Inpatient Diabetes and Hyperglycaemia

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Heart of England NHS Foundation Trust
Birmingham
Outline of the Talk

• The definitions and the burden
• The impact and the cost
• A case
• The effects of hyperglycaemia and hypoglycaemia
• Blood glucose targets in hospital
• A bit of physiology and pharmacology
• How I do it
• Conclusions
• Questions
**Definitions:**

**Medical history of diabetes:** diabetes has been previously diagnosed and treated before admission

**Newly diagnosed diabetes:** hyperglycaemia (FBG ≥6.9 mmol/L or RBG ≥11.1 mmol/L) occurring during hospital stay and confirmed after discharge

**Hospital-related hyperglycaemia:** hyperglycaemia (FBG ≥6.9 mmol/L or RBG ≥11.1 mmol/L) occurring during the hospitalisation that reverts to normal after hospital discharge.

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**The Burden**

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**Chart 1**

Prevalence of diabetes at site level, England

- Prevalence of diabetes (%)
  - 30
  - 25
  - 20
  - 15
  - 10
  - 5
  - 0

212 Hospitals participated equating to 188 sites
INPATIENT HYPERGLYCAEMIA IS COMMON

Hyperglycemia*: A Common Comorbidity in Medical-Surgical Patients in a Community Hospital

- Normoglycemia
- Known Diabetes
- New Hyperglycemia

FBG >6.9 mmol/L or RBG ≥ 11.0 mmol/L

Umpierrez G et al, J Clin Endocrinol Metab 87:970, 2002

INPATIENT HYPOGLYCAEMIA IS COMMON

Chart 18
Percentage of patients experiencing hypoglycaemic episodes by type of diabetes, England

<table>
<thead>
<tr>
<th>Type</th>
<th>Mild Hypo (3-4mmol/L)</th>
<th>Severe Hypo (&lt;3mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>41.0</td>
<td>29.9</td>
</tr>
<tr>
<td>Type 2 (insulin)</td>
<td>31.5</td>
<td>15.8</td>
</tr>
<tr>
<td>Type 2 (non insulin)</td>
<td>19.2</td>
<td>6.1</td>
</tr>
<tr>
<td>Type 2 (diet only)</td>
<td>9.6</td>
<td>2.8</td>
</tr>
</tbody>
</table>
Chart 12
'Good diabetes days' by type of diabetes, England

Days

<table>
<thead>
<tr>
<th>Days</th>
<th>Type 1</th>
<th>Type 2 (insulin)</th>
<th>Type 2 (non insulin)</th>
<th>Type 2 (diet only)</th>
<th>Other</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2.2</td>
<td>3.3</td>
<td>4.5</td>
<td>5.3</td>
<td>3.2</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Figure 1: Length of stay (LOS) data showing difference between patients with and without diabetes by specialty for elective, non-elective and combined episodes for all NHS Trusts in England (source: 2006/07 Hospital Episode Statistics (HES) data)

NB - positive figure indicates longer length of stay for patients with diabetes.
The NHS in England spends around £2.3 billion – £2.5 billion a year on inpatient care for people with diabetes, which is approximately 11% of total NHS expenditure on inpatient care.

### Unadjusted admissions and estimated expenditure for people with recorded diabetes, 2009-10 (2011-12 prices)

<table>
<thead>
<tr>
<th></th>
<th>Number of admissions with record of diabetes</th>
<th>Estimated average unit cost (tariff)</th>
<th>Estimated annual expenditure (tariff)</th>
<th>Estimated annual expenditure (tariff + 8.5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-elective admissions</td>
<td>609,452</td>
<td>£2,641</td>
<td>£1,609,736,111</td>
<td>£1,745,875,504</td>
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<tr>
<td>Elective ordinary admissions</td>
<td>150,362</td>
<td>£2,951</td>
<td>£443,660,069</td>
<td>£481,181,507</td>
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<tr>
<td>Elective day case admissions</td>
<td>327,608</td>
<td>£799</td>
<td>£261,646,664</td>
<td>£283,774,774</td>
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<tr>
<td>Total</td>
<td>1,087,422</td>
<td></td>
<td>£2,315,042,844</td>
<td>£2,510,831,784</td>
</tr>
</tbody>
</table>
A Case of Inpatient Diabetes

October 2014

• Mrs DE
• 78 year-old woman
• Admitted with AKI and DKA 2° to viral illness
• LOS - 7 days

PMH
Type 2 diabetes ketosis-prone
Hypertension
COPD
CABG
HbA1c – 12%

HbA1c and Estimated Average Glucose
HbA1c (%) eAG (mmol/l)
5 5.4
6 7.0
7 8.6
8 1.2
9 11.8
10 13.4
11 14.9
12 16.5

• Seen by DISN converted from Novomix 30 to Humulin-I bd
A Case of Inpatient Diabetes

22.09.15
• Admitted with a fall
• 19:00h Nursing note - patient declined most of her evening meal

23.09.15
• 02:00h Dr called to review CBG 1.1 mmol/L
• FY1 note – given IM Glucagon, ½ Glucogel and 100mL 10% Glucose -CBG 13.0 mmol/L
• Stop IV Glucose
• Monitor CBG hourly

23.09.15
• 11:00h JD WR
• Note – Events overnight noted very low BGs, BGs ↑ and ↓. Having frequent hypos.
• Earlier in the week agreed to sheltered accommodation. No recollection of discharge destination.
• Plan – reduce Humulin-I by 4 units
• Speak to Diabetes consultant re conversion to Glargine
• Arrange best interest meeting
A Case of Inpatient Diabetes

25.09.15

• 05:30h Nursing note
• CBG 3.0 mmol/L
• Given Glucogel, cup of tea and 2 biscuits
• Recheck CBG 5.0 mmol/L

25.09.15

• 11:00h JD WR
• Applying for guardianship
• BGs high on admission may have not been taking Metformin and Linagliptin at home
• HbA1c between 9.4 - 11.8% since 2013
• Note severe hypo on 23.09.15
• Not had insulin since the 23.09.15
• Plan – stop insulin, PRN Novorapid if required, target HbA1c 9-10% comfortably as all we need to do is limit hyperosmolar symptoms and stop dangerous hypos.
• Diabetes Consultant review
# BLOOD GLUCOSE (BG) MONITORING CHART

**Target blood glucose 6-10 mmol/L**
- Pre-meal: 6.0-8.0 mmol/L
- Post-meal: 8.0-10.0 mmol/L

<table>
<thead>
<tr>
<th>Frequency Required: QDS 2 for first 24 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time:</td>
</tr>
<tr>
<td>5:00 AM to 6:59 AM</td>
</tr>
<tr>
<td>Morning Breakfast</td>
</tr>
<tr>
<td>6:00 AM to 7:59 AM</td>
</tr>
<tr>
<td>Breakfast</td>
</tr>
<tr>
<td>7:00 AM to 8:59 AM</td>
</tr>
<tr>
<td>Breakfast</td>
</tr>
<tr>
<td>Lunch</td>
</tr>
</tbody>
</table>

## Monitor BG QDS for first 3/4 in all patients admitted with diabetes or newly diagnosed hyperglycaemia
- Daily – Diet controlled in target range
- QBS (pre-meal & pre-bed) – for patients on basal bolus insulin regimen and/or insulin pump therapy in target range

### Significant Hyperglycaemia
- Follow intravenous guidance if BG >20mmol/L or 1.6mmol/L check ketones. Give correction dose of rapid acting insulin. Medical team review treatment & seek help from diabetes inpatient team, if required.

### Mild Hyperglycaemia
- If persistent, review antidiabetic medication and adjust accordingly to achieve BG in target range.
- In target range
- No need to change antidiabetic medication. If stable consider reducing frequency of monitoring

### Hypoglycaemia usually <4.8mmol/L
- Use HYPBOX MILD
- 1/2 bottle of Glucotab or 1x bottle of Glucose liquid rapid MODERATE = 1-2 tubes of Glucogon
- SEVERE = Glucagon 1mg IM or 150ml 10% glucose intravenously

### Action/Comment
- e.g. NBM; Hypo - given Glucose liquid blast, ketone result 0.6; snack given; any additional insulin dose and time etc.

