Differential effects of intravenous and subcutaneous insulin sliding scales

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Article points

1. The use of insulin sliding-scale regimens is common, despite growing evidence suggesting they are often ineffective and may be dangerous.
2. Insulin sliding scales are labour intensive, and regimens are frequently not given as prescribed.
3. Subcutaneous regimens may not result in an improvement in hyperglycaemia, thus delaying discharge from hospital.

Key words

- Sliding scales
- Intravenous
- Subcutaneous

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The use of insulin sliding scales remains controversial. Their use has been discouraged for several years by standard-setting organisations, yet they continue to be used regularly, and often inappropriately. The authors of this study set out to determine the effectiveness of the insulin sliding-scale regimen in the prevention and treatment of acute hyperglycaemia in hospitalised individuals, with or without a previous diagnosis of diabetes, in their institution. The authors attempted to identify whether change was needed regarding the current method of glycaemic control for inpatients.

Good glycaemic control in the hospital setting has been shown to be associated with improved patient outcomes (Bruno et al, 2008). Despite this, the control of inpatient blood glucose levels often remains a low-priority consideration in individuals in whom diabetes is not the primary cause for admission (Clement et al, 2004).

Inpatient hyperglycaemia has been associated with several detrimental effects, some of which are listed in *Box 1*. As many studies have shown, glycaemic control remains an important factor in determining clinical outcomes in hospitalised individuals (Van den Berghe et al, 2001; Conner et al, 2005; Baker et al, 2006; 2008). While there are no current recommendations for inpatient blood glucose levels in the UK, recommendations from the US suggest an upper limit of 6.1 mmol/L for people in intensive care, and fasting blood glucose levels between 5.0 and 7.2 mmol/L, with postprandial readings of <10 mmol/L in the non-critical care setting (Clement et al, 2004; American Diabetes Association, 2008).

Aims

To determine the effectiveness of insulin sliding scales in the prevention and treatment of acute hyperglycaemia in hospitalised individuals with or without a previous diagnosis of diabetes.

Patients and methods

Design and subjects

The study used a single-centre retrospective case notes analysis of glycaemic control in

people on medical and surgical wards, and the intensive therapy and coronary care units at the Norfolk and Norwich University Hospital NHS Foundation Trust between September 2007 and February 2008.

All patients were adults, and were receiving intravenous (IV) or subcutaneous (SC) insulin using a sliding scale. Individuals on a sliding scale for less than 24 hours, children, pregnant women with diabetes, and those people who had seen a diabetes inpatient specialist nurse, were excluded from the study (Sampson et al, 2006). The protocol was approved by the University of East Anglia.

Data collection and definitions

On admission, each individual had their bedside finger-prick blood glucose concentrations measured at 1- or 2-hourly intervals for IV sliding-scale regimens, and 4- or 6-hourly intervals for SC insulin regimens, using a hand-held glucose meter. The meter was Trust approved, and internally and externally quality assessed at weekly and 2-monthly intervals, respectively. Insulin doses were adjusted according to finger-prick blood glucose concentrations using Trust guidelines documented on the insulin sliding scale prescription charts.

Data were extracted from medical and nursing notes, and the insulin sliding-scale prescription charts. Baseline data were obtained, including age, gender, hospital ward, diagnosis of diabetes, reason for admission, and type and duration of insulin sliding scale. In addition, the total number of episodes of hypoglycaemia and hyperglycaemia were recorded, as well as including the documented blood glucose measurements. One of the authors contacted the wards daily, and prospectively collected the unique hospital number of any individuals who had been placed on an IV or SC sliding-scale regimen for 24 hours or more. These data were collected after the person had been discharged.

Hypoglycaemia was defined as a blood glucose level <4.0 mmol/L, normoglycaemia between 4.0 and 10.0 mmol/L, and hyperglycaemia as a blood glucose level >10 mmol/L.

Data analysis

Data were analysed through means and percentages, with statistical analyses performed using an unpaired student *t*-test and a Mann-Whitney *U*-test wherever appropriate. The selected statistical test was performed using Microsoft Office Excel 2003 or Statistical Package for the Social Sciences (SPSS) version 14.0. *P*-values <0.05 were considered statistically significant.

Results

A total of 64 inpatients who met the inclusion criteria were identified. Their demographic data are shown in *Table 1*. The top five causes of admission were:

- Cardiac chest pain (*n*=10).
- Pneumonia (*n*=10).
- Diabetic ketoacidosis (*n*=8).
- Vascular (*n*=8).
- Collapse (*n*=6).

Eighty-eight per cent of those without a previous diagnosis of diabetes were receiving IV insulin (*n*=15) compared with 100% of those with type 1 diabetes (*n*=9) and 66% of those with type 2 diabetes (*n*=25). The duration of sliding scale use is shown in *Table 2*.

