers in a 77-bed long-term care facility. They evaluated the efficacy of support surfaces and turning/repositioning patients. The 6-month incidence rate of pressure ulcers before the intensive prevention intervention was 23%, but dropped to 5% afterwards.[18] Another study by Thomas in 1996[14] showed reductions in pressure injury incidence rates after performing systematic risk assessment on admission, accurately staging pressure ulcers, using pressure-reducing mattresses, and continuing education of staff.

Similarly, at St Francis Medical Center in Illinois, a comprehensive preventative program was developed that included upgrading mattresses, clarifying staff roles and protocols, and improving measurement and communication of pressure ulcer performance data, which also reduced the incidence rate.[19] Bronson Methodist Health in Kalamazoo, MI, after initiating a skin addendum pathway for all patients at risk, developing a skin map for documentation of a breakdown, conducting a monthly compliance assessment, and accessing a "Wound Care Treatment Guide" on Bronson's intranet web, they were able to reduce their incidence rate from 9.2% to 1.3% during a span of 5 years.[20] The positive implications of our study can establish these guidelines at other trauma centers across the country. As described at DuPont Hospital for Children of the Nemours Foundation, an electronic dashboard can be used to track areas that need improvement, develop plans, and highlight the improvements.[21] The DuPont Hospital program used an Excel (Microsoft) spreadsheet to track indicators, problems, and accomplishments shared among the different departments. The goal of the electronic dashboard was for problems to be easily identified, trended, and acted on. Similarly, another study used a systematic quality improvement process called FOCUS-Plan, Do, Check, Act methodology to measure and improve practice. Complications rates fell to zero for the 39 months after implementation of interventions and outcomes monitoring.[22] We can incorporate these methodologies and ideas into our processes in the future to improve

pressure ulcer rates. Overall, all the centers used a similar approach to improving pressure ulcer incidence, including clarifying roles, changing support mattresses, educating patient/family/staff, and optimizing nutrition. Although slightly different methodologies, there was a significant reduction in HAPUs reported in all studies.

There are some limitations of our study. The first is that although this was a hospital-wide initiative, we only analyzed data from patients on the trauma service. Next, given the complexity of care of these multisystem trauma patients, we were unable to establish the direct correlation between pressure ulcer incidence rate and other outcomes, such as hospital length of stay. It was also difficult to assign a valid numerical value for the expense incurred by a pressure ulcer because of the different staging and numerous factors that contribute to the development of the pressure injury. Many studies still show inconclusive evidence as to whether there are significant differences in the effectiveness of various patient support surfaces in absorptive and pressure distributive properties in preventing pressure injuries. Lastly, we are comparing data between chronological hospital incidence rates after implementing different measures simultaneously. Therefore, we are unable to comment on the relative importance or contribution of each measure individually.

Future studies should investigate other measures that can reduce the incidence rates of hospital-acquired pressure injuries. Some reported therapies to date include galvanic electrical myostimulation, hyperbaric oxygen, and continuous bedside pressure mapping.[23-25] A meta-analysis of 15 studies evaluating the effects of electrical stimulation on the healing of chronic ulcers found that the rate of healing was 22% per week for the electrical stimulation group compared with 9% per week for the control group.[23] Hyperbaric oxygen therapy has also proven to be a successful adjunctive treatment. It mainly increases direct oxygen transport into wounds, facilitates angiogenesis, reduces inflammation, stimulates release of wound matrix stem cells, and improves toxin release.[24] Continuous bedside pressure mapping can be used to show visual pressure values to aid in repositioning. Lower pressures were found when caregivers used the visual feedback from the continuous bedside pressure mapping systems to modify their manipulative therapies.[25,26]

Process changes aimed at reducing HAPUs at our hospital were implemented in 2014 and have continued during a 3-year period with an ongoing re-evaluation and process adjustments as necessary. Implemented changes were sustained through ongoing 7-step novel preventive practices. By analyzing our data and resultant outcomes, we were able to show the effectiveness of these guidelines and propose protocols to improve outliers in the future. In addition to improved resource use and adequate equipment, which were implemented in 2014, a quarterly evaluation by our Quality Assessment and Improvement Team has led to a sustainable and significant decrease in our HAPU rates.

CONCLUSIONS

Our data indicate a significant decrease in HAPU incidence rates after execution of the process changes, despite the significant increase in the injury severity of our study population, indicated by ISS, compared with trauma patients with no HAPUs. Implementing our novel care-based pressure ulcer preventive measures proved to be an effective way to improve outcomes for our patients.