<table>
<thead>
<tr>
<th>Time</th>
<th>Action/Comment</th>
<th>Time</th>
<th>Action/Comment</th>
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<th>Action/Comment</th>
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<th>Time</th>
<th>Action/Comment</th>
<th>Time</th>
<th>Action/Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:00 AM</td>
<td>0:7 mmol/L</td>
<td>1:00 AM</td>
<td>Hypogon 0.7</td>
<td>2:00 AM</td>
<td>Hypogon 0.7</td>
<td>3:00 AM</td>
<td>Hypogon 0.7</td>
<td>4:00 AM</td>
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<td>10:00 AM</td>
<td>Hypogon 0.7</td>
<td>11:00 AM</td>
<td>Hypogon 0.7</td>
<td>12:00 AM</td>
<td>Hypogon 0.7</td>
</tr>
</tbody>
</table>

### Sign
- A: State glucose value in appropriate box
- M: Sign
- S: Sign
- G: Sign
- N: Sign
- I: Sign
- D: Sign
- F: Sign
- L: Sign
- O: Sign
- H: Sign
- R: Sign
- E: Sign
- L: Sign
- F: Sign
- O: Sign
- N: Sign
- S: Sign
- M: Sign
- A: State glucose value in appropriate box

**Type of Diabetes:**
- T2DM on diet
- T2DM on tablets
- T2DM on insulin
- T1DM
A Case of Inpatient Diabetes

26.09.15

• 13:10h Nursing note
• BGs – Hi, ketones 6.0 mmol/L
• SHO advice 4 units Novorapid
• 13:30h BGs - Hi, ketones 5.5 mmol/L

• 16:00h FY2 review
• Repeat ketones now 2.6 mmol/L
• ‘Patient had been drinking Lucozade which caused the spike’
• Plan – due to receive Metformin
• Repeat CBG at 1830h
• Give 5 units Novorapid for one off high BGs
• “Ketones though high responded to Novorapid and with her present state and non-compliance I see it not with starting on sliding scale”

• 22:00h FY1 review
• Currently BG unrecordable and ketones 1.7 mmol/L
• Plan – repeat Novorapid 4 units and recheck ketones, please contact if >0.6 mmol/L
27.09.15 – 28.9.15

- Consultant WR
- CBGs was 33 over the weekend. Had 3 bottles of Lucozade. CBG coming down.
- Plan – await court of protection and continue current treatment of Novomix (meant Novorapid)

29.09.15

- 11:00h DADOT review
- AMT4 = 0, Attention obviously altered, very drowsy but rousable. Acute event is evident
- 4AT = 8, Delirium is evident

29.09.15

- 13:15h Nursing note
- Appears to be getting more confused
- BGs 33.1 mmol/L and ketones 7.1 mmol/L – Dr informed
- Actrapid 4 units given
- For IV sliding scale
- 14:00h CT1 note
- Patient vomiting
- O/E MEWS = 2 and mild epigastric tenderness
- Imp – DKA
Mrs DE Glycaemic Control during her Admission

Capillary Blood Glucose Readings 25th - 30th September 2015
Does Glycaemic Control Matter?

Hyperglycaemia is important

PAY ATTENTION;
DON'T GET DISTRACTED & DO THE HARD WORK
Relationship between HbA1c and risk of all-cause hospital admissions among people with Type 2 diabetes

D. Yu and D. Simmons

**Figure 1** Relationship between HbA1c and risk of hospital admissions for all-cause, diabetes-coded, and cardiovascular events. The natural cubic spline model was used to present the relationship. Factors considered included nephropathy, duration of diabetes, age, sex, body mass index, blood pressure, triglycerides, total cholesterol, LDL cholesterol, and systolic blood pressure.

**HbA1c as an indicator of Diabetes Control**

<table>
<thead>
<tr>
<th>Blood Glucose (mmol/L)</th>
<th>HbA1c (mmol/mol and %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.4</td>
<td>31 5%</td>
</tr>
<tr>
<td>7.0</td>
<td>42 7%</td>
</tr>
<tr>
<td>8.6</td>
<td>53 7%</td>
</tr>
<tr>
<td>10.2</td>
<td>64 8%</td>
</tr>
<tr>
<td>11.8</td>
<td>75 9%</td>
</tr>
<tr>
<td>13.4</td>
<td>86 10%</td>
</tr>
<tr>
<td>14.9</td>
<td>97 11%</td>
</tr>
<tr>
<td>16.5</td>
<td>108 12%</td>
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</tbody>
</table>
# Type 2 Diabetes and Pneumonia Outcomes

A population-based cohort study

<table>
<thead>
<tr>
<th>30-day glucose level (mmol/l)</th>
<th>n</th>
<th>Deaths</th>
<th>Mortality (%)</th>
<th>Crude MRR (95% CI)</th>
<th>Adjusted MRR (95% CI)*</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients</td>
<td>10,414</td>
<td>5,129</td>
<td>14.2</td>
<td>1.0 (ref.)</td>
<td>1.0 (ref.)</td>
<td></td>
</tr>
<tr>
<td>≤6.1</td>
<td>5,129</td>
<td>727</td>
<td></td>
<td>1.0 (ref.)</td>
<td>1.0 (ref.)</td>
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</tr>
<tr>
<td>6.11–11.0</td>
<td>4,446</td>
<td>903</td>
<td>20.3</td>
<td>1.49 (1.36–1.65)</td>
<td>1.37 (1.25–1.51)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>11.01–13.99</td>
<td>383</td>
<td>86</td>
<td>22.5</td>
<td>1.68 (1.35–2.10)</td>
<td>1.49 (1.19–1.86)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>≥14</td>
<td>456</td>
<td>107</td>
<td>23.5</td>
<td>1.79 (1.46–2.20)</td>
<td>1.71 (1.40–2.10)</td>
<td>&lt;0.01</td>
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<tr>
<td>Patients with type 2 diabetes</td>
<td>1,307</td>
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</tr>
<tr>
<td>≤6.1</td>
<td>279</td>
<td>52</td>
<td>18.6</td>
<td>1.0 (ref.)</td>
<td>1.0 (ref.)</td>
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<tr>
<td>6.11–11.0</td>
<td>545</td>
<td>95</td>
<td>17.4</td>
<td>0.93 (0.66–1.30)</td>
<td>0.96 (0.69–1.35)</td>
<td>0.82</td>
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<tr>
<td>11.01–13.99</td>
<td>188</td>
<td>40</td>
<td>21.3</td>
<td>1.18 (0.78–1.78)</td>
<td>1.24 (0.82–1.88)</td>
<td>0.31</td>
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<tr>
<td>≥14</td>
<td>295</td>
<td>65</td>
<td>22.0</td>
<td>1.24 (0.86–1.78)</td>
<td>1.46 (1.01–2.12)</td>
<td>0.04</td>
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<tr>
<td>Other patients</td>
<td>9,107</td>
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<tr>
<td>≤6.1</td>
<td>4,850</td>
<td>675</td>
<td>13.9</td>
<td>1.0 (ref.)</td>
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<tr>
<td>6.11–11.0</td>
<td>3,901</td>
<td>808</td>
<td>20.7</td>
<td>1.56 (1.41–1.73)</td>
<td>1.43 (1.29–1.59)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>11.01–13.99</td>
<td>195</td>
<td>46</td>
<td>23.6</td>
<td>1.81 (1.34–2.44)</td>
<td>1.65 (1.23–2.23)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>≥14</td>
<td>161</td>
<td>42</td>
<td>26.1</td>
<td>2.07 (1.51–2.82)</td>
<td>1.91 (1.40–2.61)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Data are n unless otherwise indicated. *Adjusted for sex, age group, level of comorbidity, alcoholism-related conditions, and use of antibiotics and immunosuppressive drugs before admission.
Does Glycaemic Control Matter?

Hypoglycaemia is important

PAY ATTENTION;
DON'T GET DISTRacted & DO THE HARD WORK
We do not have the tools to achieve tight glycaemic control (4.0-6.0 mmol/L) without causing hypoglycaemia!