Glycaemic control is outlined in *Table 3*. *Figures 1* and *2* show the effects of each sliding scale on glycaemic control.

Page points

1. On admission, each individual had their bedside finger-prick blood glucose concentrations measured at 1- or 2-hourly intervals for intravenous sliding-scale regimens, and 4- or 6-hourly intervals for subcutaneous insulin regimens.
2. Hypoglycaemia was defined as a blood glucose level <4.0 mmol/L, normoglycaemia between 4.0 and 10.0 mmol/L, and hyperglycaemia as a blood glucose level >10 mmol/L.

Box 1. Some of the detrimental effects of inpatient hyperglycaemia.

- Increased cardiac mortality after an acute myocardial infarction (Capes et al, 2000).
- Increased mortality after cerebrovascular event (Kannel and McGee, 1979).
- Increased mortality after cardiac surgery (Furnary et al, 2004).
- Increased infarct size post-cerebral vascular accident (Scott et al, 1999).
- Increased rates in nosocomial infection and sepsis (Pomposelli et al, 1998).
- Increased mortality among critically ill patients (Van den Berghe et al, 2001).
- Prolonged length of stay (Sampson et al, 2007b).

Table 1. Demographic results of participants (*n*=64).

Category	Results
Male (% [*n*])	58 (37)
Mean age (years)	62.6
Previously undiagnosed diabetes (% [*n*])	27 (17)
Type 1 diabetes (% [*n*])	14 (9)
Type 2 diabetes (% [*n*])	59 (38)
On IV or SC regimens (% [*n*])	77 (49) / 23 (15)
Males receiving IV sliding scale (% [*n*])	81 (30)
Females receiving IV sliding scale (% [*n*])	70 (19)
Mean age of those on IV or SC regimens (years)	58.8 / 74.9 (*P*=0.0016)
Place of care:	
General medical wards (%)	8
Specialty metabolic ward (%)	28
General surgical wards (%)	16
Intensive therapy or coronary care (%)	48

IV=intravenous; SC=subcutaneous

Table 2. Mean duration of sliding scale use (days).

Overall	3.2
Male or female	3.1 vs. 3.25 (*P*=0.85)
Intravenous versus subcutaneous	2.69 vs. 4.8 (*P*=0.004)

Table 3. Glycaemic control.

Overall percentage of hypoglycaemia (%)	2
Hypoglycaemic episodes: IV versus SC (%)	2 vs. 1 (*P*=0.09)
Hyperglycaemic episodes: IV versus SC (%)	38 vs. 30 (*P*=0.23)

IV=intravenous; SC=subcutaneous

Discussion

The insulin sliding scale, either IV or SC, has been heavily criticised, with mounting evidence against its use as it has been shown to be ineffective, or even dangerous (Queale et al, 1997; Hirsch, 2009). The IV sliding scale may be useful in individuals who are unable to eat or drink, but the SC sliding scale has no evidence base. Despite this, over half of all hospitals in the UK still recommend its use (Sampson et al, 2007a).

The results of the present study show that while glycaemic control does not deteriorate on SC sliding scales, it also does not improve. This is in contrast to the improvement seen using an IV regimen.

These data support previous work by Queale et al (1997), demonstrating that the use of a sliding scale leads to erratic glycaemic control while in hospital. The results also indicate that sliding scales appear unable to maintain appropriate blood glucose concentrations, with high glycaemic variability using either regimen; although this significantly improved towards the last 36 hours on the IV sliding scale.

The SC insulin sliding-scale regimen yielded no significant improvements in mean blood glucose concentrations during any time, comparing the mean of the first 12 hours with the last 12 hours (8.8 vs 7.7 mmol/L; *P*=0.31); this was regardless of gender. Potential causes may be due to the older patient population in the SC group, and the difference of route administration – which is technique dependent – and the small sample size. The latter issue is an important limitation in this study.

Mean glucose levels in the IV group improved over the study duration. This may be as a result of the younger patient population, the route of administration being more effective at reducing technique problems, and possibly more frequent blood glucose monitoring.

The data presented reflect a failure to achieve recommended blood glucose control. The authors acknowledge that this may be due to a number of factors, including poor implementation of the sliding scale, or because it is ineffective, owing to its retrospective approach, rather than a preventative approach, to the treatment and management of hyperglycaemia. The prospective use of a basal–bolus regimen has been shown to be significantly better in controlling blood glucose levels in non-critically ill, hospitalised individuals (Umpierrez et al, 2007).

Limitations

Data in the study were collected retrospectively after patients had been discharged.

