CE 1.5 ANCC Contact Hours

Improving Thermoregulation for Trauma Patients in the Emergency Department: An Evidence-Based Practice Project

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ABSTRACT

Extensive evidence exists on the association between hypothermia and increased morbidity and mortality in trauma patients. Gaps in practice related to temperature assessment have been identified in literature, along with limited personnel knowledge regarding management of patients with accidental hypothermia. An interdisciplinary team identified gaps in practice in our institution regarding temperature assessment and documentation of rewarming and initiated an evidence-based practice project to change practice at our institution. The goals were to decrease time to temperature assessment, increase core temperature assessment, and increase implementation of appropriate rewarming methods. This project used the Iowa Model of Evidence-Based Practice to provide a framework for execution and evaluation. We conducted a literature review to address all aspects of hypothermia, including incidence, associated and contributing factors, prevention, recognition, and treatment. This evidence-based knowledge was then applied to clinical practice through staff education and training, equipment availability, and environmental adjustments. More patients with hypothermia and hyperthermia were identified in 2017, as compared with 2016. There was a significant increase in core temperature assessment from 4% in 2016 to 23% in 2017 ($p < .001$). Blanket use in normothermic patients increased in 2017 ($p = .002$). This project is an example of how nurses can utilize an evidence-based practice model to translate research into clinical practice. Best practice interventions regarding temperature assessment and rewarming measures for trauma patients can be successfully implemented with negligible cost. Further research should be dedicated to examine barriers to implementation and adherence to evidence-based practice interventions.

Key Words

Hypothermia, Nursing, Thermoregulation, Trauma

Unintentional injuries are the fourth highest cause of death for Americans and lead to an estimated 28.1 million visits to emergency departments (EDs) yearly (Heron, 2016). Many trauma patients are hypothermic, defined as body temperature of less than 36°C (96.8°F; Block, Lilienthal, Cullen, & White, 2012). Hypothermia has been reported in as many as two-thirds of all trauma patients, of this, 9% present with body temperatures of 33°C (91.4°F) or lower (Farkash et al., 2002).

Extensive evidence exists on the association between hypothermia and increased morbidity and mortality for trauma patients (Balvers et al., 2016; Ireland, Endacott, Cameron, Fitzgerald, & Paul, 2011; Keane, 2016; Langhelle, Lockey, Harris, & Davies, 2010; Simmons, Pittet, & Pierce, 2014; van der Ploeg, Goslings, Walpoth, & Bierens, 2010; Zafren & Mechem, 2017). Along with metabolic acidosis and coagulopathy, hypothermia is a factor in the "triad of death," a cycle that can decrease the success of resuscitation efforts (Keane, 2016; Simmons et al., 2014). Hypothermia leads to peripheral vasoconstriction, followed by lactate buildup and acidosis (Keane, 2016). In addition, hypothermia leads to a decrease in thrombin production, inhibition of fibrinogen synthesis, and impaired platelet aggregation and adhesion. These deleterious effects are seen starting at body temperatures of 36°C (96.8°F) and progressively worsen with further temperature drops (Martini, 2009; Mitrophanov, Rosendaal, & Reifman, 2013; Wolberg, Meng, Monroe, & Hoffman, 2004). Hypothermia increases risk for arrhythmias, which are frequently unresponsive to cardioactive drugs, electrical pacing, and defibrillation (Soar et al., 2010). Other associated complications include multiorgan failure, pulmonary edema, hypoglycemia, hyperkalemia, and infection (American College

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of Surgeons Committee on Trauma, Simon, & Hunt, 2014; Keane, 2016; van der Ploeg et al., 2010). Large multicenter studies have identified hypothermia as a significant and independent predictor of mortality (Balvers et al., 2016; Ireland et al., 2011), making patient temperature an important modifiable risk factor in the ED for mortality among trauma patients. For example, one study found that hypothermic trauma patients who had further temperature drop in the ED had a 50% mortality versus 29.9% mortality among those who did not have further temperature drop (Ireland et al., 2011).

Fortunately, hypothermia is arguably the easiest factor of the triad of death to address (Keane, 2016). Various modalities are available for temperature assessment and detection of hypothermia, such as oral, tympanic, rectal, and bladder thermometers (van der Ploeg et al., 2010). There exist a multitude of rewarming methods with varying degrees of efficacy, including warmed intravenous fluids, warmed blankets, forced-air warming blankets, bladder irrigation, gastric irrigation, and arteriovenous bypass (Paal et al., 2016; van der Ploeg et al., 2010). Trauma nurses should be encouraged to take ownership of vital sign assessment, including early temperature evaluation (Keane, 2016), and initiate appropriate steps for rewarming. Gaps in practice related to temperature assessment have been identified in the literature, along with limited personnel knowledge regarding management of patients with accidental hypothermia (van der Ploeg et al., 2010). At our own institution, an interdisciplinary team identified gaps in practice regarding temperature assessment and documentation of rewarming and initiated an evidence-based practice (EBP) project to change practice.

