Dextrose 10% or 50% in the treatment of hypoglycaemia out of hospital? A randomised controlled trial

C Moore, M Woollard

Objective: To investigate whether 10% dextrose given in 5 g (50 ml) aliquots is more effective than 50% dextrose given in 5 g (10 ml) aliquots in the treatment of out of hospital hypoglycaemia.

Design: Randomised controlled trial.

Setting: Out of hospital patients attended by paramedics from a large UK ambulance service.

Participants: 51 unresponsive adult patients with blood glucose levels ≤ 4 mmol/l.

Intervention: 5 g (50 ml) intravenous aliquots of 10% dextrose or 5 g (10 ml) intravenous aliquots of 50% dextrose to a maximum dose of 25 g.

Main outcome measures: To compare for each dextrose concentration the time to achieve a Glasgow Coma Scale (GCS) score of 15, and the dose required to obtain a blood glucose level of ≥ 4.5 mmol/l.

Results: There were no statistically significant differences between the groups with regard to age or sex, median pretreatment GCS, pretreatment blood glucose level, or proportion of patients with insulin dependent diabetes. Following treatment, there were no statistically significant differences in median time to recovery (8 minutes), median post-treatment GCS, or number of subjects experiencing a further hypoglycaemic episode within 24 hours (four per group). The median total dose of dextrose administered was significantly less with the 10% concentration (10% = 10 g, 50% = 25 g, p < 0.001) and median post-treatment blood sugar levels were also significantly lower (10% = 6.2 mmol/l and 50% = 9.4 mmol/l, p = 0.003). There were no reports of extravasation injuries in either group.

Conclusions: Dextrose 10% delivered in 5 g (50 ml) aliquots is administered in smaller doses than dextrose 50% delivered in 5 g/10 ml aliquots, resulting in lower post-treatment blood glucose levels. We therefore recommend it as the intravenous treatment of choice for adult hypoglycaemia.

Before 1999, 50% dextrose and glucagon were the principal treatments available to UK emergency ambulance personnel caring for unconscious or unresponsive hypoglycaemic patients. Dextrose 50% is a hypertonic solution of glucose available in prefilled syringes containing 25 g glucose in 50 ml water (IMS mini-jet, International Medication Systems (UK), Leatherhead, Surrey, England). In south-east Wales, at the time of this study, it was administered intravenously in 5–10 g (10–20 ml) increments, titrated against effect after confirming hypoglycaemia by capillary or venous blood sugar level.

High concentrations of glucose can cause cerebral oedema and death in children. In 1999, a revised UK paramedic training syllabus and manual were introduced and in 2000, the Joint Royal Colleges Ambulance Liaison Committee (JRCALC) published its prehospital treatment guidelines. Both recommended 10% dextrose for the reversal of hypoglycaemia in children and pregnant women. Subsequently, 10% dextrose became available in most UK ambulances and its use and recommended for the reversal of all hypoglycaemic episodes.

A literature search retrieved a number of papers evaluating the use of 50% dextrose and glucagon. However, no research was found that evaluated 10% dextrose for the treatment of hypoglycaemia, although one paper reported that, as with any hypertonic solution, extravasation injury is possible.

This randomised controlled trial aimed to compare the efficacy and safety of 5 g aliquots of 10% and 50% dextrose in the out of hospital treatment of adult hypoglycaemic patients.

METHODS

Participants

We included hypoglycaemic patients aged 18 years or over from south-east Wales (UK), whose level of consciousness and ability to cooperate did not allow administration of oral carbohydrates, whose blood sugar was < 4 mmol/l, and in whom intravenous access had been gained in three or fewer attempts. We excluded conscious, cooperative patients, who were able to take oral carbohydrate or who were administered dextrose, glucagon, or Hypostop (Bio-diagnostics Ltd, Upton-on-Severn, Worcestershire, UK) before the arrival of the paramedics.

