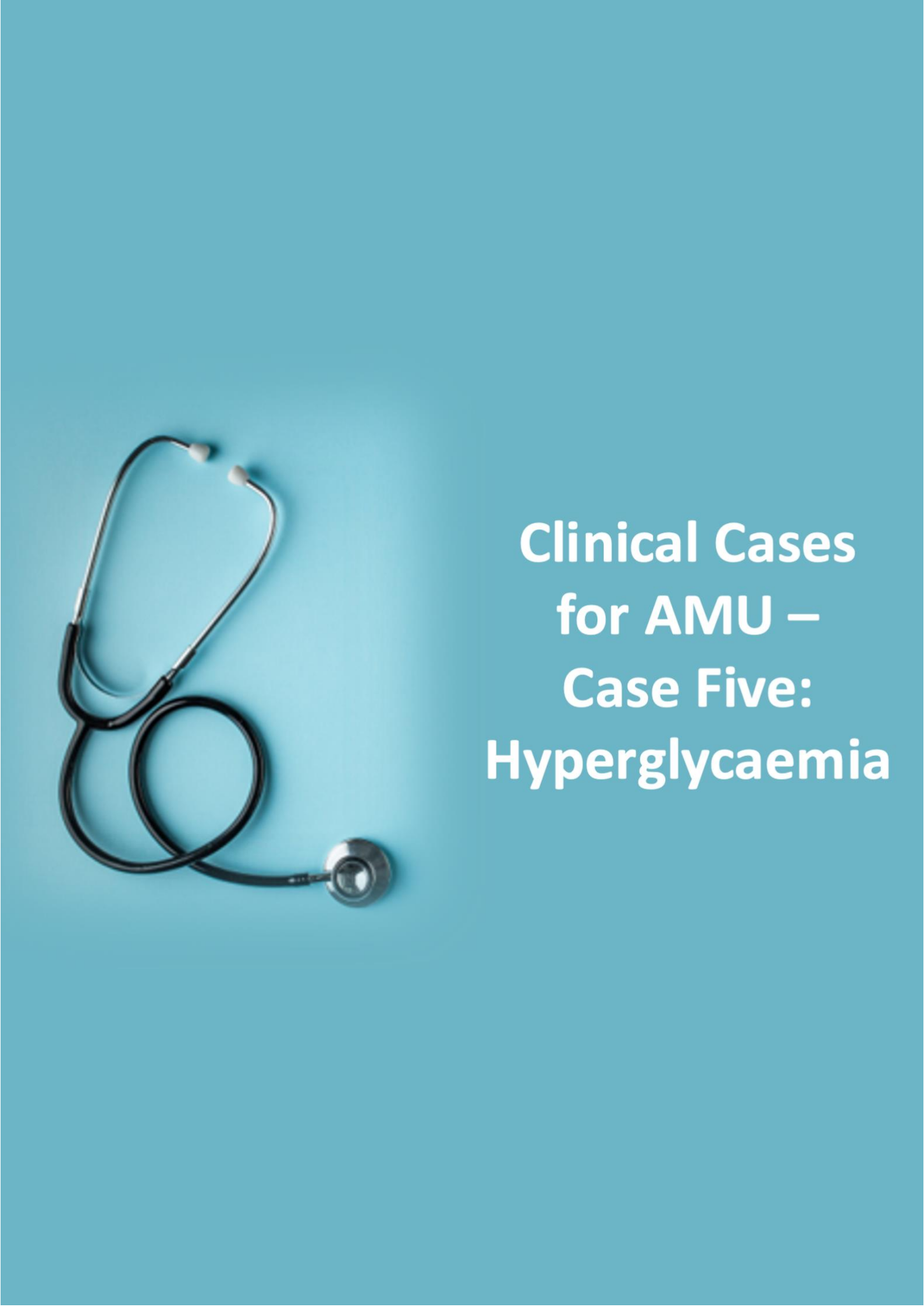


Clinical Cases for AMU – Case Five: Hyperglycaemia

Introduction

These cases are designed to support your learning during your time in Acute and General Medicine. You can use them when you have free time on the ward. They can be done either alone, or in a small group. They use fictional scenarios to demonstrate learning points from common presentations to the Acute Medical Unit (AMU) and on the General Medical wards. As you work through the cases, you will find a mixture of case discussions, practical activities, and practice questions to assess your learning.

If there is a knowledge check or interpretation exercise, the answer can be found on the back of the same page that the question is on.

Case History

A 33-year-old male (Stephen) with a background of Type 1 Diabetes presents to the Emergency Department with abdominal pain, nausea, and weakness. He has been unwell for 2 days with a vomiting illness and has been unable to eat and drink as usual. He decided to stop taking his regular insulin for this period.

Type 1 diabetes was diagnosed during childhood for which he takes Lantus 10 units BD and Novorapid 3-5 units before meals. He states that his blood sugars are usually well controlled, but you note that he has failed to attend his last two appointments with the diabetes team.
He has no other background of note and does not take any other regular medications.
He drinks alcohol at the weekend, totalling 30 units over 2 days. He is an occasional tobacco and cannabis smoker.

On examination

Stephen is a very slim male with evidence of possible malnutrition. There is a fruity, sweet smell to his breath. He is breathing fast and deeply (Kussmaul's breathing) but saturating well on room air and chest auscultation is clear. Capillary refill time is 4 seconds, he has dry mucous membranes and poor skin turgor. He is drowsy and a little muddled with a GCS of 14. Abdomen is generally tender, but there is no peritonism. Bowel sounds are present.

<u>Knowledge Check One</u>

Based on the information available, what is the most likely diagnosis?

<u>Activity One</u>

You proceed to measure blood glucose and blood ketones using point of care devices.

Ask the doctors and nurses on the ward if anybody needs their blood sugars or ketones checked using point of care devices. Note that there are many inpatients with diabetes, especially on wards 207 or 208, some of whom may not be checking their blood sugars as frequently as they should. You can help with this!

Knowledge Check One - Answer

In a patient with Type 1 Diabetes Mellitus who has been unwell, with reduced oral intake and has not been taking their insulin, you should be suspicious of DKA. This impression would be supported by the Kussmaul breathing, which is deep, laboured respiration in response to metabolic acidosis.

Knowledge Check Two

1. Describe the biochemical triad which defines DKA.
2. What initial investigations would you plan?

Activity Two

Ask the doctors and nurses on the ward if anybody needs venepuncture.
Practise attaching or ask one of the junior doctors or ANPs how to attach a blood gas syringe to a venepuncture needle.

Interpretation One

Stephen has his capillary blood glucose and ketones taken by the nursing staff. You take a venous blood gas. The results are below.