METHODS

Context

NYU Langone Hospital—Brooklyn (formerly NYU Lutheran Medical Center) is a 450-bed teaching facility located in southwest Brooklyn, New York City. It is a Level I trauma center with more than 75,000 annual ED visits. In 2016, 2,383 trauma cases were evaluated at NYU Langone Hospital—Brooklyn (NYU Langone Medical Center, 2016). The year 2016 marked several milestones for NYU Langone Hospital—Brooklyn, including its first year as part of the NYU Langone Health System, and the launch of a new electronic medical record (EMR).

Approach

Our project utilized the Iowa Model of Evidence-Based Practice to provide a framework for execution and evaluation (Brown, 2014). Thermoregulation in trauma patients was a problem-focused trigger. It was determined that the trigger is of high priority to the ED and trauma program, which facilitated organizational engagement. An interdisciplinary team formed that was charged with developing and implementing EBP change. Relevant publications were gathered and evaluated for reliability, validity, and bias. The team found sufficient research with consistent findings to warrant a practice change. The changes were piloted for a 3-month period to assess for feasibility and any improvement in outcomes.

The clinical nurse specialist (CNS) conducted a systematic search on PubMed for articles pertaining to temperature assessment, incidence, and implications of hypothermia on trauma patients, rewarming methods, and prior EBP projects on thermoregulation for trauma patients. Evidence-based practice interventions were derived from the best available clinical evidence with a focus on clinical expertise and patient values and expectations (Melnyk & Fineout-Overholt, 2014).

Block et al. (2012) developed and implemented a nurse-led, evidence-based protocol to improve temperature control in hypothermic trauma patients. The team sought to expand on its project and conduct a literature review to address all aspects including incidence of hypothermia, associated and contributing factors, prevention, recognition, and treatment. The evidence-based knowledge was then applied to clinical practice through staff education and training, equipment availability, and environmental adjustments. The project's goals were to decrease time to temperature assessment, increase core temperature assessment, and increase implementation of appropriate rewarming methods.

PRACTICE CHANGES

Warmed Blankets

Prevention of hypothermia or further heat loss in trauma patients is a primary concern. Impaired homeostasis, prehospital exposure, and resuscitation efforts can all lead to hypothermia in trauma patients (Keane, 2016). Trauma patients are also fully exposed in the early stages of assessment as part of the primary survey (Emergency Nurses Association, 2014). Warmed blankets are not adequately utilized during trauma evaluation as the team needs access to the patient for acquiring intravenous access, performing a Focused Assessment with Sonography in Trauma, and other assessments and interventions. The team encouraged the use of warm blankets for all patients when exposure was not necessary for medical interventions.

Trauma Bay Temperature

In preparation for the EBP changes, the CNS discussed with leadership from point of care, pharmacy, and central processing whether a room temperature of 80°F would negatively impact equipment and supplies located in the trauma bay. It was determined that temperature change would not disrupt normal storage and function of equipment.

With collaboration from the engineering department, the trauma bay ambient temperature was set to the recommended 80°F (Block et al., 2012; Zafren & Mechem, 2017). Staff were educated about the importance of keeping the trauma bay doors closed at all times to maintain the temperature. In order for the trauma doors to remain closed at all times, extensive reinforcement was required with staff of all disciplines, including nursing, nursing assistants, physicians, and environmental services. Education on the importance of hypothermia prevention for the exposed, critical patient was conducted frequently through huddles. Regular reminders were provided to the staff to ensure that the trauma bay doors remained closed.

Temperature Assessment

Prior studies have shown a pervasive lack of temperature assessment in trauma patients (Block et al., 2012; Ireland et al., 2006; Langhelle et al., 2010). The use of peripheral thermometers to expedite temperature assessment has been promoted in some works (Block et al., 2012; Keane, 2016). However, a systematic review and meta-analysis found that peripheral thermometers lack clinically acceptable accuracy. Their use is discouraged when accurate body temperature measurement will influence clinical decision, such as in postoperative, injured, or critically ill patients (Niven et al., 2015). Huddles were held to raise awareness about the significance of accidental hypothermia on trauma patients. The need for patient temperature assessment on arrival was reinforced, with an emphasis on core temperature evaluation.