Interventions

To be consistent with the existing South-East Wales paramedic protocol for 50% dextrose, we randomised patients to receive either 10% or 50% dextrose in 5 g increments. This was considered appropriate as it allowed us to compare equivalent doses of the two solutions. To ensure that the dose of 10% dextrose was measured accurately, the paramedics used a syringe attached to a three-way tap to draw up 50 ml aliquots from a 500 ml infusion bag attached to a giving set. The 10 ml aliquots administered to the 50% dextrose group were measured using 5 ml calibration markings on the prefilled syringes. The paramedics were instructed to administer the 5 g bolus and wait for one minute before administering subsequent aliquots, until either the Glasgow Coma Scale (GCS) score had returned to 15 or the maximum cumulative dose of 25 g of dextrose had been administered. Time taken to regain GCS 15 was calculated from the time the first incremental dose was administered.
Outcomes
Our key outcome measure for this study was intergroup comparison of the time taken to regain a GCS score of 15 following the administration of two concentrations of dextrose. Secondary outcome measures included post-treatment blood glucose levels, the total dose of dextrose given, and the time required to achieve a capillary blood sugar level of >4.5 mmol/l, measured using Roche Accu-Check “Advantage” blood glucose meters and test strips (Roche Diagnostics Ltd, Bell Lane, Lewes, East Sussex, UK). The paramedics were asked to record incidences of extravasation and to score the convenience of administering each concentration of dextrose using a Likert scale. The researchers followed up all patients to determine whether there had been a recurrent episode of hypoglycaemia within 24 hours of treatment.

Consent
Due to the confused or unconscious state of hypoglycaemic patients it was not possible to obtain informed consent from the participants prior to recruitment into the trial. Instead, when they were recovered and oriented after treatment, the paramedics informed them that they had been recruited for a study that was comparing the efficacy of two different concentrations of dextrose. Each participant was given an information pack describing the trial with a form and preaddressed envelope so that participants could withdraw their data from the study at any time. Ethical approval was obtained from the Bro Taf Health Authority Local Research Ethics Committee.

Sample size
Following a pilot study, it was established that a total sample size of 50 was required (25 subjects per group) to detect a three minute difference between the groups in a return to full consciousness (GCS 15), with power of 0.85 and α of 0.05.

Randomisation
A total of 240 study forms (120 per group) identifying the concentration of dextrose to be administered were pre-randomised for order using SPSS (version 10.0.5) and assigned a unique sequential number. Each form was put in an opaque envelope and packed in consecutively numbered groups of 10, which were then placed in participating ambulance service vehicles. Following confirmation that a subject met the inclusion criteria, paramedics responsible for their care opened the lowest numbered envelope remaining in the vehicle’s pack and administered the dextrose concentration detailed on the study form inside. The randomisation sequence was concealed and held by one of the chief investigators until recruitment was completed.

Blinding
Due to the differences in appearance of the two formulations of dextrose it was not possible to blind the paramedics to the concentration of dextrose given.
Statistical methods
We used SPSS to conduct the Mann–Whitney U test for intergroup comparisons of age, pretreatment and post-treatment GCS and blood sugar, total dose of dextrose administered, time to recovery, time on scene, and ease of administration. StatsDirect (version 2.2.78, CamCode, Ashwell, UK) was used to calculate p values and 95% confidence intervals for intergroup differences in proportions with regard to sex, insulin dependent diabetes, and post-treatment recurrent hypoglycaemia.

RESULTS
Demographics and recruitment
We collected the data for this study from 28 October 2002 to 25 October 2003. See fig 1 for details of patient recruitment. A total of four randomisation envelopes were opened out of sequence. In two cases this did not alter the dextrose concentration that should have been administered had the correct envelope been selected. No evidence of a deliberate attempt to break the randomisation sequence was identified. We analysed the data on an intention to treat basis. We are aware of one protocol violation. One of the participants in the 10% group received a total dose of 30 g rather than 25 g. This was a result of a paramedic failing to use a three-way tap and setting up a free running drip instead.

There were no significant differences between the groups in age or sex characteristics or the number of patients with insulin dependent diabetes. Pretreatment GCS and blood glucose levels were also similar in both groups (table 1).