Blood glucose meter reads "HI". Blood ketones meter: 4.1 mmol/L

Test	Result	Normal Range
pH	7.15	7.35 – 7.45
pO_2 (kPa)	5.6	11.1 – 14.4
pCO_2 (kPa)	3.7	4.7 – 6.4
HCO_3^- (mmol/L)	16	22 - 28
Base Excess (mmol/L)	-8	-2 - 3
Glucose (mmol/L)	36.2	
Lactate (mmol/L)	3.5	<2

Interpret these results

Knowledge Check Three

1. Describe the common precipitants for DKA
2. List the drugs/medications that can be associated with DKA

Knowledge Check Two – Answers

1. DKA is defined by:
    a. Hyperglycaemia (blood glucose >11)
    b. Ketosis/ketonaemia/ketonuria (capillary blood ketones >3 mmol/L or ketones 2+ or more on standard urinalysis)
    c. Metabolic acidosis (pH <7.3)
2. You would proceed to take a full set of bloods (including FBC, U&Es, LFTs, CRP, amylase, Calcium, formal glucose) and a venous blood gas as well as measuring point of care blood glucose and blood ketones.

Interpretation One – Answer

The venous blood gas demonstrates a metabolic acidosis. Acidosis is demonstrated by a pH of less than 7.35. We know it is metabolic as the bicarbonate is low. Taken with the blood glucose and blood ketones results, the venous blood gas is consistent with a diagnosis of DKA. This is a venous blood gas, so a full analysis of gas exchange cannot be undertaken, but note the hypocapnia reflecting hyperventilation.

Knowledge Check Three - Answers

1. The commonest causes of DKA are:
    a. inadequate insulin therapy
    b. infection
    c. myocardial infarction or other acute illness.
2. Any condition which causes physiological stress and increases counter-regulatory hormones can precipitate DKA including trauma, surgery, and pregnancy.
   Medicines that can precipitate DKA include:
    a. Corticosteroids (increase insulin resistance)
    b. Thiazides
    c. SGLT2 inhibitors (prevent reabsorption of glucose and facilitate its excretion in urine)
    d. Sympathomimetics (alter glucose metabolism)
    e. Cocaine
    f. Cannabis
    g. Acute alcohol intoxication

Knowledge Check Four

Senior or critical care support should be sought in the case of severe DKA.

Which of the following are indicators of severe DKA?

1. Blood ketones >3
2. Hypokalaemia on admission (<3.5 mmol/L)
3. Oxygen saturations <92% on air
4. Bicarbonate <15 mmol/L
5. GCS <12

Activity Three

In NHS Lothian (and across Scotland), there is a standard protocol for the management of DKA. The protocol has been included with this pack. Look through the protocol to familiarise yourself with it. Think about why each of the elements of the protocol are required. What else have you noticed about the protocol? There is some information in the answers to read through when you are done.

Diabetic Ketoacidosis Care Pathway 1
0 – 4 Hours Emergency Management

Page 1 of 2

Time of Arrival	:	Location		Date	/ /

Aim: To improve the acute management of diabetic ketoacidosis in adults aged 16 and over
Definition: Severe uncontrolled diabetes with:
a) ketonaemia/ketonuria; b) metabolic acidosis;
c) usually with hyperglycaemia
Severe DKA = pH less than 7.1 or H^+ greater than 80 mmol/L or HCO_3^- less than 5 mmol/L

DKA
AFFIX PATIENT LABEL

Consultant/Senior physician should be called immediately if:
- Cerebral Oedema
- Hypokalaemia on admission (less than 3.5 mmol/L)
- Severe DKA
- Reduced conscious level

1. Immediate actions	✓
Confirm diagnosis (H^+ > 45 or HCO_3^- <18 or pH <7.3 on **venous gas**)	
Check U&Es, laboratory blood glucose, capillary or urinary ketones	
Confirm patient ≥16 years – IF NOT, DISCUSS WITH PAEDIATRIC TEAM URGENTLY	
Record time of arrival	

2. Management 0 – 60 minutes	✓
Commence IV 1 litre Sodium Chloride 0.9% over 1 hour within 30 minutes of admission	
Time and sign fluid commencement (on reverse)	
Commence soluble insulin IV 6 units/hour within 30 minutes of admission	
Time and sign start of insulin (on reverse)	
Record SEWS	

Other interventions to be considered	✓		✓
ECG and consider cardiac monitor		Blood cultures	
Record GCS score		Central line	
Insert catheter if oliguric		Chest X-ray	
MSSU		DVT prophylaxis	
If protracted vomiting insert NG tube		**If deteriorating, consultant or senior physician called**	

3. Ongoing Management (1 – 4 hours)					✓
Record: SEWS		ECG		GCS	
Time and sign ongoing Sodium Chloride 0.9% replacement (on reverse)					
Hour 2: 1 litre Sodium Chloride 0.9% + Potassium Chloride (KCL)					
Hours 3 & 4: 500mls Sodium Chloride 0.9% per hour + Potassium Chloride (KCL)					
Review Potassium (K^+) result Prescribe KCL in 500ml Sodium Chloride 0.9% bag as: *(not to be administered at a rate of >20 mmol/hour Unless discussed with ST4 or above)*			None if anuric or K+ greater than 5 mmol/L 10 mmol if between 3.5 – 5 mmol/L 20 mmol if less than 3.5 mmol/L		
Check finger prick glucose hourly	1hr	2hrs	3hrs	4hrs	
Lab glucose, U&Es and HCO_3^- at:		2hrs		4hrs	

If Blood Glucose falls to ≤14 mmol/L in first 4 hours	✓
Commence 10% Glucose 500mls with 20 mmol KCL at 100ml/hr	
Continue Sodium Chloride 0.9% at 400mls/hr + KCL (as per table above) until end of hour 4	
Reduce insulin to 3 units/hour	
Maintain blood glucose >9 mmol/L and <14 mmol/L adjusting insulin rate as necessary	
If blood glucose <9 mmol/L adjust insulin to maintain level between 9 and 14 mmol/L (see appendix)	
If blood glucose >14 mmol/L see appendix	
Progress on to second DKA Care Pathway "4 hours until discharge"	

! PLEASE COMPLETE DKA FLOW CHART (OVERLEAF) AT PRESENTATION AND HOURLY THEREAFTER !