Study Characteristics of the Major Intervention Trials Evaluating Glycaemic Control in ICU

<table>
<thead>
<tr>
<th></th>
<th>Van den Berge et al</th>
<th>Van den Berge et al</th>
<th>NICE-SUGAR</th>
<th>GLUCONTROL</th>
<th>VISEP</th>
<th>De la Rosa et al</th>
<th>Arabi et al</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of eligible patients</td>
<td>1562</td>
<td>2110</td>
<td>7294</td>
<td>1108</td>
<td>600</td>
<td>812</td>
<td>780</td>
</tr>
<tr>
<td>Number of patients included</td>
<td>1548</td>
<td>1200</td>
<td>6022</td>
<td>1101</td>
<td>488</td>
<td>504</td>
<td>523</td>
</tr>
<tr>
<td>% of medical patients</td>
<td>0</td>
<td>100</td>
<td>62.9</td>
<td>40.4</td>
<td>46.9</td>
<td>48.8</td>
<td>83.2</td>
</tr>
<tr>
<td>% of surgical/postoperative admissions</td>
<td>96</td>
<td>0</td>
<td>37.1</td>
<td>56.1</td>
<td>NA</td>
<td>17.2</td>
<td>16.8</td>
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<td>Design</td>
<td>Single centre</td>
<td>Single centre</td>
<td>Multicentre</td>
<td>Multicentre</td>
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<tr>
<td>Mean Age</td>
<td>63</td>
<td>64</td>
<td>60</td>
<td>65</td>
<td>65</td>
<td>46</td>
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<tr>
<td>Mean admission APACHE II score</td>
<td>9.0</td>
<td>23.0</td>
<td>21.1</td>
<td>15.0</td>
<td>20.2</td>
<td>15.6</td>
<td>22.8</td>
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<tr>
<td>Nutrition</td>
<td>Primarily parenteral; 200-300 g intravenous dextrose in first 24 hours after surgery</td>
<td>Primarily parenteral; patients taking anything by mouth at enrollment were excluded</td>
<td>Primarily enteral; early enteral feeding stressed</td>
<td>Primarily enteral; twice as many calories via enteral route as via parenteral route</td>
<td>Primarily enteral; &gt;35% given enteral nutrition on day 1</td>
<td>Primarily enteral or total parenteral nutrition</td>
<td>Primarily enteral nutrition</td>
</tr>
<tr>
<td>% of calories given IV</td>
<td>87.0</td>
<td>87.0</td>
<td>29.5</td>
<td>27.0</td>
<td>66.0</td>
<td>7.0</td>
<td>7.9</td>
</tr>
<tr>
<td>Target control (mmol/L)</td>
<td>10.1 - 11.0</td>
<td>10.1 - 11.0</td>
<td>7.8 - 10.0</td>
<td>7.8 - 10.0</td>
<td>10.1 - 11.0</td>
<td>10.1 - 11.0</td>
<td>10.1 - 11.0</td>
</tr>
<tr>
<td>Target IIT (mmol/L)</td>
<td>4.4 - 6.1</td>
<td>4.4 - 6.1</td>
<td>4.4 - 6.1</td>
<td>4.4 - 6.1</td>
<td>4.4 - 6.1</td>
<td>4.4 - 6.1</td>
<td>4.4 - 6.1</td>
</tr>
<tr>
<td>BG values reached in control (median or mean)</td>
<td>8.5 ± 1.8</td>
<td>8.5 ± 1.7</td>
<td>8.1 ± 1.4</td>
<td>7.7 ± 1.9</td>
<td>8.4 ± 1.8</td>
<td>8.2 (6.8-10.0)</td>
<td>9.5 ± 1.9</td>
</tr>
<tr>
<td>BG values reached in IIT (median or mean)</td>
<td>5.7 ± 1.1</td>
<td>6.1 ± 1.6</td>
<td>6.6 ± 1.4</td>
<td>6.1 ± 2.0</td>
<td>6.2 ± 1.0</td>
<td>6.5 (5.6-7.8)</td>
<td>6.4 ± 1.0</td>
</tr>
<tr>
<td>Mortality IIT vs Control (%)</td>
<td>4.6 vs 8.0 p = 0.04</td>
<td>24.2 vs 26.8 p = 0.31</td>
<td>27.5 vs 24.9 p = 0.02</td>
<td>17.2 vs 15.3 p = 0.41</td>
<td>24.7 vs 26.0 p = 0.74</td>
<td>33.1 vs 31.2 CI 1.06 (0.82 to 1.37)</td>
<td>13.5 vs 17.1 p = 0.3</td>
</tr>
<tr>
<td>Hypoglycaemia control (%)</td>
<td>0.8</td>
<td>3.1</td>
<td>0.5</td>
<td>2.7</td>
<td>4.1</td>
<td>1.7</td>
<td>3.1</td>
</tr>
<tr>
<td>Hypoglycaemia IIT (%)</td>
<td>5.0</td>
<td>18.7</td>
<td>6.8</td>
<td>8.7</td>
<td>17.0</td>
<td>8.5</td>
<td>28.6</td>
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<tr>
<td>% of patients treated with insulin control</td>
<td>39</td>
<td>70</td>
<td>69</td>
<td>66</td>
<td>74</td>
<td>47</td>
<td>75</td>
</tr>
<tr>
<td>% of patients treated with insulin IIT</td>
<td>99</td>
<td>98</td>
<td>97</td>
<td>96</td>
<td>98</td>
<td>97</td>
<td>99</td>
</tr>
<tr>
<td>Mean amount of insulin infused (units/day) control</td>
<td>33</td>
<td>10</td>
<td>17</td>
<td>10</td>
<td>5</td>
<td>12</td>
<td>31</td>
</tr>
<tr>
<td>Mean amount of insulin infused (units/day) IIT</td>
<td>71</td>
<td>59</td>
<td>50</td>
<td>43</td>
<td>32</td>
<td>52</td>
<td>71</td>
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<tr>
<td>% with pre-existing diabetes</td>
<td>13</td>
<td>17</td>
<td>20</td>
<td>18</td>
<td>30</td>
<td>12</td>
<td>40</td>
</tr>
</tbody>
</table>
OBJECTIVE—To prospectively evaluate the association between hypoglycemia and dementia in a biracial cohort of older adults with DM.

PARTICIPANTS—We studied 783 older adults with DM (mean age, 74.0 years; 47.8% of black race/ethnicity; and 47.6% female) who were participating in the prospective population-based

Those who experienced a hypoglycaemic event had a 2-fold increased risk for developing dementia compared with those who did not (34.4% vs 17.6%, P < .001; multivariate-adjusted HR, 2.1; 95% CI, 1.0–4.4).

Older adults with DM who developed dementia had a greater risk for having a subsequent hypoglycaemic event compared with participants who did not develop dementia (14.2% vs 6.3%, P < .001; multivariate-adjusted HR, 3.1; 95% CI, 1.5–6.6).

A. Time to dementia associated with a preceding hypoglycemic event. B. Time to a hypoglycemic event associated with a preceding dementia diagnosis.
Mechanism of Hypoglycaemia causing Cardiovascular Disease

Figure 1—Mechanisms by which hypoglycaemia may affect cardiovascular events. Hypoglycemic events may trigger inflammation by inducing the release of C-reactive protein (CRP), IL-6, and vascular endothelial growth factor (VEGF). Hypoglycemia also induces increased platelet and neutrophil activation. The sympathoadrenal response during hypoglycemia increases adrenaline secretion and may induce arrhythmias and increase cardiac workload. Underlying endothelial dysfunction leading to decreased vasodilation may also contribute to cardiovascular risk.
Update on Mrs DE

- Admitted 6 weeks later with AMI
What should the inpatient blood glucose target be?

**TARGET BLOOD GLUCOSE LEVEL FOR INPATIENTS WITH DIABETES:**

6.0 – 10.0 mmol/L

*Pre-meal 6.0-7.8mmol/L Post-meals 7.8-10.0mmol/L*

**Suggested frequency monitoring**

<table>
<thead>
<tr>
<th>Type of Diabetes</th>
<th>Frequency</th>
<th>Monitoring Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet Controlled</td>
<td>Once daily</td>
<td>Pre-breakfast (Fasting) or 2hrs post lunch</td>
</tr>
<tr>
<td>Anti-diabetic Medication</td>
<td>Twice daily</td>
<td>Pre-breakfast (Fasting) and 2hrs post lunch or evening meal</td>
</tr>
<tr>
<td>Insulin Treated (Well controlled)</td>
<td>Twice daily</td>
<td>Pre-breakfast (Fasting) and pre-evening meal</td>
</tr>
<tr>
<td>Insulin Treated (Above target)</td>
<td>Four times per day</td>
<td>Pre-breakfast (Fasting), pre-lunch, pre-evening meal and pre-bedtime</td>
</tr>
</tbody>
</table>
KEEP CALM AND
STUDY
PATHOPHYSIOLOGY
AND PHARMACOLOGY
The Basal–Bolus Concept

<table>
<thead>
<tr>
<th>Insulin component</th>
<th>Properties</th>
</tr>
</thead>
</table>
| **Basal**         | · Near-constant insulin level throughout the day  
                    · Suppresses hepatic glucose production and lipolysis overnight and during prolonged periods between meals  
                    Insulin requirement to suppress hepatic glucose production between meals  
                    · Covers ~50% of daily insulin needs |
| **Bolus**         | · Immediate rise and sharp peak at 1 hour  
                    · Limits post-meal hyperglycemia  
                    Insulin requirement to maintain normal glucose disposal after eating  
                    · Cover ~50% of the total daily insulin requirement (10-20% at each meal) |

Insulin Secretion

- In non-diabetic individuals, approximately 50% of the total daily insulin is secreted during basal periods, suppressing lipolysis, proteolysis, and glycogenolysis.
- The remainder of insulin secretion 50%, is prandial.
Physiologic Insulin Secretion: 24-Hour Profile

- Insulin (µU/mL)
  - basal insulin

- Glucose (mg/dL)
  - basal glucose

Time of day:
- AM: 7, 8, 9, 10, 11, 12, 1, 2, 3, 4, 5
- PM: 6, 7, 8, 9

Insulin effect:
- NPH
- Detemir (Levemir®)
- Glargine (Lantus®)
- Regular
- Lispro (Humalog®)
- Aspart (Novolog®)
- Glulisine (Apidra®)
- Inhaled insulin

Action profiles of the available insulins.
Therefore basal insulin is continuous insulin and bolus/prandial insulin is secreted in burst in response to eating.