Outcome data
We analysed the data on an intention to treat basis to recovery of normal consciousness. There were no significant differences between the groups in time to recovery to maximum consciousness (GCS of 15); median post-treatment GCS, or the proportion of participants experiencing a further hypoglycaemic episode within 24 hours.

DISCUSSION
We did not find any difference in the efficacy of treatment between the two groups in the present study. However, despite both cohorts having similar GCS and blood sugar levels before treatment, subjects in the 50% group received a median of 15 g more glucose than those in the 10% group, and these subjects were more likely to have post-treatment blood sugar level were significantly higher in the 50% group, and these subjects were more likely to have received the maximum permitted dose of 25 g (table 2).

An exploratory analysis of patients without a maximum GCS score of 15 following treatment is shown in table 3. Although all three patients had euglycaemic post-treatment blood sugar levels, all required hospital admission. One of these patients was suspected of being under the influence of illegal drugs, one was a known alcoholic, and one had a serious intercurrent urinary tract infection.

Table 1 Comparison of the demographic data of the two study groups. Values are median (range, interquartile range).

<table>
<thead>
<tr>
<th></th>
<th>10% Group (n = 25)</th>
<th>50% Group (n = 26)</th>
<th>Difference, p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>55 (22 to 93, 38 to 74)</td>
<td>54 (22 to 81, 43 to 66)</td>
<td>−2, p = 0.692</td>
</tr>
<tr>
<td>Pretreatment GCS</td>
<td>4 (3 to 14, 3 to 8)</td>
<td>6 (3 to 14, 3 to 12)</td>
<td>+2, p = 0.400</td>
</tr>
<tr>
<td>Pretreatment blood glucose (mmol/l)</td>
<td>1.50 (0.00 to 3.80, 1.20 to 1.80)</td>
<td>1.40 (0.00 to 3.70, 0.78 to 1.83)</td>
<td>−0.1, p = 0.317</td>
</tr>
</tbody>
</table>

GCS, Glasgow Coma Scale

Table 2 Differences in outcome measures between the two study groups. Values are median (range, interquartile range)

<table>
<thead>
<tr>
<th></th>
<th>10% Group (n = 25)</th>
<th>50% Group (n = 26)</th>
<th>Difference, p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dose of dextrose (g)</td>
<td>10 (5 to 30, 10 to 15)</td>
<td>25 (10 to 25, 15 to 25)</td>
<td>+15, p &lt; 0.001</td>
</tr>
<tr>
<td>Post-treatment blood glucose (mmol/l)</td>
<td>6.20 (4 to 17, 5.15 to 9.10)</td>
<td>9.40 (4.30 to 18.50, 8.28 to 11.60)</td>
<td>+3.2, p = 0.003</td>
</tr>
<tr>
<td>Post-treatment GCS</td>
<td>15 (6 to 15, 15 to 15)</td>
<td>15 (3 to 15, 15 to 15)</td>
<td>0, p = 0.400</td>
</tr>
<tr>
<td>Time to GCS 15 (min)</td>
<td>8 (1 to 30, 5 to 15)</td>
<td>8 (2 to 19, 4 to 11)</td>
<td>0, p = 0.733</td>
</tr>
<tr>
<td>Time on scene (min)</td>
<td>40 (13 to 25, 30 to 51)</td>
<td>35 (15 to 61, 23 to 45)</td>
<td>−5, p = 0.162</td>
</tr>
<tr>
<td>Ease of administration score</td>
<td>2 (1 to 4, 1 to 3)</td>
<td>1 (1 to 5, 1 to 2)</td>
<td>−1, p = 0.142</td>
</tr>
</tbody>
</table>

GCS, Glasgow Coma Scale

Table 3 Analysis of patients not achieving a Glasgow Coma Scale (GCS) score of 15