DKA Care Pathway 1 V8 V NHS Lothian V5

Authors: NHS Scotland, Dr F.W. Gibb, Dr S. Ritchie & Dr. K Adamson

Diabetic Ketoacidosis Care Pathway 1
0 – 4 Hours Emergency Management

Page 2 of 2

Fluid (Potassium) prescription sheet

	FLUID	VOL (ml)	RATE	PRINT NAME	SERIAL NO	TIME BEGUN	GIVEN BY
DATE	POTASSIUM	DOSE (mmol)		SIGNATURE	BATCH NO		
A	Sodium Chloride 0.9%	500ml	1L/hour			:	
B	Sodium Chloride 0.9%	500ml	1L/hour			:	
C	Sodium Chloride 0.9%	500ml	1L/hour			:	
D	Sodium Chloride 0.9%	500ml	1L/hour			:	
E	Sodium Chloride 0.9%	500ml	500ml/hr			:	
F	Sodium Chloride 0.9%	500ml	500ml/hr			:	

Once Blood Glucose <14 mmol/L start Glucose 10%

G	Glucose 10%	500ml	100ml/hr			:	
	KCL	20 mmol					
H	Glucose 10%	500ml	100ml/hr			:	
	KCL	20 mmol					
I						:	

Intravenous Insulin Prescription

DATE	TIME	INSULIN RATE (units/hr)	TYPE OF INSULIN	PRINT NAME	GIVEN BY
				SIGNATURE	
	:	6 units/hour when blood glucose >14 mmol/L	ACTRAPID		
	:	3 units/hour when blood glucose <14 mmol/hr	ACTRAPID		

Supplementary notes

1. Guidance on bicarbonate
Do not use bicarbonate.
2. Potassium Replacement
KCL should not normally be administered at a rate of >20mmol/hour. In patients with end stage renal failure, be particularly careful and discuss with a Consultant/ Senior Physician before using.
3. WBC Count
The WBC count is often raised in DKA and antibiotics should only be administered if there is clear evidence of infection.
4. Blood Glucose >14 mmol/L
If Blood Glucose rises >14mmol/L do not stop glucose, adjust insulin to maintain level between 9 and 14 mmol/L (see appendix)
5. Signs of Cerebral Oedema
Adults up to the age of 25 may be at risk of cerebral oedema. Consider if • Headaches• Reduced conscious level. • Monitoring for signs of cerebral oedema should start from the time of admission and should continue until up to at least 12 hours after admission

• Administer IV mannitol (100mls of 20% over 20 minutes) or dexamethasone 8mg (discuss with Consultant) • Undertake CT scan to confirm findings; • Consider ITU (an indication for checking arterial blood gases) • If there is a suspicion of cerebral oedema or the patient is not improving as expected /within 4 hours of admission, call Consultant.
6. Laboratory Blood Glucose Testing
It is reasonable to use a point-of-care blood glucose meter to monitor blood glucose level if the previous laboratory Blood Glucose value is <20 mmol/L .
7. Insulin Management
Insulin should be prescribed, beginning at 6 units/ hour. Rate will generally be reduced with time depending on clinical circumstances, presence of long acting insulin and to avoid a fall of >5mmol/L as rapid falls in Blood Glucose may be associated with cerebral oedema.

Do not stop glucose once started

Authors: NHS Scotland, Dr F.W. Gibb, Dr S. Ritchie & Dr. K Adamson

Diabetic Ketoacidosis Care Pathway 2
From 4 hours until discharge

Page 1 of 2

Time pathway started	:
Location	
Date	/ /

AFFIX PATIENT LABEL

DKA

Subsequent Management	✓
Review Blood Glucose results and U&Es	
Prescribe usual long acting subcutaneous insulin (if relevant) along with IV insulin (Detemir, Glargine, Insulatard, Humulin I *etc.*) at patient's usual times	
Continue Sodium Chloride 0.9% + Potassium Chloride (KCL) at 250 mls/hr until Blood Glucose <14 mmol/L	

When Blood Glucose falls <14 mmol/L (if not fallen in first 4 hours)	✓
Commence Glucose 10% with 20 mmol KCL at 100 ml/hour	
Reduce Sodium Chloride 0.9% to 150 mls/hour + KCL (according to Potassium [K⁺] table below)	
Reduce insulin to 3 units/hour	
Maintain Blood Glucose >9 mmol/L and ≤14 mmol/L adjusting insulin rate as necessary	
Review U&Es	
Review K^+ result and replace KCL in 500ml Sodium Chloride 0.9% bag as: •None if anuric or >5mmol/L •10 mmol if level 3.5 – 5 mmol/L •20 mmol if level <3.5 mmol/L	
Measure and record Lab Blood Glucose, U&Es and HCO_3^- 4 hourly for 24 hours (Measure Lab Blood Glucose 2 hourly if Blood Glucose >20 mmol/L 8 hours ☐ 12 hours ☐ 16 hours ☐ 20 hours ☐ 24 hours	
Convert back at next convenient meal time to usual subcutaneous insulin regimen when: •HCO_3^- within normal reference range •Patient eating normally Stop IV fluids and IV insulin 30 minutes after usual injection of pre-meal subcutaneous insulin	
Phone/refer for specialist diabetes review before discharge. If not available, ensure specialist team receives a copy of the discharge summary	
Do not discharge until HCO_3^- normal (unless discussed with the diabetes team), established on usual subcutaneous insulin regimen and eating normally	

When Blood Glucose rises >14 mmol/L after glucose commenced	✓
•Continue glucose 10% with 20 mmol KCL at 100ml/hr •Continue Sodium Chloride 0.9% at 150 mls/hr + KCL •Increase insulin to maintain Blood Glucose >9 mmol/L and ≤14 mmol/L •When blood glucose ≤14 mmol/L adjust insulin rate as necessary to maintain Blood Glucose >9 and <14 mmol/L **(see Appendix for "Guidance on Adjusting Insulin Infusion Rate" for this Care Pathway)**	

Good Clinical Practice
Record SEWS and GCS Score. Finger prick Blood Glucose hourly
Review other investigations
If not improving at start of this pathway / after 4 hours: •Check that equipment is working •Confirm venous access is secure •Check non-return valve on pump •Replace 50ml syringe with fresh Sodium Chloride 0.9% and insulin •Call Consultant / Senior Physician if all the above is working and the patient still deteriorating

ENSURE INSULIN IS PRESCRIBED BEFORE PATIENT LEAVES HOSPITAL

! PLEASE COMPLETE DKA FLOW CHART AT PRESENTATION AND HOURLY THEREAFTER !

