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Original article

# Tiered protocol implementation improves treatment of hypoglycaemia in a neurosciences critical care and surgical intensive care unit☆

Megan A. Van Berkel[a], Jennifer MacDermott[b], Kathleen M. Dungan[c], Charles H. Cook[d], Claire V. Murphy[e,*]

[a] Department of Pharmacy, Methodist Le Bonheur Healthcare, University Hospital, United States
[b] Riverside Methodist Hospital, United States
[c] Division of Endocrinology, Diabetes & Metabolism, Ohio State University, United States
[d] Department of Surgery, Beth Israel Deaconess Medical Center, United States
[e] Department of Pharmacy, The Ohio State University Wexner Medical Center, United States

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ABSTRACT

*Background:* Although studies demonstrate techniques to limit hypoglycaemia in critically ill patients, there are limited data supporting methods to improve management of existing hypoglycaemia.
*Objective:* Assess the impact and sustainability of a computerised, three tiered, nurse driven protocol for hypoglycaemia treatment.
*Design:* Retrospective pre and post protocol study.
*Setting:* Neurosciences and surgical intensive care units at a tertiary academic medical centre.
*Measurements:* Patients with a hypoglycaemic episode were included during a pre-protocol or post-protocol implementation period. An additional six-month cohort was evaluated to assess sustainability.
*Results:* Fifty-four patients were included for evaluation (35 pre- and 19 post-protocol); 122 patients were included in the sustainability cohort. Hypoglycaemia treatment significantly improved in the post-protocol cohort (20% vs. 52.6%, $p = 0.014$); with additional improvement to 79.5% in the sustainability cohort. Time to follow-up blood glucose was decreased after treatment from 122 [Q1–Q3: 46–242] minutes pre-protocol to 25 [Q1–Q3: 9–48] minutes post protocol ($p < 0.0001$). This reduction was maintained in the sustainability cohort [median of 29 min (Q1–Q3: 20–51)].
*Conclusion:* Implementation of a nurse-driven, three-tiered protocol for treatment of hypoglyacemia significantly improved treatment rates, as well as reduced time to recheck blood glucose measurement. These benefits were sustained during a six-month period after protocol implementation.


## Implications for clinical practice

- Implementation of a three tiered, nurse driven protocol on admission to the intensive care unit allows the nurse to administer dextrose immediately for hypoglycaemic events per protocol, regardless of aetiology.
- Treatment rates of hypoglycaemia were significantly improved after protocol initiation and these treatment rates were sustained six months after the initial education period.
- Time to follow-up monitoring of blood glucose after a hypoglycaemic event was also decreased after protocol initiation, aiding to detect persistent hypoglycaemic events.

☆ Address where work was performed: The Ohio State University Wexner Medical Center.

* Corresponding author at: Burn/Surgical Critical Care, Department of Pharmacy, The Ohio State University Wexner Medical Center, 410 W 10th Avenue, Room 368 Doan Hall, Columbus, OH 43210, United States.
*E-mail address:* Claire.Murphy@osumc.edu (C.V. Murphy).

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## Introduction

Hypoglycaemia during critical illness can occur from aetiologies including liver dysfunction, sepsis, insulin administration and ingestion of oral antidiabetic agents, such as sulfonylureas (Kasiborod et al., 2009; Martens and Tits, 2014). With reported hypoglycaemia incidences ranging between 15 and 75%, it is essential that clinicians are aware that even mild hypoglywcemia is associated with increased risk for mortality (Finfer 2012; Jacobi et al., 2012; Turchin et al., 2009). While techniques such as continuous glucose monitoring and software guided insulin infusion protocols can reduce the risk of hypoglycwemia, it is unlikely that hypoglycaemia will ever be completely eradicated (Brunner et al., 2011; Mesotten, 2013).

There are limited data on how to effectively manage hypoglycaemia and many published evaluations of hypoglycaemia protocols are limited to patients with existing diagnosis of diabetes or patients without critical illness (Coats and Marshall, 2013; Harrison et al., 2013; Anthony, 2007). Overtreatment of hypoglycaemia can unintentionally induce glycaemic variability (GV), which has also been associated with poor outcomes (Ali et al., 2008; Ceriello, 2013; Dosset et al., 2008; Jacobi et al., 2012; Krinsley, 2008). Recently, a six-tiered approach to correct hypoglycaemic events using varying doses of dextrose can reduce GV associated with treatment (Arnold, 2015). To standardise and improve treatment of hypoglycaemic episodes in our surgical intensive care unit (SICU) and neurosciences critical care unit (NCCU), we developed a simplified three-tiered protocol for hypoglycaemia management. This protocol was implemented after a one year review of hypoglycaemia in these units revealed significant variability in untreated hypoglycaemic events (defined as blood glucose (BG) <70 mg/dL). We hypothesised that implementation of a nurse driven, tiered protocol would improve treatment frequency of hypoglycaemia, and that sustainability of the protocol would be achieved.

