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INTENSIVE CARE UNIT MANAGEMENT OF FEVER FOLLOWING TRAUMATIC BRAIN INJURY

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Summary

Fever, in the presence of traumatic brain injury (TBI), is associated with worsened neurologic outcomes. Studies prior to the publication of management guidelines revealed an undertreatment of fever in patients with neurologic insults. Presently the adult TBI guidelines state that maintenance of normothermia should be a standard of care therefore improvement in management of fever in these patients would be expected. The specific aims of the study were to: 1) determine the incidence of fever (T> 38.5° C) in a population of critically ill patients with TBI. 2) describe what interventions were recorded by intensive care unit (ICU) nurses in managing fever. 3) ascertain the rate of adherence with published normothermia guidelines. Medical record review of available hospital records was conducted on patients admitted to a level I trauma center following severe TBI (N=108) from the parent study. Temperature data was abstracted and contemporaneous nursing documentation was examined for evidence of intervention for fever and adherence with published standards. Data analyses were performed that included descriptive statistics. Seventy-nine percent of TBI patients (85/108) had at least one recorded fever event while in the ICU. However in only 31% of events did the patient receive any documented intervention by nursing staff for the elevated temperature. The most frequently documented intervention was pharmacologic (358/1166 elevations). Other nursing actions (e.g. use of fan) accounted for a minority (<1%) of nursing interventions documented. Patients were more likely to have a high temperature that exceeded 40°C (13%) than a temperature that was normothermic (5%). There continues to be an under treatment of fever in patients with TBI by critical care nurses despite our knowledge of its negative effects on outcomes. There remains a gap in translation between patient outcomes research and bedside practice that needs to be overcome, thus research efforts need to now focus on understanding nurses' decision-making processes and the best methods of fever reduction in patients with TBI.

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Keywords

head injury; hyperthermia; normothermia; clinical decision making; evidence-based practice

Introduction

Fever is an adaptive response of the body to a perceived threat that often does not require intervention and for which intervention may even be perceived as counterproductive (Holtzclaw, 2002). However in certain patient populations, temperature elevations may be extremely detrimental and intervention is necessary. One such population is patients with traumatic brain injury (TBI) where the presence of fever in the acute phase is associated with worse outcomes for patients including longer intensive care unit (ICU) stays, increased intracranial pressure, lower Glasgow Coma Scale scores, and poorer functional status (Natale et al., 2000; Jiang et al., 2002; Stocchetti et al., 2002; Diringer et al., 2004). In the presence of TBI, fever may be associated with increased excitatory amino acid release, increased vasogenic edema, increased intracranial pressure, and increased metabolic expenditure, ultimately resulting in increased neuronal loss (for review see Thompson et al., 2003b). Fever in the TBI patient may result from a number of sources including infection, drug reactions, deep vein thrombosis, or central nervous system-mediated as a result of the injury (Thompson et al., 2003a). A recent study reported that more than 80% of critically ill TBI patients experience brain temperatures over 38ºC in the first three days following injury (Childs et al., 2005).

Even when a protocol is in place, the bedside nurse is often the primary clinical decision maker regarding interventions to instigate for fever (O'Donnell et al., 1997; Kilpatrick et al., 2000), as he/she must determine whether or not to follow said protocol. A number of studies conducted prior to the publication of management guidelines revealed an under treatment of fever in patients with neurologic insults (Albrecht et al., 1998; Kilpatrick et al., 2000). One study found that fourteen percent of neurologically vulnerable febrile patients did not receive any intervention and some patients received only non-pharmacologic intervention, despite the presence of a management protocol specifying a first-tier pharmacologic therapy (Kilpatrick et al., 2000). In another study, only seven percent of closed head injury patients received antipyretic medications in doses appropriate to treat fever (Albrecht et al., 1998). A third study showed that only 59% of patients experiencing fever were treated appropriately by nurses on a mixed acute care unit (Grossman et al., 1995).

