Back to Basics: Adherence With Guidelines for Glucose and Temperature Control in an American Comprehensive Stroke Center Sample

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ABSTRACT

Background: Variance from guideline-directed care for glucose and temperature control remains unknown in the United States at a time when priorities have shifted to ensure rapid diagnosis and treatment of acute stroke patients. However, protocol-driven nursing surveillance for control of hyperglycemia and hyperthermia has been shown to improve patient outcomes. **Methods:** We conducted an observational pilot study to assess compliance with American guidelines for glucose and temperature control and association with discharge outcomes in consecutive acute stroke patients admitted to 5 US comprehensive stroke centers. Data for the first 5 days of stroke admission were collected from electronic medical records and entered and analyzed in SPSS using descriptive statistics, Mann-Whitney *U* test, Student *t* tests, and logistic regression. **Results:** A total of 1669 consecutive glucose and 3782 consecutive temperature measurements were taken from a sample of 235 acute stroke patients; the sample was 87% ischemic and 13% intracerebral hemorrhage. Poor glucose control was found in 33% of patients, and the most frequent control method ordered (35%) was regular insulin sliding scale without basal dosing. Poor temperature control was noted in 10%, and 39% did not have temperature recorded in the emergency department. Lower admission National Institutes of Health Stroke Scale score and well-controlled glucose were independent predictors of favorable outcome (discharge modified Rankin Scale score, 0–2) in reperfusion patients. **Conclusion:** Glucose and temperature control may be overlooked in this era of rapid stroke diagnosis and treatment. Acute stroke nurses are well positioned to assume leadership of glucose and temperature monitoring and treatment.

Keywords: acute stroke, guideline compliance, hyperglycemia, hyperthermia

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The authors declare no conflicts of interest.

DOI: 10.1097/JNN.0000000000000358

Assessment and management of hyperglycemia and fever have long been identified as important in recovery of neurologic function after stroke.[1–10] Hyperglycemia contributes to brain injury by promulgating acidosis and free radical production that can increase infarct volume and edema,[1–6] whereas fever significantly increases metabolic demand, free radical production, and neurotransmitter release.[7–10] Combined, hyperglycemic, and febrile states may disadvantage recovery in patients provided with even the highest level of neurologic services at comprehensive stroke centers (CSCs), despite delivery of the most sophisticated, advanced care available today.[11–16] Because of this, international guidelines cite the need for glucose and temperature control in acute stroke patients.[17–19]

The Quality in Acute Stroke Care trial[20] showed that evidence-based protocol-driven nursing control of glucose, fever, and swallow function could significantly reduce 90-day death and dependency, and mortality out of a median of 4 years after stroke.[20,21] Although guidelines existing at the time of the trial identified parameters for both glucose and temperature control, internationally, there has been poor medical and nursing oversight for these factors.[22,23] Current American Heart Association/American Stroke Association (AHA/ASA) guidelines state that glucose should be maintained between 140 and 180 mg/dL (<10 mmol/L) and that normothermia should be maintained with temperature less than 38°C.[17] However, the degree to which CSCs in the United States adhere to these guidelines currently remains unknown.

Today's focus on rapid assessment and diagnosis of and treatment for acute stroke patients has most American CSCs in pursuit of emergency department (ED) arrival to intravenous alteplase tissue plasminogen activator (IVtPA) treatment times of less than 30 minutes using methods first developed in Helsinki, Finland, and successfully implemented in Melbourne, Australia,[24,25] with additional goals of rapid access to the interventional suite for thrombectomy candidates and rapid initiation of blood pressure (BP) lowering for intracerebral hemorrhage (ICH) cases. How this rapid care paradigm has impacted US clinicians' attendance to basic yet important measures such as glucose and temperature remains largely unknown, although international uptake and successful implementation of evidence from the Quality in Acute Stroke Care trial has been shown to be sparse.[26] Therefore, we undertook a pilot study to determine the degree of variance from guideline-specific care for glucose and temperature control and examined related patient outcomes in an American CSC sample.