Continuous insulin = basal insulin and switches off ketogenesis

How would we manage without basal insulin?
Because the liver is secreting glucose into the bloodstream continuously, a complete lack of insulin, even for just an hour or two, would result in a sharp rise in blood glucose level (2.5 mmol/L/h). Without basal insulin, cells would resort to burning only fat for energy, and produce ketones.

How would we manage without bolus/prandial insulin?
Without prandial insulin, we are unable to control post prandial glucose. Suffice it to say that prandial insulin is necessary for maintaining blood glucose control, after food.
The Hyperglycaemia of Diabetes
What do you do when a patient has hyperglycaemia +/- ketosis?

This pack has been designed to improve the safe administration of Insulin infusions.

**Insulin Infusion Pack**

This pack **MUST BE** used to prepare and administer **ALL** insulin infusions. It contains a triple lumen with anti-reflux valve to prevent accidental bolus of insulin.

**NHS Logistics code: EVX219**

**Pack Contents**

- 1 x Triple lumen Octopus with anti-reflux valves, code: 0842.312
- 1 x 50ml Luer-lock syringe
- 1 x BD Micro-fine 1ml U-100 insulin syringe
- 1 x V-Green protected line, 150cm

**Additional items required to set-up and safely administer an Insulin infusion**

- Actrapid insulin
- 0.9% Saline
- Needle
- Drug additive label
- Infusion pump
- Valid prescription
- Sliding scale monitoring chart

**VRIII or FRIII are just ways of giving basal insulin**
Therefore

- **Basal insulin** reflects your BG overnight, fasting BG and pre-prandial BG (depending on the gap between meals)

- **Bolus insulin** reflects your post-prandial BG

Glucose concentrations are a surrogate for insulin concentrations.

High glucose = need more insulin

Low glucose = need less insulin
Insulin Requirement in Hospital

- **Basal insulin** replacement consists of a long-acting insulin preparation administered regardless of the patient’s oral intake status, with the premise of matching hepatic (endogenous) glucose production.

- **Prandial/Bolus insulin** replacement requires a rapid-acting insulin preparation given to cover nutritional needs.

- **Correction/Supplemental insulin** (Bolus insulin) replacement requires a rapid-acting insulin to correct blood glucose values that exceed predetermined glycaemic targets.

![Physiologic Insulin Secretion](image)

1. **Nutritional Insulin:** Promote glucose utilization
2. **Basal Insulin:** Suppresses glucose production between meals and overnight
3. **Correction/Supplemental Insulin:** Additional insulin to treat hyperglycemia
When unwell basal insulin requirement may remain constant or increase. Also depending on whether the patient is eating or not the bolus insulin requirement may increase or decrease. If the patients is not eating basal insulin only will suffice, however, correction doses of insulin will be required to maintain good blood glucose control.
How I Manage Inpatient Diabetes and Hyperglycaemia
HbA\textsubscript{1c}:

- **HbA\textsubscript{1c}** tells you where you have arrived, but does not tell you how you got there.

- **Capillary Blood Glucose (CBG)** monitoring tells you the route you have taken.

- The **medication** used is the mode of transport.
Intravenous insulin in the form as a variable rate intravenous insulin infusion (VRIII) is usually not required and should be restricted for use in selected cases.

- What’s wrong with Sliding Scale by itself?
  - **Reactive Approach** - waiting until BG elevates
  - Causes rollercoaster effect for patient
  - Basal/bolus approach is **proactive**; more like normal insulin delivery
  - Basal bolus with correction should be used, not correction by itself in most cases.
Controlling Inpatient Hyperglycaemia

• Subcutaneous insulin should be the main mechanism of controlling inpatient hyperglycaemia.

• Oral antidiabetic agents are usually not sufficient to control hyperglycaemia during an acute illness.

• For patient’s already on insulin and who are hyperglycaemic their insulin should be increased and the effect reviewed every 1-2 days.

• For those on oral agents or diet, weight–based insulin in the form of NPH (Insulatard or Humulin-I) should be added.
Prescribing and Administration of Anti-Diabetic Agents in Hospital

Definitions

Late prescriptions - incorrect medications prescribed at 2200h
Late administration - medications administered between 2300h - 0600h
Delayed administration - medications administered more than 2 hours of the prescribed time

Remember the purpose of insulin is to allow you take up and store all that lovely energy that is produced after a meal.

Do we normally eat at 2200h?
So why prescribed treatments that will lower BG.
**MANAGEMENT OF HYPERGLYCAEMIA IN HOSPITALISED PATIENTS**

**INDICATIONS for insulin:** CBG not control with oral agents and/or symptomatic hyperglycemia. Review previous HbA1c results

<table>
<thead>
<tr>
<th>Common INSULIN REGIMES</th>
<th>Basal insulin (added to oral agents)</th>
<th>Premixed insulin</th>
<th>Background (basal) and mealtime (bolus) insulin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consider as Initial Regimen if Patient ---</td>
<td>Is feeling overwhelmed and/or is fearful of injections Has mostly elevated Fasting BG</td>
<td>Has elevated Fasting and/or Post-meal CBG</td>
<td>For tight blood glucose control Prefers flexible schedule Has elevated Fasting and/or Post-meal CBG</td>
</tr>
<tr>
<td>Timing of insulin</td>
<td>Basal insulin added to oral agents Start with one dose usually at evening (or morning but same time each day)</td>
<td>Premixed insulin: start with 2 doses with breakfast and with evening meal</td>
<td>Background (basal) and mealtime (bolus) insulin</td>
</tr>
<tr>
<td>Initial Starting Dose</td>
<td>TDD = 0.3 unit/Kg</td>
<td>TDD = 0.5 units/Kg Administered twice daily 50% TDD breakfast and 50% evening meal</td>
<td>TDD = 0.5 units/Kg 50% TDD as basal and remaining 50% divided into 3 equal doses with meals</td>
</tr>
</tbody>
</table>

Consider lower dose of 0.2 unit/Kg in elderly, CKD 3/4 & higher dose of 0.6 unit/Kg in obese, on steroids or previous HbA1c > 9.0% (75 mmol/mol)

**Examples of dose calculation**
- 80 Kg person: 80 x 0.3 unit = 24 units Titrate basal insulin based on average 2 days fasting BG
- 80 Kg person: 80 x 0.5 = 40 units 20 units with breakfast and 20 units with evening meal
- 80 Kg person: 80 x 0.5 unit = 40 units Basal insulin 20 units and 6 units of rapid acting insulin with each meal

**Adjusting insulin dose**
2 to 4 units of insulin every 2 days if CBG remains above target. Target Fasting, Pre evening meal and 2 hour Post prandial capillary blood glucose (CBG)
- Aim FBG 5.0 to 7.0 mmol/L
- if FBG remains elevated, titrate the evening dose of premixed insulin and if pre-evening meal CBG remains elevated titrate the morning pre-mixed insulin
- Titrate basal insulin if FBG remains persistently elevated. Titrate mealtime insulin based on 2-hour postprandial BG readings. (Target Post meal reading 10mmol/L)

To adjust one insulin dose at a time. Advice REGULAR bedtime snack. “Tight control” may be required, e.g. in acute infections, pre/post operative period, ITU/HDU patients. “Tight control” may not be desirable, e.g. in terminally ill patients, frail elderly.