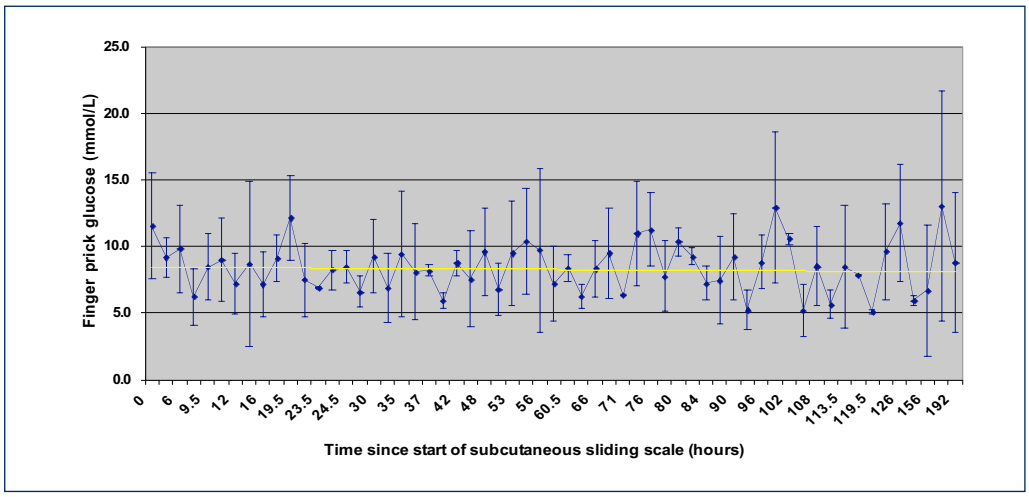

Figure 1. Mean plasma glucose over time using a subcutaneous insulin sliding scale (n=15). No overall improvement in glycaemic control was observed from the first 12 hours of the start of the sliding scale through to the last 12 hours before being taken off the regimen (mean blood glucose levels 8.8 vs 7.7 mmol/L; P=0.31). This was the same across all wards (data not shown).

This meant that some of the data were missing or incomplete. Furthermore, the sample size was relatively small and from a single institution, with unequal proportions between the IV and SC regimens.

Recommendations

As a result of this study, the authors have successfully convinced their Trust that the use of SC sliding scales needs to be reassessed. The use of the basal–bolus regimen is due to be trialled on wards that currently use the SC regimen to assess the impact on glycaemic control, nursing staff time and length of stay.

In addition, the results of this work have been disseminated widely in the Trust, making healthcare professionals reconsider whether the use of a sliding scale is the most appropriate regimen for the patient, or whether it is being instituted for the perceived ease of use for the staff.

Finally, the results have been highlighted to those involved in the care of people with diabetes, so that when optimal glycaemic control is not being achieved, they call in the inpatient diabetes specialist nurses sooner than was being done previously.

Conclusion

The use of SC sliding scale insulin in this study did not improve glycaemic control on a variety of wards, or between men and women; however, IV insulin led to better glycaemic control. This aspect of inpatient management needs more attention, and further standards of care need to be implemented. ■

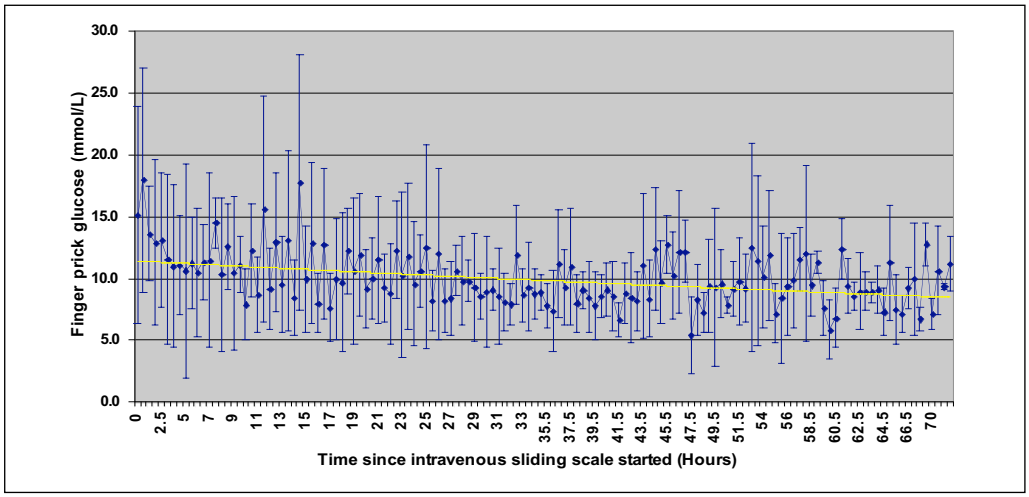

Figure 2. Mean plasma glucose over time using an intravenous insulin sliding scale (n=49). There was a significant improvement in mean blood glucose concentration from the first 12 hours to the last 12 hours (11.8 vs 7.6 mmol/L; P=0.0005).

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