Methods

Institutional review board approval was obtained for the conduct of a multisite observational study to assess compliance with AHA/ASA stroke guidelines for glucose and temperature control in consecutive acute stroke patients from 5 American CSCs. Glucose and temperature values from admission to discharge (or day 5) were collected along with control methods ordered, admission National Institutes of Health Stroke Scale (NIHSS) scores, ICH scores, length of stay (LOS), discharge disposition, and discharge modified Rankin Scale (mRS) scores. Because the Glasgow Coma Scale component of the ICH score does not by itself identify the full spectrum of neurologic deficits,[27–31] NIHSS scores were measured in both ischemic stroke and ICH patients as a measure of neurologic disability. Stroke was classified as either ischemic stroke or ICH; subarachnoid hemorrhage and transient ischemic attack patients were excluded from study enrollment. Subject age, sex, and racial characteristics were not collected to fully mask subject identification; hospital characteristics and provider type, training, and experience were also not collected to ensure de-identification of all managing interdisciplinary practitioners.

> These findings represent an opportunity for nurses to impact outcomes through advocacy for better methods to control glucose and temperature.

Data were obtained from electronic medical records to avoid interdisciplinary staff awareness of study aims and prevent researcher interference with care provision. Glucose measures were collected in milligrams per deciliter per US hospital standards but are reported in both milligrams per deciliter and millimoles per liter for international dissemination. Temperature measurements recorded in degrees Fahrenheit were transformed to degrees Celsius for consistency with AHA/ASA guidelines. Well-controlled glucose was defined as values maintained throughout hospitalization at less than 180 mg/dL (10 mmol/L), and well-controlled temperature was defined as temperature maintained at less than 38°C throughout hospitalization. Data were entered and analyzed in SPSS (IBM, v. 24) using descriptive statistics, Mann-Whitney *U*, Student *t* tests, and logistic regression.

Results

Overall Sample Findings

A total of 235 consecutive acute stroke patients were evaluated in the pilot study, resulting in 1669 consecutive glucose and 3782 consecutive temperature measurements throughout the hospitalization period. The sample consisted of 204 ischemic stroke patients (87%) and 31 ICH patients (13%). Discharge disposition was 44% home, 9% outpatient rehabilitation, 26% inpatient rehabilitation, and 18% skilled nursing facility; 3% died in hospital.

Overall, 31% of the sample (n = 73) had a history of type 2 diabetes mellitus (DM), and there were no patients included with type 1 DM. Not surprisingly, admission glycated hemoglobin (HbA1c) was significantly lower at 5.7 ± 0.65 (median, 5.7; range, 4.8–11.2) in patients without a history of DM, compared with 8.3 ± 2.3 (median, 7.7; range, 5.0–14.1; 95% confidence interval [CI], 1.9-3.1; $P < .001$) in patients with a preexisting DM diagnosis. Average glucose during hospitalization was also significantly lower at 117 ± 25 (median, 112) for patients without a preexisting DM diagnosis, compared with 176 ± 53 (median, 169; 95% CI, 45–71; $P < .001$) for patients with a preexisting DM diagnosis. Among patients without a preexisting diagnosis of DM, 78 (48%) had admission HbA1c levels ranging from 5.7 to 6.4 consistent with prediabetes, and 10 (6%) had levels greater than or equal to 6.5 consistent with an unknown DM diagnosis. The most frequent method (35%) for glucose control was regular insulin sliding scale without establishment of a basal dose.

Overall, temperature was greater than 37.5°C (noncompliant with European/Australian standards) for greater than or equal to 4 hours in 63 patients (27%) and greater than 38°C (noncompliant with US standards) for greater than or equal to 4 hours in 24 patients (10%). In 19 patients (8%), temperature was poorly controlled for greater than 8 hours (range, 9–96 hours; median, 16.5 hours with poor control). Interestingly, 92 patients (39%) did not have temperature recorded in the ED on admission.

Ischemic Stroke Sample

In the 204 acute ischemic stroke patients, median admission NIHSS score was 4 (interquartile range [IQR], 1–10), with a total of 41 (20%) treated with IVtPA alone, whereas 4 (2%) were treated with thrombectomy alone, and 8 (4%) received combined treatment with both IVtPA and thrombectomy. Overall hospital LOS was 4.8 ± 4 (median, 4) days for ischemic stroke patients, and discharge mRS score was 2 (IQR, 1–4). Table 1 summarizes findings in patients with acute ischemic stroke dichotomized by reperfusion treatment status.