Initially published in 1996, the TBI management guidelines state that maintenance of normothermia should be a standard of care (Brain Trauma Foundation/American Association of Neurologic Surgeons, 1996; Brain Trauma Foundation/American Association of Neurologic Surgeons, 2000; Society of Critical Care Medicine/World Federation of Pediatric Intensive and Critical Care Societies, 2003); thus improvement in achieving normothermia in these patients would be an expected outcome since the publication of the guidelines. Control of body temperature has also been recognized as an important component of care in the United Kingdom (Johnston et al., 2003).

Therefore the aims of this study were:

1. To determine the incidence of fever in a population of critically ill patients with TBI
2. To describe what interventions were recorded by ICU nurses in the management of fever
3. To ascertain the rate of adherence with published normothermia guidelines

Methods

Retrospective medical record review of available hospital records was conducted on patients admitted over a two year period (2000–2002) to a level I trauma center following a primary diagnosis of severe TBI (n=108) enrolled in a parent study. The study was approved by the University's Institutional Review Board under the goals of the parent study for which subjects gave informed consent. The goal of the parent study was to examine the impact of a continuous bedside system of cerebral perfusion pressure feedback monitoring on nursing management and its relationship to patient outcomes. For each subject, temperature data recorded while in the ICU was abstracted from the electronic medical record for the first week post-injury. Data abstracted from the parent data set included demographic data (age, gender, race/ethnicity), injury severity (Glasgow Coma Scale (Teasdale and Jennett, 1974), Injury Severity Score (Baker and O'Neill, 1976)), clinical injury characteristics and mechanism of injury. Contemporaneous nursing documentation was examined in the medical record using the flowsheet, medication administration record, and nursing notes for evidence of intervention for fever. Fever was defined as a temperature greater or equal to 38.5°C (either tympanic or core) as this is the temperature specified within institution-specific protocols. In this setting, the written "fever protocol" for all ICU patients consists of assessment of temperature at a minimum of every 4 hours, orders for administration of acetaminophen 650mg every 4 hours if the temperature is 38.5°C or higher, and reassessment of the temperature within 2 hours after any intervention for elevated temperature. Any additional nursing interventions are left to the discretion of the individual nurse. Normothermia was defined as a temperature of 37°C (Hinkle, 2004). At the time of the review there was no specific protocol for fever management of TBI patients.

Results

Patient demographics are presented in Table 1. Motor vehicle crashes (48%) and falls (21%) were the primary mechanism of injury for this population which is consistent with TBI nationally. Seventy-nine percent (85/108) of TBI patients had at least one recorded fever event while in the ICU. The mean maximal temperature of this cohort of critically ill TBI patients was 39.0°C (range 37.3–41.8°C). Patients were more likely to have a high temperature that exceeded 40°C (13%) than a temperature that was normothermic (5%). The mean number of febrile episodes during the first week while in the ICU was 4.4 per patient (range 0–18). However for only 31% of the recorded temperature elevations did the patient receive any documented intervention for fever by nursing staff. Although we consistently found documentation within the nursing notes that the plan of care was to "follow fever protocol", this was not actually implemented in the majority of cases. Interestingly, 20% of acetaminophen doses (91/445) were given at temperatures less than 38.5°C. Per document analysis, delay in implementing the treatment protocol occurred in 57.7% of febrile episodes. The most frequently documented intervention was pharmacologic (358/1166 elevations) (See Table 2). Other nursing actions (e.g. use of fan) accounted for a minority (<1%) of nursing interventions documented (Table 2). In 20% of cases, patients were receiving regularly ordered medications that could have altered temperature, including beta-blockers, steroids, levothyroxin, and aspirin.

Discussion

Nursing documentation regarding accompanying signs and symptoms of fever was very limited; therefore, it was difficult to ascertain what role, if any, these signs and symptoms played in the decision to treat fever. Limitations of this study include the retrospective nature of the study. It is possible that nurses performed interventions for patient temperature elevations that were not documented in the medical record. Within the nursing notes on all patients, the

investigator consistently found documentation to follow the institution protocol for fever management; however this did not occur. Two main issues are identified from this study regarding treatment of fever in TBI patients in the ICU: 1) there appears to be a lack of intervention by nursing for patients with fever and 2) in the majority of cases there was a delay in treatment before intervention was initiated. As this was a retrospective study of the patient medical record, we did not have access to nursing staff data, however, it would be of particular interest to note if staff variables such as time since orientation, years in nursing or education level correlated with adherence to the institution protocol.