<table>
<thead>
<tr>
<th>Unique identifier</th>
<th>Group</th>
<th>Blood sugar</th>
<th>GCS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
</tr>
<tr>
<td>Pre, pretreatment; post, post-treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>82</td>
<td>10%</td>
<td>1.3</td>
<td>11.4</td>
</tr>
<tr>
<td>212</td>
<td>10%</td>
<td>3.8</td>
<td>9.7</td>
</tr>
<tr>
<td>23</td>
<td>50%</td>
<td>1.1</td>
<td>8.7</td>
</tr>
</tbody>
</table>

GCS, Glasgow Coma Scale
administered 50% dextrose were more likely to have received the maximum dose of 25 g than those given the 10% concentration. The reasons for this are unclear, but may be related to the presentation of the 50% solution or to usual practice before the trial. It is also possible that the pharmacokinetics of the two solutions are different, and that 50% dextrose delivered in 5 g (10 ml) boluses has a slower onset of action, encouraging the administration of additional increments before initial aliquots have taken effect.

Two of the subjects contacted by the researchers after treatment reported that before the study they had often had difficulty bringing their blood glucose back to their expected usual level after being treated by paramedics using 50% dextrose. This might imply that the lower cumulative doses administered with the 5 g (50 ml) aliquots of 10% dextrose could assist patients in controlling their post-treatment blood sugar levels. Evidence suggests that administration of dextrose can have a detrimental effect on patients at risk of cerebral ischaemia, such as victims of stroke, cardiac arrest, or head trauma. Avoidance of hyperglycaemia has a neuroprotective effect and reduces mortality and morbidity in the critically ill. The relatively lower post-treatment blood sugar levels associated with the use of 10% dextrose administered in 5 g (50 ml) aliquots may, therefore, offer a safer option for the treatment of hypoglycaemia in these categories of patient.

Limitations of the study
Follow up data were not available for three patients in the 10% group and four in the 50% group, but these missing data would not have significantly changed this study’s primary finding. The total number of patients who presented with hypoglycaemia in the study area during the trial period was not available. Although this did not influence the randomisation process, it is possible that the outcome of those patients not recruited for the trial could have altered its results had they been included.

CONCLUSIONS
Dextrose 10% administered in 5 g (50 ml) aliquots was found to be as effective and safe as 50% dextrose delivered in 5 g (10 ml) aliquots. Patients in the 10% dextrose group received a median of 15 g less glucose than those in the 50% group, were less likely to receive the maximum permitted dose, and consequently had post-treatment blood glucose levels that were 3.2 mmol/l lower on average. We therefore recommend 10% dextrose administered in 5 g (50 ml) aliquots as the first choice intravenous therapy for the treatment of hypoglycaemia in adults.

ACKNOWLEDGEMENTS
The authors would like to thank all the paramedics who participated in this study, in particular, K Dwyer who asked the question “If we can use 10% dextrose for pregnant females, why can’t we use it for all adults?” A Smith, K Roberts, and K Pitt helped identify relevant papers. R Whitfield provided expert advice about the randomisation strategy and E Green, P Burrows, and P Wilkins helped with preparation of the data collection forms.

AUTHORS’ CONTRIBUTIONS
C Moore had the idea for the study and collected the data. M Woollard and C Moore designed the study, analysed the data, and wrote and edited this paper.

REFERENCES

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Dextrose 10% in the Treatment of Out-of-Hospital Hypoglycemia

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Abstract

Introduction: Prehospital first responders historically have treated hypoglycemia in the field with an IV bolus of 50 mL of 50% dextrose solution (D50). The California Contra Costa County Emergency Medical Services (EMS) system recently adopted a protocol of IV 10% dextrose solution (D10), due to frequent shortages and relatively high cost of D50. The feasibility, safety, and efficacy of this approach are reported using the experience of this EMS system.

Methods: Over the course of 18 weeks, paramedics treated 239 hypoglycemic patients with D10 and recorded patient demographics and clinical outcomes. Of these, 203 patients were treated with 100 mL of D10 initially upon EMS arrival, and full data on response to treatment was available on 164 of the 203 patients. The 164 patients’ capillary glucose response to initial infusion of 100 mL of D10 was calculated and a linear regression line fit between elapsed time and difference between initial and repeat glucose values. Feasibility, safety, and the need for repeat glucose infusions were examined.