<table>
<thead>
<tr>
<th>Is CBG too high or too low?</th>
<th>CBG &gt;8</th>
<th>Increase insulin</th>
<th>CBG &lt;4</th>
<th>Reduce insulin</th>
<th>Before breakfast?</th>
<th>Which result is too high or too low?</th>
<th>Before lunch?</th>
<th>Change evening long acting insulin (on basal only regime) or evening premixed insulin on BD premixed regime</th>
<th>Before evening meal?</th>
<th>Change breakfast short acting insulin if on basal bolus regime or if on premixed BD, change the morning dose of premixed insulin</th>
<th>Units of insulin close taking</th>
<th>Change by (every 2 days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td>Units of insulin close taking</td>
<td>Change by (every 2 days)</td>
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<td></td>
<td>Units of insulin close taking</td>
<td>Change by (every 2 days)</td>
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<td></td>
<td></td>
<td>Units of insulin close taking</td>
<td>Change by (every 2 days)</td>
<td>up to 10 units</td>
<td>Change by 2 units</td>
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<td></td>
<td></td>
<td>Units of insulin close taking</td>
<td>Change by (every 2 days)</td>
<td>On 11 to 30 units</td>
<td>Change by 3-4 units</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Units of insulin close taking</td>
<td>Change by (every 2 days)</td>
<td>On &gt;30 units</td>
<td>Change by 4-6 units</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Basal Insulin</td>
<td>Prandial insulin</td>
<td>Supplemental or Correction insulin</td>
<td>Pre-mixed Twice Daily Insulin</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Name</strong></td>
<td>Glargine (Lantus) Levecir (Detemir) Insulatard or Humulin-I</td>
<td>Novorapid Humalog Glulisine</td>
<td>Novorapid Humalog Glulisine</td>
<td>Novomix 30 Humalog Mix 50 Humalog Mix 25</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td><strong>What is it</strong></td>
<td>Consists of a long-acting insulin preparation administered regardless of the patient’s oral intake status, with the premise of matching hepatic (endogenous) glucose production</td>
<td>Rapid-acting insulin preparation given to cover nutritional needs.</td>
<td>Rapid-acting insulin to correct blood glucose values that exceed predetermined targets.</td>
<td>Pre-mixed combination of intermediate acting and short rapid acting insulin. This is a combination of basal (intermediate) and bolus (rapid-acting) insulin</td>
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</tr>
<tr>
<td><strong>Do you continue when not eating</strong></td>
<td>Yes, may require a reduced dose</td>
<td>No, as patient is not eating</td>
<td>If the patients is not eating basal insulin only will suffice, however, correction doses of insulin will be required to maintain good BG control</td>
<td>Yes, but at 50% of the TDD OR Convert to basal insulin only at 50% of their TDD</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>What percentage of the TDD to give when not eating</strong></td>
<td>50% of the TDD</td>
<td>None</td>
<td>Variable</td>
<td>50%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>What do when unwell</strong></td>
<td>Basal insulin requirement may remain constant or increase.</td>
<td>Depending on whether the patient is eating or not the bolus insulin requirement may increase or decrease</td>
<td>Correction doses of insulin may be required to maintain good BG control. If repeated correction doses are required the patient’s current should be reviewed (probably requiring increasing)</td>
<td>Pre-mixed doses may need to increase</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Monitoring required to adjust insulin dose</strong></td>
<td>Pre-breakfast (fasting) and pre-evening meal BG</td>
<td>2 hours post meal BG</td>
<td>Variable</td>
<td>Pre-breakfast (fasting) and pre-evening meal BG..</td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>
### Mrs A is a type 1 diabetic on a basal bolus regime

<table>
<thead>
<tr>
<th></th>
<th>Breakfast</th>
<th>Lunch</th>
<th>Evening Meal</th>
<th>Bed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humalog</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Glargine</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

He presents with symptoms consist with pyelonephritis fever, loin pain, dysuria and a urine dipstick positive for leucocytes and nitrites. Investigations - WCC 24.7, CRP 212 and CBG 8.4 mmol/L. He is feeling nauseous and does not feel like eating.

**What do you do to control his BG?**

**Answer -** Continue Glargine and suspend Humalog while not eating

<table>
<thead>
<tr>
<th></th>
<th>Breakfast</th>
<th>Lunch</th>
<th>Evening Meal</th>
<th>Bed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humalog</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Glargine</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Mr C is a type 2 diabetic on a premixed bd insulin regime

<table>
<thead>
<tr>
<th></th>
<th>Breakfast</th>
<th>Lunch</th>
<th>Evening Meal</th>
<th>Bed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novomix 30</td>
<td>32</td>
<td></td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

He presents with diarrhoea. He is fluid resuscitated and started on replacement and with 0.9% NaCl with KCl. CBG is 6.4 mmol/L and capillary ketones 0.1. He does not feel like eating.

**What should be done with his insulin regime to control his BG?**

**Continue current regime at 50% of the usual dose**

<table>
<thead>
<tr>
<th></th>
<th>Breakfast</th>
<th>Lunch</th>
<th>Evening Meal</th>
<th>Bed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novomix 30</td>
<td>16</td>
<td></td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>
Use charts that inform and guide as well as monitor
All patients with diabetes must have 4 glucose tests in the first 24 Hrs

Frequency of testing must be determined daily

Name: Joe Bloggs
Ward: 1
PID: NI123456
Date of Birth: 1/1/1960

BLOOD GLUCOSE (BG) MONITORING CHART
Target blood glucose 6-10 mmol/L
Pre-meal: 6.0-8.0 mmol/L  Post-meal: 8.0-10.0 mmol/L

<table>
<thead>
<tr>
<th>Date</th>
<th>01/01/2011</th>
<th>02/01/2011</th>
<th>03/01/2011</th>
<th>04/01/2011</th>
<th>05/01/2011</th>
<th>06/01/2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Required:</td>
<td>QDS 3 QDS 3 QDS 3 QDS 3 QDS 3 QDS 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check blood glucose BEFORE MEALS at the set times. If more frequent readings please record the time below and cross out set times.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast</td>
<td>06:30</td>
<td>06:30</td>
<td>06:30</td>
<td>06:30</td>
<td>06:30</td>
<td>06:30</td>
</tr>
<tr>
<td>Lunch</td>
<td>12:00</td>
<td>12:00</td>
<td>12:00</td>
<td>12:00</td>
<td>12:00</td>
<td>12:00</td>
</tr>
<tr>
<td>Bed</td>
<td>22:00</td>
<td>22:00</td>
<td>22:00</td>
<td>22:00</td>
<td>22:00</td>
<td>22:00</td>
</tr>
</tbody>
</table>

Blood Glucose Value
State BG value in appropriate box

Insert time

3 or more hyper / hypo refer to Diabetes Specialist Nurse

Action/Comment
e.g. NBM; Hypo - given Glucose liquid blast, ketone result 0.4mmol/L
0.6 snack given; any additional insulin dose and time etc.

Sign

Remember to sign

Monitor BG QDS for first 24h in all patients admitted with diabetes or newly diagnosed hyperglycaemia
Daily - Diet controlled in target range
BD - on tablets and or once/twice daily insulin in target range
QDS (pre-meal & pre-bed) - for patients on basal bolus insulin regimen and/or insulin pump therapy in target range

Significant hyperglycaemia
Follow intranet guidance If BG T2DM >20mmol/L or T1DM >15mmol/L check ketones. Give correction dose of rapid acting insulin. Medical team review treatment & seek help from diabetes inpatient team, if required

Mild Hyperglycaemia
If persistent, review antidiabetic medication and adjust accordingly to achieve BG in target range.

In target range
No need to change antidiabetic medication. If stable consider reducing frequency of monitoring

If BG <6.0mmol/L at risk of hypoglycaemia, if persistent review medication

Hypoglycaemia usually <4.0mmol/L
Use HYPOBOX
MILD - 3-5 Glucolats or x1 bottle of Glucose Liquid Blast
MODERATE - 1-2 tubes of Glucagel
SEVERE - Glucagon 1mgIM or 150ml 10% Glucose intravenously
Hypoglycaemia is a capillary blood glucose (CBG) of 4.0mmol/L or less. Wherever possible, check blood glucose level prior to treatment. If patient asymptomatic, repeat test.

<table>
<thead>
<tr>
<th>4.0mmol/L</th>
<th>3.0mmol/L</th>
<th>2.0mmol/L</th>
<th>1.0mmol/L</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MILD</strong></td>
<td><strong>MODERATE</strong></td>
<td><strong>SEVERE</strong></td>
<td></td>
</tr>
<tr>
<td>Patient conscious and able to swallow</td>
<td>Patient conscious and able to swallow, but in need of assistance</td>
<td>Patient unable to swallow. Unconscious or fitting</td>
<td>SEEK URGENT MEDICAL HELP</td>
</tr>
<tr>
<td>Trembling, sweating, hungry, tingling, headache, anxiety, palpitations, nausea, forgetfulness</td>
<td>Difficulty concentrating, confusion, weakness, giddiness, drowsiness, unsteady, headache, dizziness, difficulty focusing and speaking</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Step 1**

**USE HYPO BOX**
Administer 10g-20g fast acting glucose*
- 3-5 x Glucose tablets (4g glucose per tablet) or 1 x 59ml bottle of Glucose Juice

**USE HYPO BOX**
Ensure gag reflex is present.
Administer 1-2 tubes of Glucose Gel
(10g glucose per tube) If no gag reflex use IV

Wait 15 minutes and recheck glucose levels, and record.
If reading is still below 4.0mmol/L, or if no physical improvement, repeat STEP 1

**Step 2**

**REPEAT STEP** 1 twice (except only use Glucagon only once). If after this if glucose still below 4.0mmol/L, give intravenous bolus of 10% Glucose 150ml and start an infusion of 10% Glucose at 50-100ml/h to maintain CBG between 6-10mmol/L. Once 3 consecutive hourly readings are above 10.0mmol/L stop the Glucose infusion. If volume is a concern use 20% Glucose (administered ideally centrally) at 25-50ml/h.