Authors: NHS Scotland, Dr F.W. Gibb, Dr S. Ritchie & Dr. K Adamson

Diabetic Ketoacidosis Care Pathway 2
From 4 hours until discharge

Page 2 of 2

Fluid (Potassium) prescription sheet

	FLUID	VOL (ml)	RATE	PRINT NAME	SERIAL NO	TIME BEGUN	GIVEN BY
DATE	POTASSIUM	DOSE (mmol)		SIGNATURE	BATCH NO		
A	Sodium Chloride 0.9%	500ml	250ml/hr			:	
B	Sodium Chloride 0.9%	500ml	250ml/hr			:	
C	Sodium Chloride 0.9%	500ml	150ml/hr			:	
D	Sodium Chloride 0.9%	500ml	150ml/hr			:	
E	Sodium Chloride 0.9%	500ml	150ml/hr			:	
F	Sodium Chloride 0.9%	500ml	150ml/hr			:	
G	Sodium Chloride 0.9%	500ml				:	

Once Blood Glucose <14 mmol/L start Glucose 10%

H	Glucose 10%	500ml	100ml/hr			:	
	KCL	20 mmol					
I	Glucose 10%	500ml	100ml/hr			:	
	KCL	20 mmol					
J						:	

Intravenous Insulin Prescription

DATE	TIME	INSULIN RATE (units/hr)	TYPE OF INSULIN	PRINT NAME	GIVEN BY
				SIGNATURE	
	:	6 units/hour	ACTRAPID		
	:	3 units/hour	ACTRAPID		
	:				

Supplementary notes

1. Continuation of Insulin It is reasonable to use a point-of-care blood glucose meter to monitor blood glucose level if the previous laboratory blood glucose value is less than 20 mmol/L.

2. Consider Precipitating Factors
Common causes include:
• Omissions of insulin
• Infection
• Newly diagnosed
• Myocardial infarction
• Combination of the above.

Authors: NHS Scotland, Dr F.W. Gibb, Dr S. Ritchie & Dr. K Adamson

Diabetic Ketoacidosis Care Pathway 2
APPENDIX

**** Guidance on adjusting insulin infusion rate to maintain blood glucose to more than (>) 9mmol/L and less than or equal to (≤) 14 mmol/L**

•Initially insulin will be infused at 6 units / hour and reduced to 3 units / hour once blood glucose is ≤ 14 mmol/L.

•***The aim is to maintain blood glucose levels >9mmol/L and ≤ 14 mmol/L***.

•If the blood glucose rises to >14mmol/L following the commencement of IV **Glucose 10% (dextrose),** and IV insulin is running at 3 units / hr, increase the insulin infusion rate to 4units / hr, checking the **blood** glucose (BM) hourly. If the glucose remains elevated after 1 hour, the IV insulin infusion rate can be increased to 5 units / hr.

•If blood glucose falls to <9mmol/L then reduce the insulin infusion rate to 2 units / hr, checking the **blood** glucose (BM) hourly. It is essential to maintain an adequate infusion of insulin during treatment of diabetic ketoacidosis (DKA) and therefore the insulin infusion rate should not reduce below 2 units / hr.

•In the situation where the blood glucose is <9mmol/L and insulin is running at 2 units / hr, increase the rate of infusion of Glucose 10% **(dextrose)** to maintain glucose in target. If this occurs, ensure:
1) IV access is secure
2) The infusion pumps are functioning correctly,
3) Glucose 10% **(dextrose)** is prescribed and running correctly
4) Replace the 'insulin infusion' 50ml syringe with fresh Sodium Chloride **0.9%** and insulin

DO NOT STOP IV Glucose 10% (DEXTROSE) INFUSION ONCE IT IS COMMENCED

Amendments to the insulin rate can be prescribed in the chart below if there is insufficient space in the care pathway:

Intravenous Insulin Prescription

DATE	TIME	INSULIN RATE (units/hr)	TYPE OF INSULIN	PRINT NAME	GIVEN BY
				SIGNATURE	
	:				
	:				
	:				
	:				

AFFIX PATIENT LABEL

Author: Dr. S Ritchie

Knowledge Check Three– Answers

1. No - blood ketones >3 indicates a diagnosis of DKA. Blood ketones >6 is a marker of severe DKA
2. Yes - hypokalaemia on admission (<3.5 mmol/L) is a marker of severe DKA
3. Yes - Oxygen saturations <92% on air
4. No - Bicarbonate <15 mmol/L indicates an acidosis, necessary for the diagnosis of DKA. Bicarbonate <5 mmol/L indicates severe DKA, as does pH <7.0
5. Yes - GCS <12

Activity Three – Answer

The DKA protocol can, at first, seem quite complex. This section will explain why each element is important.

- Fluids – One of the mainstays of DKA management is aggressive fluid resuscitation. When people have the high blood glucose readings that are associated with DKA, they become very dehydrated. Normally, all of the glucose filtered by the glomerulus is reabsorbed in the proximal tubule of the kidney by the SGLT2 transport protein. When the blood glucose is very high, this transport protein becomes saturated, resulting in high concentrations of glucose in the urine. Through osmosis, the high glucose concentration drags water into the collecting system, resulting in high volumes of urine being produced, and subsequent dehydration. Patients with DKA are very fluid deplete and require large volumes of fluid to replace the fluid lost.
- Insulin – DKA is a state of insulin deficiency. IV insulin is required to correct hyperglycaemia and to 'switch off' ketogenesis
- Potassium – Relative insulin deficiency results in reduced potassium uptake into skeletal muscle. Hyperosmolality in the blood results in potassium efflux from cells. This potassium is lost in urine during the osmotic diuresis associated with hyperglycaemia, so total body potassium will be low in DKA. When IV insulin is initiated, it will drive extracellular potassium into cells. A combination of these two factors can result in potentially life-threatening hypokalaemia. Therefore, IV potassium is a requirement of the treatment of DKA, even if blood potassium levels are normal.
- Glucose – During the management of DKA, IV glucose is started when the blood glucose drops below 14mmol/L to prevent hypoglycaemia. This is particularly important as IV insulin cannot be stopped during the management of DKA.

The DKA protocol is very effective but can be intimidating when first looked at. You may have noticed that the protocol requires regular observation, blood glucose and ketone measurement, and regular formal laboratory bloods. Additionally, it requires multiple infusions concurrently. For these reasons, the DKA protocol should only be administered in monitored areas where there are sufficient nursing staff who have been appropriately trained in its use. This is often in a Critical Care area, but in the Royal Infirmary of Edinburgh it can also be administered in AMU Base One.

Read through the following management steps and identify the stages on the NHS Lothian DKA protocol as you progress.

Standard Initial Management (0-1hr)

1. Intravenous fluids should be started as soon as DKA is confirmed.
   Commence IV 1 litre Sodium Chloride 0.9% over 1 hour within 30 minutes of admission.
2. Start a fixed-rate intravenous insulin infusion (FRIII) according to local protocols
   e.g., soluble insulin IV 6 units/hour within 30 minutes of admission

Knowledge Check Four

How would your initial fluid therapy change if the patient was hypotensive with a BP of 84/56mmHg?