Appropriate Escalation of Rewarming Measures

Rewarming measures available and a clear pathway of escalation based on the patient's temperature were outlined. Nursing staff competencies for use of the rapid infuser with automatic fluid warming are maintained through yearly competency training. More invasive core rewarming measures, such as warm irrigation of the bladder, stomach, or pleural space, are to be implemented by physicians in rare scenarios of severe hypothermia that require aggressive rewarming (van der Ploeg et al., 2010; Zafren & Mechem, 2017). The importance of follow-up temperature assessment was also stressed, because trauma patients have been shown to have further temperature drop during resuscitation (Block et al., 2012; van der Ploeg et al., 2010).

Educational Interventions

A thermoregulation checklist was adapted from a previous work (Block et al., 2012) in collaboration with ED management, ED nurse educator, and the manager of the surgical intensive care unit (Figure 1). Final feedback and adjustments were provided by staff nurses. Huddles were conducted by the CNS multiple times per day for 1 week before launching the checklist. All ED nurses received a mass e-mail outlining the EBP project and checklist. After go-live, weekly huddles were conducted with staff of all shifts. During huddles, the checklist was disseminated with education and rationale for each field. Experienced and motivated staff nurses were approached to serve as champions. The champions were asked to promote

Patient label

Trauma bay external temperature ___________ F/C (80F)

Patient Temp on Arrival ___________F/C Time: _______ Source: ______

(Rectal temp for Level 1, environmental exposure, AMS, Provider/RN discretion)

Patient Temp at end of trauma ___________F/C Time: _______ Source: ______

Normothermia 96.8-98.9F	Mild Hypothermia 95-96.8F	Moderate – Severe Hypothermia <94.9F
Interventions		
☐ Warm Blankets	☐ IVF & Blood through fluid warmer	☐ IVF and Blood through fluid Warmer
☐ All blood products through fluid warmer	☐ Bair Hugger	☐ Bair Hugger
		☐ RT for warm oxygen therapy
Monitoring		
☐ Temp Q30min x2 Then per protocol	☐ Gaymar Continuous Temperature	☐ Gaymar Continuous Temperature
	☐ Temp documentation in Epic Q15min	☐ Temp documentation in Epic Q15min
⇐	Return to Normothermia when temp >96.8F ⇐	Return to Mild Hypothermia when temp >94.9F

Figure 1. Hypothermia checklist for all level 1 and level 2 trauma activations. Adapted from "Evidence-Based Thermoregulation for Adult Trauma Patients," by J. Block, M. Lilienthal, L. Cullen, and A. White, 2012, *Critical Care Nursing Quarterly*, 35(1), pp. 50–63. doi:10.1097/cnq.0b013e31823d3e9b. Reprinted with permission from the authors.

the checklist and thermoregulation interventions to their peers, as well as periodically checking implementation of rewarming measures. Random trauma charts were audited by the CNS with verbal or e-mail feedback provided to the staff. The thermoregulation checklist outlined expectations for assessment and interventions of trauma patients.

Evaluation

The impact of the interventions was assessed by review of all charts for Level 1 and Level 2 trauma activations from January to March 2017. Trauma activations from January to March of 2016 were also reviewed and entered in REDCap, a secure data collection portal (Harris et al., 2009), to serve as a comparison group in understanding the impact of the intervention. The CNS verified every 20th record against the EMR to ensure the accuracy of collected data. All completed checklists were collected and reviewed. Compliance with temperature assessment and documentation, rewarming methods implemented, and trauma bay temperature were reviewed. Findings postintervention were compared with trauma patients from the same time period in 2016.

Data analysis included descriptive statistics for all variables and assessment of differences between the pre- and postintervention time frames using the χ^2 test, Fisher exact test, and Student *t* test as appropriate. All data analysis was completed in R version 3.3.3 (R Core Team, 2016) using RStudio version 1.0.136 (RStudio Team, 2015). Analysis also included assessment of certain variables collected only in the postintervention time period, such as trauma bay temperature and adherence to the new protocols. Informal feedback was collected from the staff during the project.

RESULTS

During the period of January–March 2017, there were 193 trauma activations. Of these activations, 82 (41%) had a completed checklist; however, we were able to analyze data for all trauma activations using data from the chart. More patients with hypothermia and hyperthermia were identified in 2017 than those in 2016. There was a significant increase in core temperature assessment from 4% in 2016 to 23% in 2017 ($p < .001$). Blanket use in normothermic patients increased in 2017 ($p = .002$) (Table 1).