Findings in Ischemic Strokes Without Reperfusion Treatment

In patients not meeting criteria for any form of reperfusion therapy, baseline median NIHSS was

TABLE 1. Glucose and Temperature Findings in Patients With Acute Ischemic Stroke

Group	Good Control	Poor Control	Difference
Ischemic stroke without reperfusion treatment	Glucose	Glucose	
	Admission NIHSS, 2 (IQR, 1–5.5)	Admission NIHSS, 2 (IQR, 0–4.25)	*P* = NS
	Discharge mRS, 2 (IQR, 1–4)	Discharge mRS, 2 (IQR, 1–4)	*P* = NS
	LOS: 4.1 ± 3; median, 3	LOS: 4.5 ± 3; median, 3	*P* = NS
	Temperature	Temperature	
	Admission NIHSS, 2 (IQR, 1–4.5)	Admission NIHSS, 6 (IQR, 2–21.5)	*P* = .001
	Discharge mRS, 1 (IQR, 1–3)	Discharge mRS, 4 (IQR, 2–4.75)	*P* < .001
	LOS: 3.7 ± 3; median, 3	LOS: 6.4 ± 3; median, 5	*P* < .001
Ischemic stroke with any reperfusion treatment	Glucose	Glucose	
	Admission NIHSS, 9 (IQR, 4–14.5)	Admission NIHSS, 13 (IQR, 5.25–19)	*P* = NS
	Discharge mRS, 1.5 (IQR, 1–4)	Discharge mRS, 4 (IQR, 3–4)	*P* = .006
	LOS: 5.9 ± 6; median, 3	LOS: 7.6 ± 5; median, 7.5	*P* = .044
	Temperature	Temperature	
	Admission NIHSS, 7 (IQR, 4–12)	Admission NIHSS, 14 (IQR, 9.75–19.5)	*P* = .015
	Discharge mRS, 1 (IQR, 1–3)	Discharge mRS, 4 (IQR, 3.75–4.25)	*P* = .001
	Total LOS: 4.6 ± 4; median, 3	Total LOS: 9.9 ± 6.7; median, 8	*P* < .001

Note. Good control indicates maintenance of glucose less than 180 mg/dL (<10 mmol/L) or maintenance of temperature less than 38°C; poor control exceeds these limits.
Abbreviations: IQR, interquartile range; LOS, length of stay; mRS, modified Rankin Scale score; NIHSS, National Institutes of Health Stroke Scale score; NS, not significant.

2 (IQR, 1–5), with a median discharge mRS score of 2 (IQR, 1–4), and in these cases, glucose control was not associated with differences in discharge mRS score and LOS (Table 1). Temperature was positively correlated with admission NIHSS scores (r = 0.403, P < .001) in patients without reperfusion treatment, and those with fever and poor temperature control were significantly more disabled on admission (NIHSS median, 6; IQR, 2–21.5; P = .001) compared with normothermic patients (NIHSS median, 2; IQR, 1–4.5). Poorly controlled febrile status was associated with significantly worse discharge mRS scores (mRS median, 4 vs 1; P < .001) and longer total hospital LOS (6.4 ± 3 vs 3.7 ± 3 days, P < .001) compared with normothermic patients (Table 1). However, with discharge mRS score dichotomized to favorable outcome (mRS, 0–2) and poor outcome (mRS, 3–6), admission NIHSS score alone was an independent predictor of good discharge mRS score; for every point decrease in admission NIHSS (B = −0.351; OR, 0.70; 95% CI, 0.60-0.82; P < .001), the odds of good neurologic outcome were significantly improved.