Results: The study cohort included 102 men and 62 women with a median age of 68 years. The median initial field blood glucose was 38 mg/dL, with a subsequent blood glucose median of 98 mg/dL. The median time to second glucose testing was eight minutes after beginning the 100 mL D10 infusion. Of 164 patients, 29 (18%) required an additional dose of IV D10 solution due to persistent or recurrent hypoglycemia, and one patient required a third dose. There were no reported adverse events or deaths related to D10 administration. Linear regression analysis of elapsed time and difference between initial and repeat glucose values showed near-zero correlation.

Conclusions: In addition to practical reasons of cost and availability, theoretical risks of using 50 mL of D50 in the out-of-hospital setting include extravasation injury, direct toxic effects of hypertonic dextrose, and potential neurotoxic effects of hyperglycemia. The results of one local EMS system over an 18-week period demonstrate the feasibility, safety, and efficacy of using 100 mL of D10 as an alternative. Additionally, the linear regression line of repeat glucose measurements suggests that there may be little or no short-term decay in blood glucose values after D10 administration.


Introduction

Prehospital first responders and other medical personnel historically have treated patients with hypoglycemia with 50% dextrose solution (D50). The D50 is a hypertonic solution of glucose available in prefilled syringes containing 25 grams of glucose in 50 mL of water. Although individual protocols vary, in patients unable to take oral glucose, it is often given as a bolus after initial patient assessment, glucometer confirmation of hypoglycemia, and obtaining of intravenous access.

There are several reasons, both practical and theoretical, that treating hypoglycemia with a bolus of D50, despite long tradition, may not be the right choice. First, there is a nationwide shortage of D50 in the United States, which has affected the ability of Emergency Medical Services (EMS) systems to stock adequate supplies of the solution. It also is relatively more expensive than other glucose-containing solutions. Prefilled 50 mL syringes of D50 are available to the California Contra Costa County EMS system at a cost of $5.58 each, versus $1.62 for a 250 mL bag of 10% dextrose solution (D10), from which a 100 mL aliquot is initially infused. In addition, D50 is more viscous than other
intravenous fluids and often requires two hands to administer, preventing paramedics from doing other tasks such as electrocardiograms or neurological assessments, during its administration.

Theoretical reasons to avoid D50 include the potential greater risk of extravasation injury, potential supratherapeutic dosing of glucose causing hyperglycemia, and direct toxic effects of hypertonic dextrose itself. Animal models have demonstrated the toxic effect of glucose infusions in the settings of cardiac arrest and stroke. Experimental data suggests that hyperglycemia is neurotoxic to patients in the setting of acute illness. Although no data has linked the use of D50 in the prehospital setting to adverse outcomes, using a lower concentration in a greater total volume of solution might help to mitigate some of the potential risks of D50.

Further, despite its long use, there is little data to support D50 as a given standard. Review of prior literature reveals only one trial comparing D50 to D10 for the treatment of hypoglycemia. In a trial of 51 adult hypoglycemic patients with altered mental status treated by paramedics from a large United Kingdom ambulance service, patients were randomized to receive 5 gram (50 mL) intravenous aliquots of D10 or 5 gram (10 mL) intravenous aliquots of D50 to a maximum dose of 25 grams. There was no statistical difference in the main outcome of time to regain normal consciousness, leading researchers to conclude that their D10 protocol was safe and effective. The D10 group received less total glucose and had lower post-treatment glucose levels in the study.

Beginning January 1, 2013, the California Contra Costa County EMS system began using 100 mL of intravenous D10 as its primary intravenous agent to treat hypoglycemia, and collected 18 weeks of clinical and demographic data as part of ongoing quality control measures examining this approach. Previously, D50 had been the first-line intravenous dextrose agent in this system. The decision was made largely due to frequent shortages of D50 and the relative lower cost of D10, as well as the theoretical benefit of not using D50. As a part of the protocol change, and in coordination with study investigators, demographic and clinical data on patients who received D10 in the field were collected prospectively by EMS personnel. The goal of this study was to present and analyze the data collected on patients who were hypoglycemic on EMS arrival and received intravenous D10 as their initial treatment, and to position these results in the context of the relevant literature on this approach.