Our institution did not have continuous temperature monitoring of the trauma bay preintervention. On the day that trauma bay temperature was adjusted (January 2017), the thermostat setting and thermometer reading were 70°F. After the intervention, trauma bay ambient temperature was monitored and recorded in the checklist during trauma activations. The CNS monitored and trended the bay temperature over the course of 3 months of the project (Figure 2). Over the period of 3 months, there was a steady increase in the average temperature of the trauma bay.

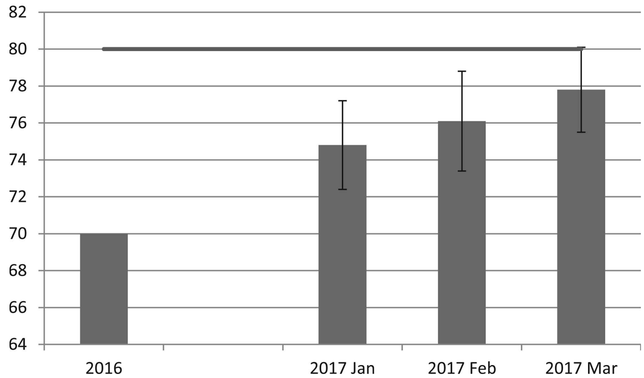

Figure 2. **Changes in trauma bay ambient temperature over time. Error bars represent standard deviation.**

Another goal of this project was to increase compliance with temperature assessment during trauma evaluations. While the number of temperatures taken within 9 minutes of activation dropped between 2016 and 2017, the overall number of temperatures taken within 19 or fewer minutes increased slightly from 81.4% to 83.9% (Table 2). Of note, the previous EMR made it easier to backdate all trauma documentation, which may have made the times to first temperature in 2016 appear shorter than they were in practice. Core temperature assessment increased from 4.9 % in 2016 to 24.4% in 2017 ($p < .001$) (Table 1).

Over the two 3-month periods reviewed for this project, there were a total of 10 hypothermic patients. Indoor exposure was the most common mechanism associated with hypothermia and was a factor in all three cases of severe hypothermia. All hypothermic patients were identified from rectal temperatures. Alcohol ingestion was identified in 40% of hypothermic patients (Table 3).

DISCUSSION

Various sources provide a range of temperature cutoffs for hypothermia (Block et al., 2012; Keane, 2016; Langhelle et al., 2010; Niven et al., 2015; van der Ploeg et al., 2010). To create a process with standardized interventions, the team set the hypothermia cutoff at 96.8°F (Langhelle et al., 2010; Niven et al., 2015). While this cutoff is higher than some found in the literature, hypothermia has been associated with progressively worsening coagulopathy starting at 96.8°F (Mitrophanov et al., 2013; van der Ploeg et al., 2010; Zafren & Mechem, 2017).

One project goal was to improve time to first temperature. Previous articles have recommended use of peripheral thermometers because of the ease of obtaining a temperature reading (Block et al., 2012; Keane, 2016). Oral thermometers are accurate in confirming normothermia but lack accuracy in hypothermic patients and are subject to interference from head and face temperature (Paal et al., 2016). A systematic review and meta-analysis found that peripheral thermometers lack clinically acceptable

TABLE 1 Patient Characteristics and Main Results

	2016 n = 271	2017 n = 202	p
Characteristics			
Age in years (median, IQR)	52.4 (28.2, 74.9)	68.6 (45.1, 81.8)	<.001
Sex			.278
Male	163 (60.1)	110 (54.7)	
Female	108 (39.9)	91 (45.3)	
Temperature category			.006
Hyperthermia	6 (2.2)	13 (6.4)	
Normothermia	261 (96.3)	179 (88.6)	
Mild hypothermia	0 (0)	4 (2.0)	
Moderate-severe hypothermia	2 (0.7)	4 (2.0)	
Missing	2 (0.7)	2 (1.0)	
Temperature source			<.001
Oral	174 (64.2)	142 (70.3)	
Rectal	7 (2.6)	43 (21.3)	
Tympanic	2 (0.7)	1 (0.5)	
Axillary	9 (3.3)	4 (2.0)	
Missing	70 (29.2)	12 (5.9)	
Warming measures			
Normothermia	n = 261	n = 179	
Blankets	208 (79.7)	163 (91.1)	.002
Mild hypothermia	No patients	n = 4	N/A
Blankets		4 (100)	
Warm IV fluids		0 (0)	
Moderate-severe hypothermia	n = 2	n = 4	
Blankets	1 (50)	2 (50)	1.0
Bair hugger	2 (100)	3 (75)	1.0
Warm IV fluids	1 (50)	3 (75)	1.0
Checklist completed	–	82 (40%)	

Note. IQR = interquartile range; IV = intravenous.

accuracy. Their use was discouraged in critical or injured patients and any scenario where accurate body temperature would influence decisions (Niven et al., 2015). Of note, all cases of hypothermia were detected with core temperature readings. One patient in 2016 had an initial oral temperature of 97.0°F and a rectal temperature of 87.9°F. Increased use of rectal thermometers in 2017 may have contributed to the increased identification of hypothermia, allowing earlier implementation of rewarming modalities and prevention of further heat loss for these trauma patients (Table 2).