Author Contributions

Study conception and design: Lam, Elkbuli, Benson, McKenney

Acquisition of data: Elkbuli, Benson, Young, McKenney

Analysis and interpretation of data: Lam, Elkbuli, Hai, McKenney

Drafting of manuscript: Lam, Elkbuli, Benson, Young

Critical revision: Lam, Elkbuli, Benson, Young, Morejon, Boneva, Hai, McKenney

REFERENCES

1. Reddy M, Gill SS, Rochon PA. Preventing pressure ulcers: a systematic review. JAMA 2006;296:974.
2. Lyder C, Yu C, Stevenson D, Mangat R, et al. Validating the Braden Scale for the prediction of pressure ulcer risk in blacks and Latino/Hispanic elders: a pilot study. Ostomy Wound Manage 1998;44[Suppl]:42S–49S.
3. Strategies for Preventing Pressure Ulcers, Joint Commission Perspectives on Patient Safety. Available at: http://patientcarelink.org/wp-content/uploads/2017/10/2017-hapu_change_package_508.pdf. Accessed March 23, 2009.
4. Cuddigan J, Ayello EA, Sussman C, et al. Pressure Ulcers in America: Prevalence, Incidence, and Implications for the Future. Reston, VA: National Pressure Ulcer Advisory Panel; 2001.
5. Lyder CH. Pressure ulcer prevention and management. JAMA 2003;289:223.
6. Russo CA, Elixhauser A. Hospitalizations related to pressure sores, 2003. Available at: http://www.hcup-us.ahrq.gov/reports/statbriefs/sb3.pdf. Published April 2006. Accessed March 23, 2009.
7. Allman RM, Goode PS, Patrick MM, et al. Pressure ulcer risk factors among hospitalized patients with activity limitations. JAMA 1995;273:865–870.
8. Thomas DR. Prevention and treatment of pressure ulcers. J Am Med Directors Assoc 2006;7:46–59.
9. Blenman J, Marks-Maran D. Pressure ulcer prevention is everyone's business: the PUPS project. Br J Nursing 2017;26:16–26.

10. National Pressure Ulcer Advisory Panel. Educational and Clinical Resources. http://www.npuap.org/resources/educational-and-clinical-resources. Accessed March 23, 2009.
11. Demarre L, Beeckman D, Vanderwee K, et al. Multi-stage versus single stage inflation and deflation for alternating low pressure air mattresses to prevent pressure ulcers in hospitalized patients: a randomized controlled clinical trial. Int J Nurs Stud 2012;49:416–426.
12. Young DL, Estocado N, Landers MR, Black J. A pilot study providing evidence for the validity of a new tool to improve assignment of national pressure ulcer advisory panel stage to pressure ulcers. Advances Skin Wound Care 2011;24:168–175.
13. Lilly D, Estocado N, Spencer-Smith JB, Englebright J. Validation of the NE1 wound assessment tool to improve staging of pressure ulcers on admission by registered nurses. J Nurse Measure 2014;22:438–450.
14. Thomas DR, Goode PS, Tarquine PH, et al. Hospital-acquired pressure ulcers and risk of death. J Am Geriatr Soc 1996;44:1435–1440.
15. Renganathan BS, Preejith SP, Nagaiyan S, et al. A novel system to tackle hospital acquired pressure ulcers. Conf Proc IEEE Eng Med Biol Soc 2016:4780–4783.
16. Azuh O, Gammon H, Burmeister C, et al. Benefits of early active mobility in the medical intensive care unit: a pilot study. Am J Med 2016;129:866–871.
17. Still MD, Cross LC, Dunlap M, et al. The turn team: a novel strategy for reducing pressure ulcers in the surgical intensive care unit. J Am Coll Surg 2013;216:373–379.
18. Xakellis GC, Frantz RA, Lewis A, et al. Translating pressure ulcer guidelines into practice: it's harder than it sounds. Advance Skin Wound Care 2001;14:249–256. 258.
19. Saint Francis Medical Center. Save our skin: preventing pressure ulcers. Hospitals in pursuit of excellence. http://www.hpoe.org/resources/case-studies/1041. Accessed September 26, 2008.
20. Bronson Methodist Health. Reducing pressure ulcers. Hospitals in pursuit of excellence. http://www.hpoe.org/Case_Studies/BronsonMethodistHealth_Ulcers.pdf. Accessed April 5, 2017.
21. Hochstuhl DC, Elwell S. Plotting performance improvement progress through the development of a trauma dashboard. J Trauma Nurs 2014;21:209–215.
22. Garrett A, Drake SA, Holcomb JB. Effects of a systematic quality improvement process to decrease complications in trauma patients with prehospital peripheral intravenous access. J Trauma Nurs 2017;24:236–241.
23. Gardner SE, Frantz RA, Schmidt FL. Effect of electrical stimulation on chronic wound healing: a meta-analysis. Wound Repair Regen 1999;7:495–503.
24. Bhutani S, Vishwanath G. Hyperbaric oxygen and wound healing. Indian J Plastic Surg 2012;45:316–324.
25. Scott RG, Thurman KM. Visual feedback of continuous bedside pressure mapping to optimize effective patient repositioning. Advance Wound Care 2014;3:376–382.
26. Bhattacharya S, Mishra RK. Pressure ulcers: current understanding and newer modalities of treatment. Indian J Plastic Surg 2015;48:4–16.