Findings in Ischemic Strokes Undergoing Reperfusion Treatment

In the 53 patients who received some form of reperfusion therapy, median admission NIHSS was 10 (IQR, 4.5–17), and median discharge mRS score was 3 (IQR, 1–4), with an average LOS of 6.4 ± 5.6 (median, 4) days (Table 1). Admission NIHSS scores were similar between patients with good and poor glucose control who underwent reperfusion; however, discharge mRS scores were significantly worse in patients with poor glucose control compared with normoglycemic patients, respectively (median mRS, 4 vs 1.5; P = .006), and total hospital LOS was significantly longer when glucose was poorly controlled (7.6 ± 5 vs 5.9 ± 6 days, P = .044) compared with reperfusion patients with good glucose control (Table 1). Temperature was positively correlated with admission NIHSS scores (r = 0.315, P = .022) in patients undergoing reperfusion treatment, and febrile patients with poor temperature control had significantly higher admission NIHSS scores at baseline (median NIHSS, 14; P = .015) compared with normothermic patients (median NIHSS, 7) (Table 1). Total LOS was also significantly longer in patients with poor temperature control (9.9 ± 6.7 days, P < .001), compared with normothermic patients (4.6 ± 4 days). Febrile reperfusion patients with poor temperature control had significantly worse mRS scores at discharge (median mRS, 4; P = .001) compared with normothermic reperfusion patients (median mRS, 1) (Table 1). However, with discharge mRS score dichotomized to favorable outcome (mRS, 0–2) and poor outcome (mRS, 3–6), admission NIHSS score and average glucose during hospitalization alone were independent predictors of good discharge mRS score; for every point decrease in admission NIHSS (B = −0.142; OR, 0.87; 95% CI, 0.78-0.96; P = .008) and every point decrease in average glucose level (B = −0.024; OR, 0.98; 95% CI, 0.95-0.99; P = .039), the odds of good neurologic outcome were significantly improved.

ICH Sample

In the ICH sample, median admission NIHSS was 5.5 (IQR, 2.25–15), with a median ICH score of 1 (IQR, 1–2). Admission NIHSS was significantly positively correlated with glucose (r = 0.42, P = .031) and temperature (r = 0.523, P = .004). However, ICH score was not associated with glucose (P = NS) and showed a trend toward being positively correlated with temperature (r = 0.343, P = .059). Aggressive BP lowering (systolic BP < 140 mm Hg) was used to manage 14 ICH patients (45%), whereas BP less than 160/90 mm Hg was used to manage 17 ICH cases (55%). Three ICH patients (10%) required anticoagulation reversal with prothrombin complex concentrate. Overall hospital LOS for ICH patients was 7.3 ± 5 days (median, 6 days), and overall discharge mRS score was 4 (IQR, 2–4.5). Table 2 presents glycemic and temperature findings dichotomized by control status in the ICH sample.

Findings by Glycemic Control in ICH Patients

Nineteen ICH patients (61%) had well-controlled glucose throughout their hospitalization. Admission NIHSS was significantly higher in patients with poor glucose control (NIHSS median, 15; P = .001), compared with normoglycemic patients (NIHSS median, 3.5), but ICH scores were similar despite glycemic status (Table 2). Hospital LOS was similar in ICH patients regardless of glycemic control status, but discharge mRS scores were significantly better in ICH patients with good glucose control compared with ICH patients with poor glucose control (median mRS score, 3 vs 4, respectively; P = .034).

Findings by Temperature Control in ICH Patients

Fifteen ICH patients (48%) were normothermic throughout their hospitalization. Admission NIHSS showed a trend toward being higher in patients with poor temperature control (NIHSS median, 12; P = .052), compared with normothermic patients (NIHSS median, 4), but ICH scores were significantly higher in patients with poor temperature control (median ICH score, 2; P = .006), compared with normothermic patients (median ICH score, 1) (Table 2). Hospital LOS was significantly shorter at 4.3 ± 2 (P < .001)

TABLE 2. Glucose and Temperature Findings in Patients With Intracerebral Hemorrhage

Group	Good Control	Poor Control	Difference
Intracerebral hemorrhage	Glucose	Glucose	
	Admission NIHSS, 3.5 (IQR, 1–5.75)	Admission NIHSS, 15 (IQR, 10.25–21)	P = .001
	ICH score, 1 (IQR, 1–2)	ICH score, 1.5 (IQR, 1.5–3)	P = NS
	Discharge mRS, 3 (IQR, 1.5–4)	Discharge mRS 4 (IQR, 4–6)	P < .001
	LOS: 5.8 ± 3; median, 6	LOS: 9.7 ± 7; median, 6.5	P = NS
	Temperature	Temperature	
	Admission NIHSS, 4 (IQR, 1–9.5)	Admission NIHSS, 12 (IQR, 3–21)	P = .052
	ICH score, 1 (IQR, 0–1)	ICH score, 2 (IQR, 1–3)	P = .006
	Discharge mRS, 2 (IQR, 1–3)	Discharge mRS, 4 (IQR, 2–4.75)	P < .001
	LOS: 4.3 ± 2; median, 4	LOS: 10 ± 6; median, 8.5	P = NS