Increasing the ambient temperature was met with the most staff resistance. Block et al. (2012) reported similar difficulties in implementing warming of the environment, although they did not include data on their progress. Frequent reminders to the staff and adjustments to the trauma bay thermostat and closing of the doors were required. Although there was a steady increase in trauma bay temperature in January through March 2017, compliance with maintaining the 80°F temperature remained inconsistent, and in May 2017, after the evaluation period presented in this article, a lockbox was placed over

TABLE 2 Time to First Temperature, by Year

Time to Temperature	2016 n (%)	2017 n (%)
0-9 min	188 (69.9)	116 (60.1)
10-19 min	31 (11.5)	46 (23.8)
20-29 min	21 (7.8)	13 (6.7)
30+ min	29 (10.7)	18 (9.3)

the thermostat to ensure consistency. For the following 2 weeks, daily checks of the trauma bay temperatures revealed a consistent temperature of 80°F.

Nurses often identify lack of education, access to information, and time for implementing EBP as barriers to implementing change (Melnyk, Fineout-Overholt, Gallagher-Ford, & Kaplan, 2012). Compliance with EBP interventions can still remain low even after removing barriers. Research has identified that staff attitude and beliefs regarding whether EBP improves patient care can differ (Warren et al., 2016). Further research should be dedicated to examine barriers to culture and behavior changes necessary for implementing EBP.

During the evaluation period, overall compliance with checklist completion was 40%. The checklist served as a reminder to the staff to maintain the trauma bay at 80°F, assess patient temperature on arrival, and to prioritize core temperature evaluation and implementation of rewarming techniques. The trauma registrars will continue to complete 100% chart review and provide feedback to the ED when trauma patients do not have temperature assessment within 30 minutes.

Contextual elements that may have contributed to the success of our EBP include elements regarding our institution's support of nursing research. Over the past year, our institution has seen a substantial increase in nursing staff and better patient ratios, which allows for more time for staff education and implementation of EBP interventions. Nurses are also able to work with a research consultant, who provides support regarding project design, evaluation, and statistics.

Concurrently, recent changes at our facility made certain aspects of evaluation more difficult. Conversion to a new EMR system may have contributed to the failure to see improvement in time to first documented temperature. Furthermore, the new trauma documentation does not contain reminders for required fields and consists of multiple separate sections that require additional steps and time for documentation With documentation becoming more time consuming, temperature assessment time may be reflected as completed at a later time.

Limitations

This was a single-center EBP project in an urban Level 1 trauma center. Because of the small number of hypothermic patients, our project was unable to determine changes in patient outcomes from our interventions (Table 3).

Although this evaluation used a comparison group comprising the same months of patient admissions, enabling us to control for obvious seasonal effects related to the incidence of hypothermia, the evaluation may have been vulnerable to secular effects related to other hospital initiatives or broader changes in the health care landscape between the pre- and postintervention data. One important hospital-wide effect was the launch of a new EMR system in August 2016, which changed many workflows and made it more difficult to backdate temperatures in the system, reducing the validity of the time to temperature comparison.

CONCLUSIONS

This project is an example of how nurses can utilize an EBP model to translate research into clinical practice and demonstrated that best practice interventions regarding temperature assessment and rewarming measures for trauma patients can be successfully implemented with negligible cost. Implementation of EBP projects requires extensive staff education to facilitate cultural and behavioral changes. Further research should examine barriers to implementation and adherence to EBP interventions. Further steps for this project may include review of more trauma patient records to determine efficiency of rewarming methods and any changes in patient outcomes associated with these interventions.

TABLE 3 Characteristics of Hypothermic Patients

Mechanism of Trauma	N = 10
Indoor exposure	
Fall	5
Hanging	1
Self-inflicted wrist laceration	1
Outside exposure	
Assault	1
Fall	1
Submersion	
Accidental fall in river	1
Source of temperature	
Rectal	10 (100%)
Alcohol consumption	4 (40%)

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KEY POINTS

- Hypothermia is a high impact presentation that requires vigilance.
- Critical and trauma patients should have core temperature assessment to ensure optimal detection of abnormal temperatures.
- Extensive education is required to successfully implement evidence-based interventions and achieve practice change.

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