Ongoing management (1-4 hours)

1. Review Potassium (K+) result and replace accordingly
   Prescribe KCL in in 0.9% Sodium Chloride according to local guidelines. In Edinburgh, the diabetes team advise prescribing additional KCL in 500ml Sodium Chloride 0.9% bag as:
   - No potassium if anuric or K+ greater than 5 mmol/L
   - 10 mmol if K+ 3.5 – 5 mmol/L
   - 20 mmol if K+ <3.5 mmol/L

2. Give ongoing fluid replacement as follows:
   Hour 2: 1 litre Sodium Chloride 0.9% + Potassium Chloride (KCL)
   Hours 3 & 4: 500mls Sodium Chloride 0.9% per hour + Potassium Chloride (KCL)

3. You keep a close eye on Stephen and perform the following checks:
   - Finger glucose checked hourly at 1hr, 2hr, 3hr, 4h
   - Lab glucose, U&Es and HCO3- at 2hr & 4hr

Knowledge Check Five

1. What is the maximum infusion rate for potassium chloride on general wards?
2. How should higher rates of potassium infusion be administered? What monitoring is required?

Blood Glucose falls <14 mmol/L

As may be expected, Stephen's blood sugar falls to 13 at the 4hrly check.
You start Glucose 10% with 20 mmol KCL at 100 ml/hour
You reduce 0.9% Sodium Chloride + KCL (according to Potassium [K+] result) to 150ml/hr.
You reduce the fixed rate insulin infusion to 3 units/hour.
He is monitored closely for the next 24hours during which time his blood sugars remain stable between 9 & 14 mmol/L.
He receives his usual Lantus (long-acting insulin) at the usual time.

He seems to have make a good recovery and you consider converting Stephen back to his usual subcutaneous insulin regimen

Knowledge Check Four - Answer

You would give resuscitation fluids. An initial fluid bolus of 500 mL of normal saline (0.9% sodium chloride) should be given over 10 to 15 minutes. If SBP remains <90 mmHg you would give a further fluid bolus (over 10 to 15 minutes – often written as STAT) and get help from a senior colleague.

Knowledge Check Five – Answer

1. The infusion rate of potassium chloride should not normally exceed 10mmol/hr.
2. Faster rates of potassium infusion can be given via a central line with cardiac monitoring in situ. This should take place in a critical care environment. Potassium should not be given at a rate faster than 20 mmol/hr

Knowledge Check Six

1. List factors that suggest that it is appropriate to consider converting Stephen back to his usual subcutaneous insulin regimen.
2. How long after the usual injection of pre-meal Novorapid should the IV fluids and IV insulin be stopped?

Day Three of Admission

After making a good initial recovery, you are called to see Stephen during your night shift. The nurses on ward 207 report that they were unable to check Stephen's glucose at the usual time as he was off the ward, but when he returned at 22.30, they check his blood sugar and find that it was 3 mmol/L. On investigation it becomes apparent that Stephen missed his evening and lunchtime meals as he was off the ward, but still took his usual insulin therapy.
He is conscious, orientated, and able to swallow.

Hypoglycaemia (a blood glucose of less than 4mmol/L) is a serious condition and should be treated as an emergency regardless of level of consciousness.

Activity Four

Familiarise yourself with the equipment to manage hypoglycaemia on the ward. You should find:

1. Glucojuice, Glucotabs and GlucoGel in the ward Hypo box
2. Glucagon IM in the ward fridge
3. IV fluids in the ward treatment room
4. Biscuits, Bread and Fortijuice in the ward kitchen

Review the included NHS Lothian protocol for hypoglycaemia, which is enclosed with this pack.

Knowledge Check Seven

1. What would be your first line treatment?
2. If ineffective what would be your second line treatment?
3. You test the blood glucose after 10 minutes and it has come up to 5.6 mmol/L. What would you give next?

With the above treatment, Stephen's blood glucose improved and remains stable. You are asked by the nursing staff to prescribe insulin for the next day. On the next page is some guidance about prescribing insulin.

Management of Hypoglycaemia / Hyperglycaemia - dose adjustment

To adjust insulin doses for a twice daily fixed insulin mixture (e.g. Novomix 30 / Humulin M3 / Humalog Mix 25)
- If glucose high / low **before breakfast**, increase / decrease **EVENING** insulin dose
- If glucose high / low **before evening meal**, increase / decrease **MORNING** insulin dose

For dosage adjustment with a basal-bolus regimen (e.g. Novorapid / Humalog and Insulatard / Levemir / Lantus)
- If glucose high / low **before breakfast**, increase / decrease **EVENING** long-acting insulin
- If glucose high / low **before lunch**, increase / decrease **MORNING** short-acting insulin
- If glucose high / low **before evening meal**, increase / decrease **LUNCHTIME** short-acting insulin
- If glucose high / low **before bed**, increase / decrease **EVENING** short-acting insulin

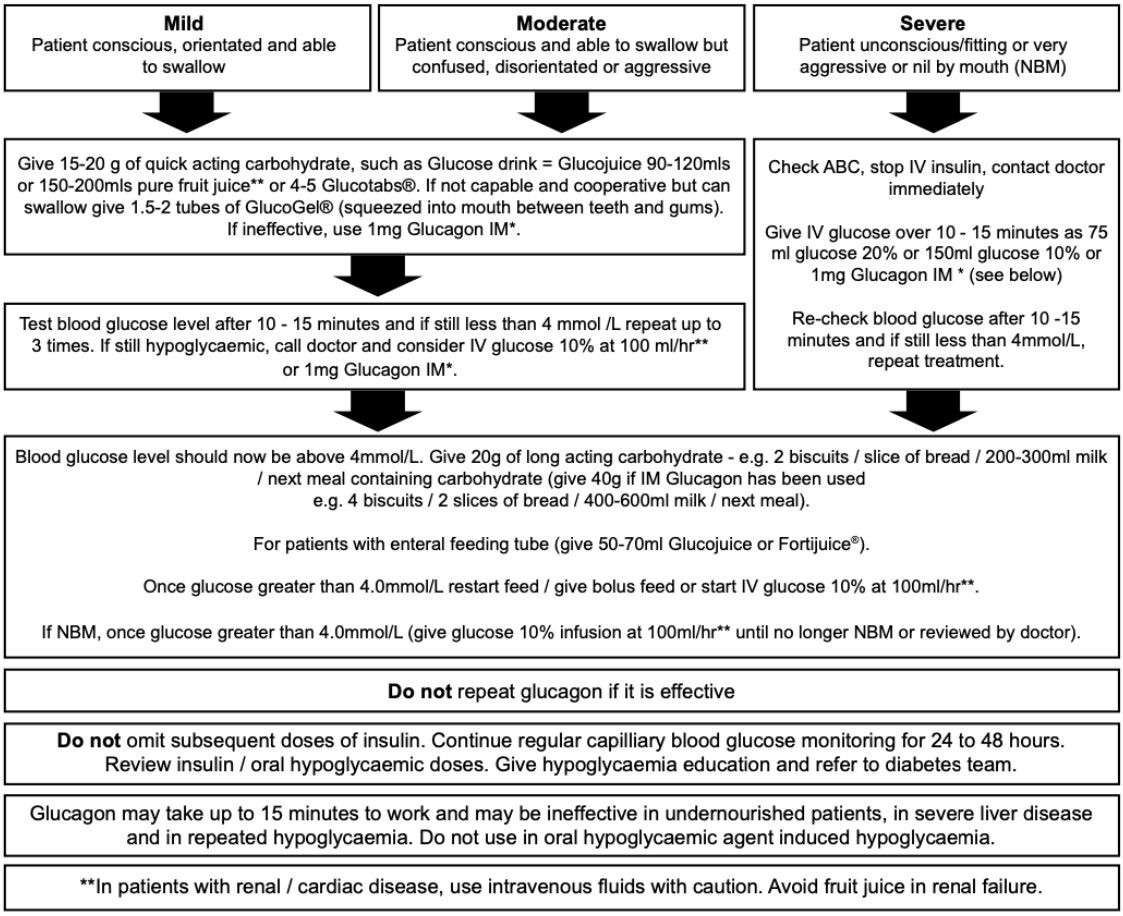
Other adjustments may necessitate a change of the mixture. For further advice please contact the Diabetes Team (Diabetes SPR or Diabetes Specialist Nurse) via switchboard.