**Step 3**

**ALWAYS FOLLOW UP WITH A STARCHY CARBOHYDRATE**
Check CBG. Once it is at 4.0mmol/L or over and patient is recovered, eat a minimum of 20g starchy carbohydrate e.g. 2 slices of bread/sandwich of low glycaemic index bread (e.g. multigrain or granary), 2 Digestive biscuits or 2 Shredded wheat.
Recheck glucose levels after 15 minutes

**Step 4**

**WHAT TO DO ABOUT THE ANTIDIABETIC MEDICATION**
1. Review CBG reading for the last 2 previous days.
2. Review the time medication was administered to see if correct i.e. before meals (24h EPA on EP)
3. If administered at the incorrect time (i.e. >60 minutes after food) – do not change the dose of the antidiabetic medication BUT speak to the ward nursing staff.

Severe Hypoglycaemia – if on oral agents stop sulphonylureas (SUs). If on insulin reduce the appropriate dose by 50%. Contact Diabetes Team.

Moderate Hypoglycaemia – if on oral agents reduce SUs dose. If on insulin reduce the appropriate dose by 30%.

Mild Hypoglycaemia – if it has occurred on the previous 2 days reduce the dose of SUs rather than Metformin. If on insulin reduce the appropriate dose by 20%. Do not change doses if has not occurred on 2 previous days.
# MANAGEMENT OF INPATIENT HYPERGLYCAEMIA IN PATIENTS ON INSULIN

**TARGET CBG 6.0 – 10.0 mmol/L**

<table>
<thead>
<tr>
<th>No.</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Review of CBG readings for the last 3 days</strong>&lt;br&gt;Less than half or 50% &gt;14.0 mmol/L – No change, continue to monitor and review CBG daily. More than half or 50% &gt;14.0 mmol/L – continue to step 2.</td>
</tr>
<tr>
<td>2</td>
<td><strong>Clinical features present – acute illness or abdominal pain and vomiting i.e. symptoms of DKA.</strong>&lt;br&gt;Type 2 Diabetes&lt;br&gt;If clinical features are present, go to step 3. If clinical features are absent go to step 5.&lt;br&gt;Type 1 Diabetes&lt;br&gt;Whether clinical features are present or absent go to stage 3.</td>
</tr>
<tr>
<td>3</td>
<td><strong>Ketone concentration (mmol/L)</strong>&lt;br&gt;Interpretation of ketones&lt;br&gt;&lt;0.6&lt;br&gt;Normal&lt;br&gt;0.6-3.0&lt;br&gt;At risk of DKA&lt;br&gt;&gt;3.0&lt;br&gt;DKA&lt;br&gt;&lt;0.6&lt;br&gt;0.6-3.0&lt;br&gt;&gt;3.0&lt;br&gt;Mild Hyperglycaemia without ketosis&lt;br&gt;Moderate to Severe Hyperglycaemia without ketosis&lt;br&gt;Diabetic ketosis without acidosis (DKWA) and Hyperglycaemia&lt;br&gt;Diabetic ketoacidosis</td>
</tr>
<tr>
<td>4</td>
<td><strong>Ketones (mmol/L)</strong>&lt;br&gt;CBG (mmol/L)&lt;br&gt;&lt;0.6&lt;br&gt;10.1-14.0&lt;br&gt;0.6-3.0&lt;br&gt;&gt;14.1&lt;br&gt;&gt;10.1&lt;br&gt;Mild Hyperglycaemia without ketosis&lt;br&gt;Moderate to Severe Hyperglycaemia without ketosis&lt;br&gt;Diabetic ketosis without acidosis (DKWA) and Hyperglycaemia&lt;br&gt;Diabetic ketoacidosis</td>
</tr>
<tr>
<td>5</td>
<td><strong>Type of Diabetic Disturbance</strong>&lt;br&gt;Initial Management&lt;br&gt;Treat as DKA with FRIII and accompanying fluids and insulin as per trust guidelines&lt;br&gt;Give a correction dose of RAIA especially if CBG &gt;20.0&lt;br&gt;Give a correction dose of RAIA&lt;br&gt;Give adequate fluid IV or oral – 500ml/h&lt;br&gt;Mild Hyperglycaemia without ketosis&lt;br&gt;Moderate to Severe Hyperglycaemia without ketosis&lt;br&gt;Diabetic ketosis without acidosis (DKWA) and Hyperglycaemia&lt;br&gt;Diabetic ketoacidosis</td>
</tr>
<tr>
<td>6</td>
<td><strong>Monitoring</strong>&lt;br&gt;Four times per day&lt;br&gt;Do not monitor ketones&lt;br&gt;CBG - hourly&lt;br&gt;Do not monitor ketones&lt;br&gt;Ketones - 2-hourly until &lt;0.6 then stop&lt;br&gt;CBG - hourly&lt;br&gt;Ketones – hourly until &lt;0.6 then stop&lt;br&gt;Mild Hyperglycaemia 10.0 - 14.0 mmol/L&lt;br&gt;Moderate Hyperglycaemia 14.1 - 20.0 mmol/L&lt;br&gt;Severe Hyperglycaemia &gt;20.0 mmol/L&lt;br&gt;Mild Hyperglycaemia without ketosis&lt;br&gt;Moderate to Severe Hyperglycaemia without ketosis&lt;br&gt;Diabetic ketosis without acidosis (DKWA) and Hyperglycaemia&lt;br&gt;Diabetic ketoacidosis</td>
</tr>
<tr>
<td>7</td>
<td><strong>Ongoing Acute Management</strong>&lt;br&gt;Check to ensure insulin is administered correctly i.e. before meals rather than being delayed.&lt;br&gt;Check the patient is eating the appropriate food i.e. not consuming extra carbohydrates e.g. chocolate.&lt;br&gt;Consider a 2nd RAIA Correction Dose after 4 hours if CBG still &gt;14.1.&lt;br&gt;Give repeated RAIA correction doses every 2 hours until ketones &lt;0.6. Continue 500mls of fluid every hour until ketosis has resolved.&lt;br&gt;If unsure treat as DKA with FRIII as per trust guidelines.&lt;br&gt;Continue FRIII until pH &gt;7.3, ketones &lt;0.6 and bicarbonate ≥18.0 Remember to continue the 0.9% NaCl + KCl to replenish Na, K and H₂O.&lt;br&gt;Additional IV 10% Glucose (100ml/h) will be required once CBG &lt;14.0.</td>
</tr>
</tbody>
</table>
**RAIA – Rapid-acting insulin analogue e.g. Novorapid, Humalog or Glulisine**

**How to Calculate the First Correction Dose**

**Type 1 Diabetes**

1. Give subcutaneous rapid acting analogue insulin. Assume that 1 unit will drop capillary blood glucose (CBG) by 2.0 mmol/L, to a maximum dose of 10 units initially. BUT wherever possible take advice from the patient about the amount of insulin normally required to correct a high blood glucose (Correction or Insulin Sensitivity Factor). Aim to correct to 8.0 mmol/L. Example if CBG was 28.0 mmol/L, 28.0-8.0 = 20.0, 20.0 ÷ 2 = 10, therefore give 10 units.

**Type 2 Diabetes**

1. Give 0.1 units/Kg of subcutaneous rapid acting analogue insulin to a maximum dose of 10 units initially. Example 100 kg patient = 100 x 0.1 = 10 units

**Both Type 1 and Type 2 Diabetes**

2. If nervous about giving the 10 units, give half i.e. 5 units and recheck CBG in 2 hours. If the CBG is falling as expected (i.e. half of the expected, fall in CBG) and not too dramatically give the remaining 5 units

3. Recheck the CBG at 2 hours after the injection to ensure it is falling, BUT do not give a 2nd dose at this stage.

**How to Calculate the Second and Subsequent Correction Doses**

1. Recheck the CBG at 4 hours after the injection (as this is the maximal effect of the insulin).

2. Repeat the correction if CBG is still above 14.0 mmol/L. In this situation the insulin dose selected should take into account the response to the initial dose consider increasing the dose if the response is inadequate.