## Methods

All adult patients were included with at least one hypoglyacemic episode, defined as BG <70 mg/dl on point of care testing or serum blood glucose while admitted to the surgical intensive care unit (SICU) or neurosciences critical care unit (NCCU) at Medical Centre between January 1, 2013 and January 21, 2013 (pre-protocol) or May 7, 2013 and May 21, 2013 (post-protocol) (Fig. 1). Patients who were incarcerated, pregnant, >89 years or <18 years of age were excluded. If patients had multiple qualifying hypoglycaemic episodes, only the first event was included for analysis. The protocol was implemented on May 1, 2013 and evaluation of the post-protocol group began after a one week period to allow for familiarisation. An additional cohort of patients with hypoglycaemia during SICU or NCCU admission between May 22, 2013 and December 31, 2013 were included to evaluate long-term sustainability of the protocol. The short post-protocol period was specified a priori to determine if the initial education period or the effects of the protocol itself were the drivers of success. The Institutional Review Board at The Ohio State University approved this study prior to its commencement.

The nurse-driven hypoglycaemia treatment protocol implemented in the SICU and NCCU utilised three tiers of dextrose doses, given based on three levels of severity of hypoglycaemia (Table 1). This was adapted from previously published data and treatment protocols from other hospitals with the purpose of reducing GV (Arnold et al., 2015; Ceriello and Kilpatrick, 2013). An associated order set in the computerised physician order entry (CPOE) system was developed and added to SICU and NCCU admission order sets. The admission orders now automatically contain PRN dextrose

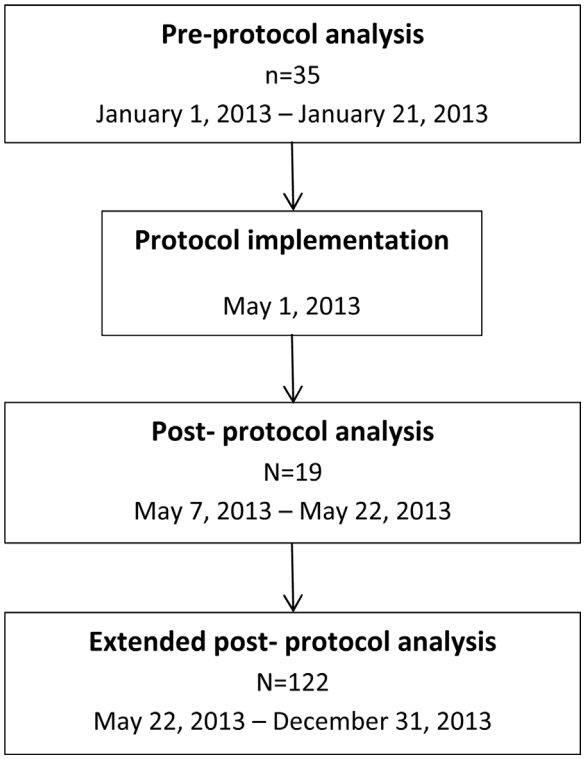


**Fig. 1.** Study Timeline.

and nursing instructions to perform repeat point-of-care glucose measurements on ICU admission for all patients. The order for dextrose is linked to the automated medication dispensing cabinet, allowing the nurse to administer dextrose immediately for hypoglycaemic events per protocol, regardless of aetiology. The ICUs at The Ohio State University Wexner Medical Centre are open admission, with nursing ratios of one nurse for every one or two patients depending on the patient acuity. In our NCCU and SICU, approximately 30% of nurses have greater than 20 years of experience, 30% have five-20 years of experience and 30% have less than 5 years of experience. Prior to protocol implementation, nursing staff were required to recognize hypoglycaemia on serum chemistry labs or with a point of care test and contact prescrCU, approximately 30% of nurses have greater than 20 years of experience, 30% have five-20 years of experience and 30% have less than fiveyears of experience. Prior to protocol implementation, nursing staff were required to recognise hypoglycaemia on serum chemistry bloods or with a point of care test and contact prescribers for orders for both dextrose treatment and follow-up BG measurement(s) for all hypoglycaemic events. The target BG range is per discretion of the admitting team, however; the standard goal for this institution is generally 140–180 mg/dL. In the ICU, the standard for BG monitoring is a minimum of point-of-care testing for all patients performed by the nurse every six hours in addition to a daily serum glucose measurement. Patients receiving continuous insulin infusion will have hourly point-of-care BG monitoring. Hyperglycaemia during the study period is initially managed via subcutaneous sliding scale with insulin in patients without known diabetes or severe hyperglycaemia. A continuous insulin infusion is initiated in patients with two consecutive blood glucose >200 mg/dl and is titrated hourly based on point-of-care BG values using a standardised nurse protocol with a target BG of 110–150 mg/dL (6.1–8.3 mmol/L).

Pre- and post-protocol cohorts were compared with a primary outcome of treatment rates of hypoglycaemia to ensure efficacy of the protocol. Treatment of hypoglycaemia was defined as administration of intravenous 50% dextrose before the next

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