Management of Acute Hypoglycaemia

Note: You will find - **1)** Glucojuice, Glucotabs and GlucoGel in the ward Hypo box. **2)** Glucagon IM in the ward fridge. **3)** IV fluids in the ward treatment room **4)** Biscuits, Bread and Fortijuice in the ward kitchen.

Algorithm for the Treatment and Management of Hypoglycaemia in Adults with Diabetes Mellitus in Hospital
Hypoglycaemia is a serious condition and should be treated as an emergency regardless of level of consciousness. Hypoglycaemia is defined as blood glucose of less than 4mmol/L (if not less than 4mmol/L but symptomatic give a small carbohydrate snack for symptom relief).

For further information: NHS Lothian Intranet > Healthcare > Diabetes > Metabolic Unit Handbook.



If hypoglycaemia occurs, DO NOT omit insulin injection if due, treat hypoglycaemia and review the insulin dose and reduce if necessary

Authors: KA/SD/JB/FR/SR <BG Hypo chart March #82B1 BF.doc>CS
Status: Final
Review by: March 2014
Verified / Approved by D&T and CDG subgroup

NHS Lothian

Medical Photography Service, NHS Lothian University Hospitals Division - 16.03.12

Knowledge Check Six – Answer

1. Switching Stephen back to his normal insulin regime should be considered when DKA has resolved, and he is eating and drinking normally. Therefore, the switch should be considered when:
   a) Stephen is eating normally
   b) Nausea and vomiting have settled
   c) Blood glucose and ketones are controlled
   d) d) the HCO3- is within the normal reference range

2. Stop IV fluids and IV insulin 30 minutes after usual injection of pre-meal subcutaneous insulin

Knowledge Check Seven

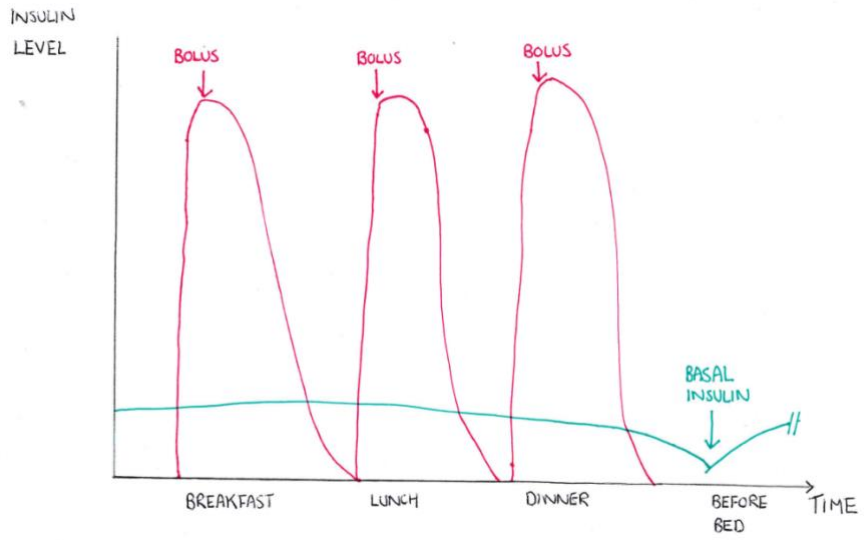
1. Initial treatment for hypoglycaemia is 15-20 g of quick acting carbohydrate. Examples include:
   a) Glucose drink - approx. 100ml of Glucojuice
   b) 4-5 Glucotabs®

2. If quick-acting carbohydrate is ineffective, use 1mg Glucagon IM

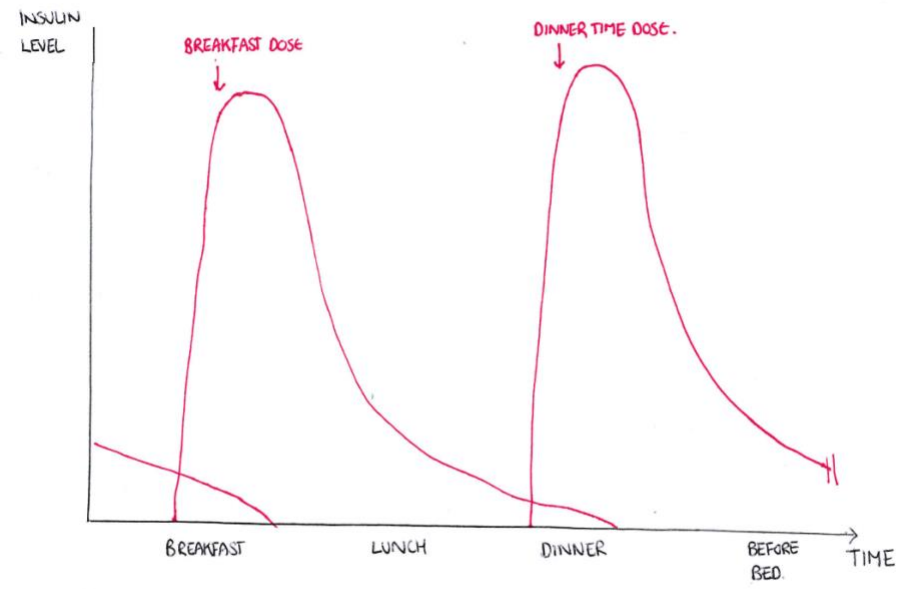
3. Give 20g of long acting carbohydrate - e.g. 2 biscuits / slice of bread / 200-300ml milk / next meal containing carbohydrate
   Give 40g of long acting carbohydrate if IM Glucagon has been used.