Example if the initial CBG was 28.0 mmol/L in a patient with T1DM, the calculated correction dose (28.0-8.0 = 20.0, 20.0 ÷ 2 = 10) given was 10 units. After 4 hours the rechecked CBG was 20.0 mmol/L. Therefore 8 units of insulin lowered CBG by 8.0mmol/L or 1 unit of insulin lowers CBG by 1.0 units. The 2nd calculated dose should be 20.0-8.0 = 12.0, therefore 12 units of insulin should be given to achieve a CBG of 8.0 mmol/L. Suggest give a maximum of 10 units which should lowered CBG to 10.0 mmol/L based on previous experience.
<table>
<thead>
<tr>
<th>Diagnostic criteria</th>
<th>DKA</th>
<th>Practice points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose mmol/L</td>
<td>Mild &gt;11</td>
<td>Euglycamic DKA can occur e.g. pregnancy, insulin pump</td>
</tr>
<tr>
<td></td>
<td>Moderate &gt;11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Severe &gt;30</td>
<td></td>
</tr>
<tr>
<td>ABG pH</td>
<td>Mild 7.35-7.30</td>
<td>HSS with Lactic acidosis can result in pH &lt;7.3</td>
</tr>
<tr>
<td></td>
<td>Moderate 7.00-7.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Severe &lt;7.00</td>
<td></td>
</tr>
<tr>
<td>HCO3</td>
<td>Mild 15-18</td>
<td>Urine Ketone not reliable (only Acetoacetate is detected by ketostix)</td>
</tr>
<tr>
<td></td>
<td>Moderate 10-15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Severe &lt;10</td>
<td></td>
</tr>
<tr>
<td>Capillary Ketone (KB= ketone bodies) Mmol/L</td>
<td>Mild 1-3</td>
<td>Betahydroxybutyrate, predominant ker in acidosis, indicates lipo inertia and liver leading to keto synthesis</td>
</tr>
<tr>
<td></td>
<td>Moderate 3-6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Severe &gt;6</td>
<td></td>
</tr>
<tr>
<td>Serum Osmolality</td>
<td>Mild Variable</td>
<td>Conscious level relates to level of osmolality</td>
</tr>
<tr>
<td></td>
<td>Moderate Variable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Severe &gt;320mOsm</td>
<td></td>
</tr>
<tr>
<td>Anion gap (AG)</td>
<td>Mild &gt;10</td>
<td>High AG acidosis- DKA, Lactic Acidosis, ETOH</td>
</tr>
<tr>
<td></td>
<td>Moderate &gt;12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Severe &gt;12</td>
<td></td>
</tr>
<tr>
<td>Mental status</td>
<td>Mild Alert</td>
<td>If conscious level impaired in DKA, consider alternative causes - CNS infections, CVA, toxin/drug ingestion</td>
</tr>
<tr>
<td></td>
<td>Moderate Alert</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Severe Stupor/coma</td>
<td></td>
</tr>
</tbody>
</table>

**FLUIDS**

- Restore circulatory volume and promote renal glucose excretion
- Clearance of ketones
- Corrects electrolytes imbalance

**POTASSIUM K**

- K is normal or elevated in DKA despite total body deficit (In acidosis H+ is exchanged for K+ into cells K<2.5 indicates severe deficit)

**INSULIN**

- Low dose insulin infusion suppresses lipolysis/ketone production and gluconeogenesis
- 0 to 60 minutes
  - U&E, FBC, BG,50sm, VB6, Cap. ketones
  - Blood cultures, MSU, CXR, ECG
  - Urinary catheter if poor urine output

**MONITORING**

- Immediate
  - Do NOT give a stat dose of insulin
  - Infuse IV at fixed rate of 0.1units/kg/hr i.e. 0.1ml/kg/hr (e.g. 7ml/hr if wt is 70kg)
  - Maximum 12 ml/hr (starting dose)

- Setting up Insulin infusion
  - (50 units Actrapid made up to 48.9ml with 0.9% NaCl)

- Basal Insulin
  - If the patient normally takes glargine (Lantus) or detemir (Levemir), continue at normal dose SC and ensure it is given
  - Continue fixed rate insulin until ketones <0.3mmol/L, venous pH>7.3 and bicarbonate>18

- 60 minutes to 6 hours
  - Aim for fall of ketones of at least 0.5mmol/L/hr or fall of BG by 3 mmol/L/hr
  - If not, call a clinician to increase insulin infusion rate by 1 unit/hr increments hourly until BG or Ketones falling at targets rate (check venous/insuffusion pump is working before increasing dose)

- 60 minutes to 8 hours
  - CBG and ketones hourly
  - Assess rate of fall CBG and ketones
  - Venous blood gas and K 2, 4 and 8 hrs

- 8 hrs to 24 hrs
  - CBG and ketones hourly
  - Recheck U&E and maintain normal K
  - Basal 8G (not required if capillary ketones <1.0 and patient is eating)

**Changing to SC INSULIN**

- (Calculate last 24 hr IV insulin dose)
- If HbA1c <7.5% or home CBG 6 to 10 mmol/L
- Restart usual insulin regime

- If HbA1c >7.5% or unknown or poor home CBG
- 50% of the total dose as basal insulin
- Glargine or Levemir once daily and 50% as bolus insulin divided into 3 equal doses with meals as Novorapid or Humalog

**Management of HSS**

- Ensure IV Fluid is started first IV Fluids 0.9% NaCl to correct circulatory volume and dehydration
- Only switch to 0.45% NaCl if the osmolality is not declining despite adequate positive fluid balance
- An initial rise in sodium is expected and is not itself an indic ation for hypotonic fluids. The rate of fall of plasma sodium should not exceed 10 mmol/L in 24 hrs
- Insulin infusion is half the DKA calculated dose (0.05 unit/kg/hour)
- The fall in blood glucose should be no more than 5 mmol/L/hr
- Potassium K replacement – as in DKA
- Full dose Anticoagulation unless contraindicated
Questions please!

It may seem a strange principle to enunciate as the very treated out of hospital. First requirement in a Hospital that it should do the sick no harm. It is quite necessary, nevertheless, to lay down such a principle, because the actual mortality in hospitals ... is very much higher than ... the mortality of the same class of diseases among patients.

Florence Nightingale, 1863
Important Statement

• Inpatient hyperglycaemia is not good for your patients
• Inpatient hyperglycaemia is not good for your patients
• Please recognise it - look at CBG monitoring charts every ward round
• Be proactive and prevent it occurring
• Target CBG in hospital 6.0-10.0 mmol/L
  – CBG 4.0-5.9 mmol/L at increased risk of hypoglycaemia
  – CBG 10.0-11.9 mmol/L at increased risk of developing severe hyperglycaemia
• Actively treat it
• Look for underlying cause and correct it
• Monitor
Daredevil (DD) – **Double Digits**

In hospital glucose concentrations in **double digits** is not good for your patients

6.0 mmol/L

In hospital glucose concentrations less than 6 puts your patient's at risk of falling down a slippery slope.
## Clinical Findings of Dehydration and Severity of DKA

<table>
<thead>
<tr>
<th>Symptom/Sign</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
<th>Very Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>% body weight loss</td>
<td>1-3%</td>
<td>3-5%</td>
<td>5-10%</td>
<td>&gt;10%</td>
</tr>
<tr>
<td>pH</td>
<td>7.25-7.30</td>
<td>7.11-7.24</td>
<td>7.00-7.10</td>
<td>&lt;7.0</td>
</tr>
<tr>
<td>Anion Gap</td>
<td>&gt;10</td>
<td>&gt;12</td>
<td>&gt;12</td>
<td>&gt;12</td>
</tr>
<tr>
<td>HCO₃⁻</td>
<td>15-18</td>
<td>10-14</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Water deficit</td>
<td>30ml/kg</td>
<td>50ml/kg</td>
<td>80ml/kg</td>
<td>100ml/kg</td>
</tr>
<tr>
<td>level of consciousness</td>
<td>Alert</td>
<td>Lethargic</td>
<td>Drowsy</td>
<td>Obtunded</td>
</tr>
<tr>
<td>Capillary refill*</td>
<td>2 s</td>
<td>2-4 s</td>
<td>&gt;4 s, cool limbs</td>
<td>&gt;4 s, cool limbs</td>
</tr>
<tr>
<td>Mucous membranes</td>
<td>Dry</td>
<td>Dry</td>
<td>Parched, cracked</td>
<td>Parched, cracked</td>
</tr>
<tr>
<td>Heart rate</td>
<td>Slightly increased</td>
<td>Increased</td>
<td>Very increased</td>
<td>Very increased</td>
</tr>
<tr>
<td>Respiratory rate/pattern*</td>
<td>Normal</td>
<td>Increased &gt;28/min</td>
<td>Increased and hyperpnoea &gt;30/min</td>
<td>Increased and hyperpnoea &gt;30/min</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>Normal</td>
<td>Normal, but orthostasis</td>
<td>Decreased</td>
<td>Decreased</td>
</tr>
<tr>
<td>Systolic BP</td>
<td>No change</td>
<td>No change</td>
<td>&lt;105 mmHg</td>
<td>&lt;100 mmHg</td>
</tr>
<tr>
<td>Diastolic BP</td>
<td>No change</td>
<td>Increase</td>
<td>Fall</td>
<td>Fall</td>
</tr>
<tr>
<td>Pulse pressure</td>
<td>No change</td>
<td>Narrow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radial pulse</td>
<td>Normal</td>
<td>Thready</td>
<td>Faint or impalpable</td>
<td>Impalpable</td>
</tr>
<tr>
<td>Skin turgor*</td>
<td>Normal</td>
<td>Slow</td>
<td>Tenting</td>
<td>Tenting</td>
</tr>
<tr>
<td>Urine output</td>
<td>Decreased</td>
<td>Oliguria</td>
<td>Oliguria/anuria</td>
<td>Anuria</td>
</tr>
</tbody>
</table>