Note. Good control indicates maintenance of glucose less than 180 mg/dL (<10 mmol/L) or maintenance of temperature less than 38°C; poor control exceeds these limits.
Abbreviations: ICH, intracerebral hemorrhage; IQR, interquartile range; LOS, length of stay; mRS, modified Rankin Scale score; NIHSS, National Institutes of Health Stroke Scale score; NS, not significant.

days in ICH patients with good normothermic temperature management, compared with 10 ± 6 days in ICH patients with poor temperature control (Table 2). Similarly, discharge mRS score was significantly better in ICH patients with good normothermic temperature management compared with ICH patients with poor fever control (mRS score, 2 vs 4, respectively; $P < .001$) (Table 2).

Discussion

Our pilot study found that hyperglycemia and temperature are often poorly controlled in acute stroke patients, despite guidelines calling for maintenance of specific parameters.[17–19] Overall, 33% of the patients were found to have poorly controlled glucose, and 10% had poorly controlled temperature (27% by European/Australian standards) for greater than or equal to 4 hours during their hospitalization, with 8% febrile for a median 16.5 hours. We also found that 39% of the patients lacked documentation of temperature measurement in the ED, and this may reflect a shift in priorities due to the current intense focus on rapid stroke diagnosis and treatment.[24,25] Collectively, these findings represent a tremendous opportunity for nurses to impact patient care and discharge outcomes through improved monitoring of glucose and temperature and advocacy for better methods to control these important parameters.

We also found that a startling 48% of the patients without a preexisting diagnosis of DM were also shown to have admission HbA1c values consistent with prediabetes status and 6% had HbA1c levels consistent with an unknown DM diagnosis. This finding showcases the importance of obtaining admission HbA1c to thoroughly understand vascular risk factors, so that appropriate secondary prevention can be provided. Because prediabetes is an important predictor of a future diabetes diagnosis, early detection places nurses in an important position to educate and counsel patients to improve health status.[32]

Interestingly, our data show that patients with higher admission NIHSS and ICH scores commonly had poor temperature control, but outcome on discharge mRS was predicted primarily by severity of neurologic disability alone. This likely indicates that patients with worse neurologic status are at a greater risk for febrile events. We suggest that this link between neurologic severity and temperature should prompt both preventative nursing care and ongoing close surveillance for fever due to either infection[33–35] or systemic inflammatory response syndrome,[36–38] particularly in severe acute stroke patients.

In reperfusion patients, we found that hyperglycemia along with neurologic severity contributed to discharge outcome on mRS, something that has been previously demonstrated in patients undergoing IVtPA treatment and/or thrombectomy.[11–16] Nursing surveillance of glucose control should be considered a top priority, especially in reperfusion cases, and we suggest that this be accompanied by advocacy for improved glycemic control measures, because we found that 35% of hyperglycemic patients had only regular insulin sliding scale orders.

Our study has limitations. First, we conducted an observational study, and as such, we are only able to report what we found without interacting with patients or staff. However, this provided us with an opportunity for "real-life" examination of how interdisciplinary providers monitor and manage 2 very important factors capable of impacting stroke recovery. Second, we limited our data collection to a small number of American CSC hospitals, and therefore our findings may not be representative of how other US CSCs manage their patients. This also provided us with only a small sample of cases for this pilot study that may not be representative of acute stroke patients admitted at other CSCs. In addition, our sample size limited the analyses we could undertake and our ability to find additional important subgroup differences, particularly in the ICH sample. However, despite these limitations, our findings are provocative and provide cause for all acute stroke nurses to examine and reflect on their individual hospital performance, including prompting team discussions of whether glucose and temperature should be regularly reported during stroke team rounds and managed using evidence-based best practices. In fact, we suggest that glycemic and temperature control may be important future core measures for stroke center hospitals.

Conclusions

Glucose and temperature management may commonly be overlooked in this current era of rapid stroke diagnosis and treatment. Our findings support the need for renewed conversation among US stroke team members about methods to ensure appropriate ongoing surveillance, rapid detection of hyperglycemia and hyperthermia, and implementation of evidence-based best practices to ensure optimal conditions for stroke recovery. Acute stroke nurses are well positioned to step up to this challenge and assume leadership of glucose and temperature monitoring and treatment.

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