Insulin regimens

There are two insulin regimes that are frequently seen in hospital inpatients. These are the basal bolus regime, and the twice-daily mixed insulin regime. The basal bolus regime involves injecting a long-acting insulin once a day (the basal insulin) to maintain satisfactory glucose levels during periods of fasting, with injections of short-acting insulin at mealtimes (the bolus insulin) to keep glucose under control following meals. This regime tries to simulate normal variations in insulin levels with meals and tends to be used in patients who have Type 1 Diabetes.



The twice-daily mixed insulin regime involves the injection of a mix of rapid-acting and intermediate acting insulin at breakfast and dinner times. The rapid acting insulin aims to keep glucose under control at these mealtimes, while the intermediate acting insulin aims to control glucose during the day. This insulin regime is often used in patients with Type 2 Diabetes who require insulin, but it is occasionally used in Type 1 Diabetes in specific circumstances.



In general, insulin is given with meals, and we are aiming for a blood glucose in the hospital between 6 and 12 mmol/L. When prescribing insulin, a key thing to remember is that you should not prescribe the dose based on the blood glucose that has been found at that mealtime. This is because the blood glucose at that mealtime reflects the previous dose of insulin that was given.

In basal bolus regimes:

- If blood glucose is high/low before breakfast, adjust the evening long-acting insulin
- If blood glucose is high/low before lunch, adjust the morning rapid-acting insulin
- If blood glucose is high/low before dinner, adjust the lunchtime rapid-acting insulin
- If blood glucose is high/low before bed, adjust the dinner time rapid-acting insulin

In twice-daily mixed insulin regimes:

- If blood glucose is high/low before bedtime or breakfast time, adjust the dinner time mixed insulin
- If blood glucose is high/low before lunchtime or dinner time, adjust the breakfast mixed insulin

To demonstrate, look at Chart One (see next page for insulin charts 1-6). For the 8th of September you can see that the blood glucose at dinner time has been low for the last 48 hours (4.1 and 3.8). This is because too much rapid-acting insulin was given at lunchtime, so it is the lunchtime dose that needs adjusted. In general, 1 unit of insulin will lower the blood glucose by 2-3 mmol/L. By applying this principle in reverse, I would reduce the lunchtime dose of insulin to 6 units, and I would anticipate the evening blood glucose would increase by 4-6mmol/L at teatime.

In Chart 2, the morning blood glucose reading for the past 48 hours is high. This is because the doses of mixed insulin being given at dinner time the night before are too low. Therefore, the dinner time Humulin M3 dose needs to be increased. When adjusting the dose of a mixed-insulin, we tend to change the dose by 10-20%. Therefore, I would increase the dinner time dose of Humulin M3 to 18 units.

<u>Interpretation Three</u>

Look through insulin charts 3, 4, 5 and 6. Based on the information given above, consider what changes you would make to the patient's insulin based on the readings in the previous 48 hours. Would you increase, decrease or leave the doses the same? By how much would you change the dose?

CHART ONE

Addressograph Label
Or
Name: LISA LILLIPUT
CHI:

NHS LOTHIAN BLOOD GLUCOSE MONITORING & SUBCUTANEOUS INSULIN PRESCRIBING CHART

Never omit insulin without consulting medical staff

If on intravenous insulin, document hourly blood glucose readings on the intravenous insulin chart

Ensure insulin is also prescribed "as per insulin chart" on the drug Kardex

Pre-admission Insulin	Dose			
	Breakfast	Lunch	Teatime	Bedtime
LANTUS	UNITS	UNITS	UNITS	20 UNITS
NOVORAPID	8 UNITS	8 UNITS	8 UNITS	UNITS

Date	Ketones Time	Blood Glucose (mmol/L) Before Breakfast	Before Lunch	Before Teatime	Before Bed	Before Breakfast Type & Units	Prescribed by/ Time Given by/ Time	Before Lunch Type & Units	Prescribed by/ Time Given by/ Time	Before Teatime Type & Units	Prescribed by/ Time Given by/ Time	Before Bed Type & Units	Prescribed by/ Time Given by/ Time	Hypoglycaemia Time / Treatment
7/9		6.7 Time 07:00	7.4 Time 12:00	4.1 Time 17:00	8.2 Time 22:00	NOVORAPID 8 UNITS	AE 14:00 AA 07:00	NOVORAPID 8 UNITS	AE 14:00 AA 12:00	NOVORAPID 8 UNITS	AE 14:00 AA 18:00	LANTUS 20 UNITS	AE 14:00 BB 22:00	
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		
8/9		5.9 Time 07:00	6.4 Time 12:00	3.8 Time 17:00	5.1 Time 22:00	NOVORAPID 8 UNITS	AE 14:00 AA 07:00	NOVORAPID 8 UNITS	AE 14:00 AA 12:00	NOVORAPID 8 UNITS	AE 14:00 AA 18:00	LANTUS 20 UNITS	AE 14:00 BB 22:00	
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		

CHART TWO

Addressograph Label
Or
Name: DAVID COPPERFIELD
CHI:

NHS LOTHIAN BLOOD GLUCOSE MONITORING & SUBCUTANEOUS INSULIN PRESCRIBING CHART

Never omit insulin without consulting medical staff

If on intravenous insulin, document hourly blood glucose readings on the intravenous insulin chart

Ensure insulin is also prescribed "as per insulin chart" on the drug Kardex

Pre-admission Insulin	Dose			
	Breakfast	Lunch	Teatime	Bedtime
HUMULIN M3	28 UNITS	UNITS	16 UNITS	UNITS
	UNITS	UNITS	UNITS	UNITS

Date	Ketones Time	Blood Glucose (mmol/L) Before Breakfast	Before Lunch	Before Teatime	Before Bed	Before Breakfast Type & Units	Prescribed by/ Time Given by/ Time	Before Lunch Type & Units	Prescribed by/ Time Given by/ Time	Before Teatime Type & Units	Prescribed by/ Time Given by/ Time	Before Bed Type & Units	Prescribed by/ Time Given by/ Time	Hypoglycaemia Time / Treatment
7/9		21.4 Time 07:00	11.1 Time 12:00	10.7 Time 17:00	19.3 Time 22:00	HUMULIN M3 28 UNITS	AE 14:00 AA 07:00	UNITS		HUMULIN M3 16 UNITS	AE 14:00 AA 07:00	UNITS		
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		
8/9		23.9 Time 07:00	12.2 Time 12:00	11.9 Time 17:00	20.1 Time 22:00	HUMULIN M3 28 UNITS	AE 14:00 AA 07:00	UNITS		HUMULIN M3 16 UNITS	AE 14:00 BB 07:00	UNITS		
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		