*Give fluid replacement over 48 hrs*
## Cannula Port 1

### INTRAVENOUS 0.9% SALINE

**Aim/Function:**
1. Fluid resuscitation and restoration of circulatory volume
2. Restore total water deficit - 100ml/kg
3. Restore total sodium deficit – 7-10mmol/kg
4. Restore total potassium deficit – 3-5mmol/kg

### Shock – SBP <90mmHg, HR >100bpm, CRT >2 secs

**Management:**
0.9% Saline aliquots 10mls/kg to max of 30mls/kg or 500-1000ml aliquots

### Not Shocked (SBP >100mmHg) >70kg

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Rate (mls/h)</th>
<th>Time (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9% Sodium chloride 1L</td>
<td>1000</td>
<td>1</td>
</tr>
<tr>
<td>0.9% Sodium chloride 1L With potassium chloride*</td>
<td>500</td>
<td>2</td>
</tr>
<tr>
<td>0.9% Sodium chloride 1L With potassium chloride*</td>
<td>500</td>
<td>2</td>
</tr>
<tr>
<td>0.9% Sodium chloride 1L With potassium chloride*</td>
<td>250</td>
<td>4</td>
</tr>
<tr>
<td>0.9% Sodium chloride 1L With potassium chloride*</td>
<td>250</td>
<td>4</td>
</tr>
<tr>
<td>0.9% Sodium chloride 1L With potassium chloride*</td>
<td>250</td>
<td>4</td>
</tr>
<tr>
<td>0.9% Sodium chloride 1L With potassium chloride*</td>
<td>125</td>
<td>8</td>
</tr>
</tbody>
</table>

**Total**

<table>
<thead>
<tr>
<th>Potassium level (mmol/L)</th>
<th>Replacement/litre fluid</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;5.5</td>
<td>Nil</td>
</tr>
<tr>
<td>3.5-5.5</td>
<td>40mmol/L</td>
</tr>
<tr>
<td>&lt;3.5</td>
<td>60-80mmol/L Seek advice from specialist</td>
</tr>
</tbody>
</table>

**Total**

- **7 Litres**
- **25 hours**

### Assess response to treatment – targets
1. CRT <2secs
2. SBP >100mmHg (MAP >70) and HR <100bpm
3. Urine output ≥0.5ml/kg

### If poor response to treatment

Give fluid boluses of 0.9% Saline aliquots 10mls/kg to max of 30mls/kg or 500-1000ml aliquots

## Cannula Port 2

### INTRAVENOUS INSULIN

**Aim/Function:**
1. Resolution of ketosis
2. Correction of acidosis
3. Resolution of hyperglycaemia if present

**Fixed dose insulin 0.1unit/kg/hr** (round up to the nearest whole number) until resolution of DKA.

**When CBG <12.0mmol/L**
Add in 5% Glucose 125mls/hr to enable fixed dose insulin to be continued.

**When CBG <8.0mmol/L**
Add in 10% Glucose 125mls/hr to enable fixed dose insulin to be continued.

**Resolution of DKA:**
- Ketones<0.3mmol/L
- pH>7.3
- Venous bicarbonate>18mmol/L

**CONTINUE THE 0.9% SALINE WITH THE GLUCOSE**

### Assess response to treatment – targets
1. Fall in ketones by 0.5-1.0mmol/hr
2. Rise in bicarbonate by 2.0-3.0mmol/hr
3. Fall in CBG by 3.0-5.0mmol/hr

### If poor response to treatment

Increase insulin by 1.0unit/hr. If after 2 consecutive hours double the fixed dose to 0.2units/kg/hr

---

**CRT** – capillary refill time  
**SBP** – systolic blood pressure  
**MAP** – mean arterial pressure  
**CBG** = capillary blood glucose
# Pre-Mixed BD Insulin

<table>
<thead>
<tr>
<th>Insulin injection</th>
<th>Which insulin affects which blood glucose reading (mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulin Regimen</td>
<td>Date</td>
</tr>
<tr>
<td>Before Breakfast Dose</td>
<td>Before Breakfast</td>
</tr>
<tr>
<td>Evening Meal Injection</td>
<td>Evening Meal Injection</td>
</tr>
</tbody>
</table>
## Basal Bolus Regime

<table>
<thead>
<tr>
<th>Insulin Injection</th>
<th>Which insulin affects which blood glucose reading (mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basal Bolus Regimen</strong> (Name)</td>
<td>Before Breakfast Dose</td>
</tr>
<tr>
<td>Date</td>
<td>Date</td>
</tr>
</tbody>
</table>

- **Basal Bolus Regimen**
- **Before Breakfast Dose**
- **Before Lunch Dose**
- **Before Evening Meal Dose**
- **Long Acting Basal**
- **Before Breakfast Glucose**
- **After Breakfast Glucose**
- **Before Lunch Glucose**
- **After Lunch Glucose**
- **Before Evening Meal Glucose**
- **After Evening Meal Glucose**
- **Before Bed Glucose**
- **During Night (0200h) Glucose**

**Insulin Injection**
- **Basal Bolus Regimen**
- **Date**

**Which insulin affects which blood glucose reading (mmol/L)**
- **Before Breakfast Dose**
- **Before Lunch Dose**
- **Before Evening Meal Dose**
- **Long Acting Basal**
- **Before Breakfast Glucose**
- **After Breakfast Glucose**
- **Before Lunch Glucose**
- **After Lunch Glucose**
- **Before Evening Meal Glucose**
- **After Evening Meal Glucose**
- **Before Bed Glucose**
- **During Night (0200h) Glucose**
KEY MESSAGES IN THE MANAGEMENT OF INPATIENT DIABETES

1. Check capillary blood glucose (CBG) on all new hospital admissions
2. Do not give stat doses of Actrapid to control hyperglycaemia
3. Do not use 50% Glucose for the treatment of severe hypoglycaemia
4. When most patients with diabetes are unwell their basal insulin requirement increases.
5. All inpatients with diabetes should have their capillary blood glucose (CBG) measured at least four times per a day for the first whole day of their admission.
6. Target blood glucose should be 6.0-7.8mmol/L premeals and 7.8-10.0mmol/L post meals.
7. Any admitted inpatient that has not had an HbA1c in the last 3 months should have one checked
8. DO NOT OMIT THE NEXT INSULIN INJECTION
KEY MESSAGES IN THE MANAGEMENT OF INPATIENT DIABETES

9. Prescribe insulins and antidiabetic agents at the correct time to avoid unnecessary hypoglycaemia

10. Review capillary blood glucose (CBG) chart daily

11. Metformin should be stopped during an acute illness, in any patients with an eGFR <40 or having contrast investigations

12. Do not over rely on insulin sliding scales

13. Hypoglycaemic episodes on sulphonylureas should be monitored closely after treatment.

14. Test for capillary ketones when the patient is hyperglycaemic to look for evidence of decompensation
Does Glycaemic Control Matter?

Glycaemic Variability is important

PAY ATTENTION;
DON'T GET DISTRACTED & DO THE HARD WORK
Glycaemic Variability causes oxidative stress which can result in endothelial dysfunction and contributes to vascular damage.

Can we reduce Glycaemic Variability?

HEART2D - multinational, randomised, controlled trial designed to compare the effects of: Prandial insulin - Humalog tds vs Fasting NPH bd or Glargine od on glycaemic control on risk for CVS outcomes in patients with T2DM after AMI.