Of particular concern, there was not the expected improvement of nursing management of fever following publishing of normothermia guidelines and additional studies demonstrating detrimental effects of fever on outcomes after TBI. The TBI management guidelines are not only covered in handouts and discussion at nursing orientation, but have been widely discussed in both medical and nursing literature, and at neuroscience and critical care nursing conferences both locally and nationally, thus nurses would have had exposure to these guidelines. On-line access to nursing and medical journals is available throughout the institution, and off-campus library access is provided to employees as well. Amount of exposure of individual nurses to this information may have varied, but due to the study design, we are unable to determine its influence. As such, it is an area for further study.

While the overall incidence of fever in this population of TBI patients was slightly higher than previously reported (79%), the rate of intervention was substantially lower (31% vs. 86% (Kilpatrick et al., 2000)). Pharmacologic therapy was the most frequently documented intervention used in the present report, which is consistent with previous studies (Grossman et al., 1995; Johnston et al., 2006; Kilpatrick et al., 2000). Acetaminophen was the most frequently used antipyretic agent, with ibuprofen being used much less frequently. Judicious use of these agents within this population may have occurred due to potential for toxicity in the former and increased bleeding potential of the latter (Holtzclaw, 2002). Other possibilities for choice include usual practices within the environment.

Physical cooling measures (fan) in conjunction with pharmacologic therapy were documented in only two cases. Independent nursing activities available for use in this setting included ice packs, tepid bathing, and cooling blankets; however documentation of these activities were not found within the medical records reviewed. These interventions have been reported to be ineffective in the majority of TBI patients (Stochetti et al., 2002; see review Thompson et al., 2003b), and may actually be contraindicated as they could induce shivering (Holtzclaw, 2002), increasing metabolic rate and decreasing cerebral oxygenation. However, research in this area has been hampered by methodological and conceptual characteristics of the studies such as definitions of fever which vary greatly, mixed populations, along with low sample sizes. Thus further systematic evaluation of the efficacy and side effects of physical cooling measures in TBI patients is warranted. Additionally, this institution did not have a specific protocol in place for management of fever in TBI patients. The lack of a systematic approach to this patient management problem is not uncommon (Johnston et al., 2006; Thompson, Kirkness et al., in press) and may be reflected in our results.

The major management goal following TBI is prevention of further brain injury from secondary insults (March et al., 2004), such as fever, which are often preventable or treatable. As the presence of fever in the patient with a TBI is likely to have a synergistic effect (Thompson et al., 2003b), rather than just an additive effect, this insult can be particularly devastating to brain tissue and thus, patient outcomes (March et al., 2004). As a result, nursing management of fever should be a priority for TBI patients, as “time equals brain” in managing secondary insults. As this sample represents practice at a single institution, these findings may not be generalizable to other settings. However our confidence in the validity of the findings is

increased by similar results during the primary investigator's pilot work completed in another region of the US.

The institutional protocol that formed the basis for this analysis defined a fever requiring intervention as a temperature equal or greater than 38.5°C; however, this temperature is higher than that proposed for treatment in the literature. The American Association of Neuroscience Nurses Core Curriculum defines pyrexia as a temperature greater than 38°C (March et al., 2004) and Marion (2001) defined hyperthermia in the neuroscience ICU as 37.5°C and recommended that treatment be initiated when temperatures exceed this threshold. In the present study, acetaminophen was available per orders for pain or temperatures ≥38.5°C, and some nurses administered acetaminophen at temperatures between 38–38.4°C, although it was unclear from the documentation the exact reason for administration as no signs or symptoms of pain were being exhibited by the patient per documentation either. It is possible, therefore, that nurses were noting the rise in patient temperature and administering acetaminophen early in order to prevent further potential neuronal damage (Thompson, Webb, Mitchell, in press). Thus, institutional protocols may hamper nurses' ability to implement evidence-based practice, but selected nurses may be using "loopholes" within the system in an attempt to circumvent these barriers. There may be other possible explanations for early administration that could not be captured in the present record-based study that would be important to explore. As there was not a standardized protocol for fever management in TBI patients, this may have been a useful guide to improve practice. Normothermia is the standard of care for temperature management in severely-injured TBI patients, but the guidelines do not provide specific direction (Brain Trauma Foundation/American Association of Neurologic Surgeons, 2000). As yet, appropriate management of fever (maintenance of normothermia) for TBI patients has not been well established and further research in this area is clearly needed.