Methods
This study was observational and quantitative using prestudy defined indicators. Study investigators were involved in the design of the EMS system’s D10 protocol, and EMS personnel in the field recorded study data prospectively during patient encounters. Analysis was focused on patients: (1) who were older than age 18; (2) who displayed symptoms of hypoglycemia on the clinical judgment of paramedics; (3) whose level of consciousness and ability to cooperate did not allow administration of oral glucose; (4) whose blood sugar was below 70 mg/dL as evaluated in the field; and (5) in whom intravenous access could be obtained. Of the 239 patients who were administered D10 by EMS personnel in the 18 weeks of data collection, 203 met these criteria (Figure 1). The remaining 36 patients were excluded by the following criteria: 29 patients received oral glucose initially by paramedics; three patients received intramuscular glucagon; and four patients were euglycemic or hyperglycemic on EMS arrival. Of the 203 patients who met criteria, 20 patients received out-of-protocol IV glucose, for example, in aliquots greater or less than 100 mL. Another 19 patients had incomplete data on response to D10, most commonly because of hospital arrival before repeat glucose value could be obtained. The remaining 164 patients received initial treatment with 100 mL of IV D10 and had repeat glucose measurements recorded.

The outcomes measured included the blood glucose response to initial infusion of 100 mL of D10 as well as repeat infusions if necessary. Given that the point-of-care blood glucose machines used by EMS personnel do not read glucose values lower than 20-25 mg/dL (depending on the machine) and instead indicate “Low,” a glucose value of 20 mg/dL was assumed when comparing relative glucose values for values of “Low” in this analysis. A linear regression line was fit between elapsed time and difference between glucose value on EMS arrival and subsequent recheck after infusion of initial 100 mL of D10. Emergency Medical Services personnel also were instructed to record any adverse events pertaining to glucose administration.

Data analysis was performed using Microsoft Excel (Version 12.3.6, Microsoft Corporation, Redmond, Washington USA). The Institutional Review Board of the Alameda Health System—Highland Hospital approved the study as exempt from review.

Results
The study cohort of 164 patients included 102 men and 62 women with a median age of 68 years and an interquartile range (IQR) of 55 years-80 years (Table 1). The median initial field blood glucose was 38 mg/dL (IQR = 28 mg/dL-47 mg/dL), with subsequent blood glucose median of 98 mg/dL (IQR = 70 mg/dL-135 mg/dL). Elapsed time after D10 administration before recheck was not uniform, with a median time to recheck of eight minutes (IQR = 5 minutes-12 minutes). Of 164 patients, 29 (18%) received an additional dose of intravenous D10 solution in the field due to
persistent or recurrent hypoglycemia, and one patient required a third dose.

Of the 164 patients analyzed, median change in glucose after D10 administration was 59 mg/dL (IQR = 32 mg/dL–95 mg/dL) (Figure 2). Three patients had a drop in blood glucose after D10 administration: one patient had a drop of 1 mg/dL; one patient had a drop of 10 mg/dL; and one patient had a drop of 19 mg/dL.

The patient with the drop of 19 mg/dL had an insulin pump infusing that was not removed by EMS personnel during D10 infusion. The remaining 161 had an elevation of their blood glucose on recheck (maximum rise to 325 mg/dL). Linear regression analysis of elapsed time and difference between initial and repeat glucose values after D10 showed near-zero correlation, which suggested that serum glucose had minimal decay over the study interval. Figure 2 shows the line of best fit for change in blood glucose after administration of D10.

There were no reported adverse events related to glucose infusion. Two patients who received intravenous D10 were pronounced dead in the field during the period of study. On review of records by investigators, both patients were unresponsive or in cardiac arrest prior to arrival of EMS personnel, and their deaths were unrelated to dextrose administration.