Due the retrospective nature of the study, the site of temperature measurement in this setting included core (pulmonary artery) and tympanic and likely underestimated the degree of fever in these patients. The temperature of the brain is higher than core temperature and this temperature gradient is larger during periods of pyrexia (Rossi et al., 2001). Future studies of temperature in TBI patients need to incorporate new technology, such as brain temperature monitoring in centers where it is available and appropriate to do so. In patients for whom invasive brain monitoring is not an option, the nurse must be cognizant that the difference between pulmonary artery and brain temperature measurements is 0.4°C at the peak of fever[15] and the differences between rectal (T_{re}) or bladder (T_{bl}) temperatures and brain (T_{br}) temperatures are generally larger (T_{re}-T_{br} 0.1–2.0°C; T_{bl}-T_{br} 0.3–1.9°C) (Henker et al., 1998). A recent study by Johnston and colleagues (2006) noted that the most common site of temperature monitoring in neurocritical care units in the United Kingdom and Ireland was the groin and axilla, a site not considered appropriate for assessment of fever in critically ill adult patients (O'Grady et al., 1998).

Conclusions

There continues to be a high incidence and an under treatment of fever in patients with TBI by nurses despite our knowledge of its negative effects on outcomes. These findings reveal no improvement in practice over 10 years despite increased attention to this issue and publication of guidelines recommending maintenance of normothermia. There remains a gap in translation between patient outcomes research and bedside nursing practice that needs to be overcome. As bedside nurses make many independent decisions in this regard, research efforts need to now focus on understanding their decision-making processes and determining the best methods of fever reduction in patients with TBI. Further study of both pharmacologic and non-pharmacologic methods for fever and hyperthermia reduction in TBI patients is warranted given the dearth of available evidence and plethora of remaining questions, including if

adequate treatment ultimately improves patient outcomes. Institutional protocols may provide barriers to implementation of evidence-based practice and need to be examined carefully. Thus, there is a need for a definition of fever from the critical care nurses' perspective, an understanding of their decisions regarding fever management in this population and clearer understanding of the barriers to evidence-based practice. It is hoped that armed with this knowledge, we can develop and test evidence-based protocols for fever management in TBI patients that are both valuable to and fully-implemented by critical care nurses. Insomuch as hyperthermia is associated with worse outcomes, we should then be able to demonstrate that reducing pyrexia actually and measurably improves TBI patient outcomes.

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Table 1

Demographic and Clinical Characteristics of Sample (N=108)

Variable	
Mean Age (SD)	38 (19)
Mean Glasgow Coma Scale-post resuscitation (GCS-PR) (SD)	7.25 (3.1)
Mean Injury Severity Scale (SD)	24.9 (9.3)
Gender (% Male)	78.7
Race/Ethnicity (%)	80.6
-Caucasian, non-Hispanic	6.5
-Hispanic/Latino	3.7
-Black	2.8
-Asian/Pacific Islander	2.8
-Native American	3.7
-Other	
Traumatic Brain Injury Characteristics (% yes)	40.7
-Subdural Hematoma	24.1
-Epidural Hematoma	5.6
-Intracranial Hemorrhage	30.6
-Intraventricular Hemorrhage	59.3
-Subarachnoid Hemorrhage	30.6
-Skull Fracture	

Table 2

Documented Nursing Interventions for Temperature Elevations > 38.5°C by ICU Nurses in Patients with Traumatic Brain Injury

Documented Intervention	Type	Frequency
None	n/a	804
Pharmacologic	Acetaminophen	354
	Ibuprofen	4
	TOTAL	358
Non-Pharmacologic	Fan	2
	Notified MD	2
	TOTAL	4