Discussion

Glucose control in critically-ill patients remains challenging. While not frequently studied in the prehospital setting, evidence on the optimal glucose range in the inpatient setting remains controversial. Hypoglycemia has known neurologic adverse effects in critically-ill patients; however, both in animal and patient studies, hyperglycemia also has been shown to negatively affect neurologic outcomes. Extrapolating inpatient data to the prehospital setting is problematic for multiple reasons. These include the relatively few monitoring resources and therapeutic interventions available in the prehospital setting, the short duration of time that patients are under EMS care, and the relatively low acuity of patients encountered in the prehospital setting compared with the intensive care unit.

Despite limitations of existing data and its relevance to the prehospital setting, the optimal treatment of prehospital hypoglycemia should have several features. First, a prehospital treatment regimen must effectively raise the blood glucose. Second, it must be feasible for prehospital care providers to implement. Third, it must be efficient across at least three dimensions: cost, time, and effort. And finally, it must be safe for patients. The current practice of utilizing D50 in the treatment of acute hypoglycemia has shown efficacy, feasibility, and safety in the limited trial data available. Several authors, however, have raised concerns regarding the potential of D50 to cause harm, despite lack of direct evidence. In theory, using smaller aliquots of glucose might mitigate concerns regarding the risk of hyperglycemia and a more dilute solution might mitigate risks regarding extravasation injury. The only clinical trial to date comparing D50 to D10 showed no difference in the primary outcome of time to return to Glasgow Coma Scale of 15; however, there were no safety differences identified.

Reported study data demonstrates that utilizing D10 as the primary intravenous treatment for hypoglycemia is efficacious, with all but three patients demonstrating an increase in their blood glucose after D10 administration. Although a patient-centered outcome such as time to return to normal mental status was not measured, previous trial data shows correlation between increase in serum glucose and return to normal mental status. Of the study patients, only 29 out of 164 (18%) received a second bolus of D10 in the field; however, some patients who only received one dose of D10 may have received additional dextrose on arrival to hospital, and relative comparison to D50 is not known. No complaints or concerns were noted by paramedics in the field in terms of ease of D10 use and how it compares with...
Some providers did note that D10 is easier to infuse, owing to its lower viscosity than D50. Economic or resource utilization analysis is not available. The data shows that D10 administration is safe, with no adverse events related to administration in this small series.

The linear regression fit line of repeat blood glucose measurement against elapsed time suggests that there may be little or no short-term decay in blood glucose values after D10 administration. Previous analysis of D50 in healthy volunteers shows that D50 reliably increases serum glucose over the first five minutes after administration; however, by 30 minutes, blood glucose levels consistently approach pretreatment levels. All of the glucose recheck times were before 30 minutes, allowing that the lack of short-term decay might not have continued if longer-term data were available on study patients. Alternatively, D10 may elicit a less aggressive insulin response than D50 and may paradoxically have a slower decay than D50 from the blood stream. Reported data are inadequate to test this hypothesis and this remains a question for future study.

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Limitations
In this study, a case series without any control group is presented, so conclusions are observational. Long-term follow-up after the prehospital setting was not available and economic analysis is not reported. The regression analysis, a simple fit line, is limited and not controlled for associated and possibly influential covariates. In addition, while there were no reported adverse outcomes related to D10 administration and all patients became euglycemic eventually, it is not clear if there were delays to euglycemia in the reported group compared to D50. Finally, in those patients who did require a second, or even a third, dose of D10, it is not possible to ascertain if there were longer-term unfavorable outcomes because of the protocol change.

Conclusions
In addition to practical reasons of cost, availability, and ease of use, theoretical risks of using D50 in the out-of-hospital setting include extravasation injury, direct toxic effects of hypertonic dextrose, and potential neurotoxic effects. The experience of one local EMS system over an 18-week period demonstrates that D10 is a safe, effective, and feasible alternative to D50 in the acute prehospital management of hypoglycemia.

Acknowledgements
The authors would like to thank all of the paramedics who treated patients in the field during the course of this study.
References