CHART THREE

Addressograph Label
Or
Name: JANE EYRE
CHI:

NHS LOTHIAN BLOOD GLUCOSE MONITORING & SUBCUTANEOUS INSULIN PRESCRIBING CHART

Never omit insulin without consulting medical staff

If on intravenous insulin, document hourly blood glucose readings on the intravenous insulin chart

Ensure insulin is also prescribed "as per insulin chart" on the drug Kardex

Pre-admission Insulin	Dose			
	Breakfast	Lunch	Teatime	Bedtime
LANTUS	UNITS	UNITS	UNITS	16 UNITS
NOVORAPID	4 UNITS	6 UNITS	6 UNITS	UNITS

Date	Ketones Time	Blood Glucose (mmol/L) Before Breakfast	Before Lunch	Before Teatime	Before Bed	INSULIN (units) Before Breakfast Type & Units	Prescribed by/ Time Given by/ Time	Before Lunch Type & Units	Prescribed by/ Time Given by/ Time	Before Teatime Type & Units	Prescribed by/ Time Given by/ Time	Before Bed Type & Units	Prescribed by/ Time Given by/ Time	Hypoglycaemia Time / Treatment
7/9	0.3 22:00	7.7 Time 07:00	6.2 Time 12:00	8.9 Time 17:00	15.9 Time 22:00	NOVORAPID 4 UNITS	A 14:00 AA 07:00	NOVORAPID 6 UNITS	A 14:00 AA 12:00	NOVORAPID 6 UNITS	A 14:00 AA 17:00	LANTUS 16 UNITS	A 14:00 BB 22:00	
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		
8/9	0.4 22:00	9.2 Time 07:00	8.3 Time 12:00	7.9 Time 17:00	17.6 Time 22:00	NOVORAPID 4 UNITS	A 14:00 AA 07:00	NOVORAPID 6 UNITS	A 14:00 AA 12:00	NOVORAPID 6 UNITS	A 14:00 AA 17:00	LANTUS 16 UNITS	A 14:00 BB 22:00	
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		
9/9		8.9 Time 07:00	Time	Time	Time	NOVORAPID 4 UNITS	A 14:00 AA 07:00	UNITS		UNITS		UNITS		
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		

CHART FOUR

Addressograph Label
Or
Name: ESTELLA HAVISHAM
CHI:

NHS LOTHIAN BLOOD GLUCOSE MONITORING & SUBCUTANEOUS INSULIN PRESCRIBING CHART

Never omit insulin without consulting medical staff

If on intravenous insulin, document hourly blood glucose readings on the intravenous insulin chart

Ensure insulin is also prescribed "as per insulin chart" on the drug Kardex

Pre-admission Insulin	Dose			
	Breakfast	Lunch	Teatime	Bedtime
HUMULIN M3	30 UNITS	UNITS	18 UNITS	UNITS
	UNITS	UNITS	UNITS	UNITS

Date	Ketones Time	Blood Glucose (mmol/L) Before Breakfast	Before Lunch	Before Teatime	Before Bed	INSULIN (units) Before Breakfast Type & Units	Prescribed by/ Time Given by/ Time	Before Lunch Type & Units	Prescribed by/ Time Given by/ Time	Before Teatime Type & Units	Prescribed by/ Time Given by/ Time	Before Bed Type & Units	Prescribed by/ Time Given by/ Time	Hypoglycaemia Time / Treatment
7/9		6.7 Time 07:00	4.1 Time 12:00	2.9 Time 17:00	9.2 Time 22:00	HUMULIN M3 30 UNITS	A 14:00 AA 07:00	UNITS		HUMULIN M3 18 UNITS	A 14:00 AA 17:00	UNITS		
		Time	Time	8.3 Time 17:30	Time	UNITS		UNITS		UNITS		UNITS		
8/9		9.1 Time 07:00	4.3 Time 12:00	2.3 Time 17:00	8.4 Time 22:00	HUMULIN M3 30 UNITS	A 14:00 AA 07:00	UNITS		HUMULIN M3 18 UNITS	A 14:00 AA 17:00	UNITS		
		Time	Time	6.6 Time 17:30	Time	UNITS		UNITS		UNITS		UNITS		
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		

CHART FIVE

Addressograph Label
Or
Name: NICHOLAS NICKLEBY
CHI:

NHS LOTHIAN BLOOD GLUCOSE MONITORING & SUBCUTANEOUS INSULIN PRESCRIBING CHART

Pre-admission Insulin	Dose			
	Breakfast	Lunch	Teatime	Bedtime
LANTUS	UNITS	UNITS	UNITS	30 UNITS
NOVORAPID	10 UNITS	10 UNITS	10 UNITS	UNITS

Never omit insulin without consulting medical staff

If on intravenous insulin, document hourly blood glucose readings on the intravenous insulin chart

Ensure insulin is also prescribed "as per insulin chart" on the drug Kardex

Date	Ketones Time	Blood Glucose (mmol/L) Before Breakfast	Before Lunch	Before Teatime	Before Bed	Before Breakfast Type & Units	Prescribed by/ Time Given by/ Time	Before Lunch Type & Units	Prescribed by/ Time Given by/ Time	Before Teatime Type & Units	Prescribed by/ Time Given by/ Time	Before Bed Type & Units	Prescribed by/ Time Given by/ Time	Hypoglycaemia Time / Treatment
7/9		3.3 Time 07:00	7.4 Time 12:00	7.7 Time 17:00	6.5 Time 22:00	NOVORAPID 10 UNITS	AA 07:45	NOVORAPID 10 UNITS	AA 12:00	NOVORAPID 10 UNITS	AA 17:00	LANTUS 30 UNITS	BB 22:00	
		6.1 Time 07:30	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		
8/9		3.2 Time 07:00	6.6 Time 12:00	7.8 Time 17:00	8.9 Time 22:00	NOVORAPID 10 UNITS	AA 07:45	NOVORAPID 10 UNITS	AA 12:00	NOVORAPID 10 UNITS	AA 17:00	LANTUS 30 UNITS	BB 22:00	
		7.3 Time 07:30	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		

CHART SIX

Addressograph Label
Or
Name: ELIZABETH BENNET
CHI:

NHS LOTHIAN BLOOD GLUCOSE MONITORING & SUBCUTANEOUS INSULIN PRESCRIBING CHART

Pre-admission Insulin	Dose			
	Breakfast	Lunch	Teatime	Bedtime
HUMULIN M3	20 UNITS	UNITS	20 UNITS	UNITS
	UNITS	UNITS	UNITS	UNITS

Never omit insulin without consulting medical staff

If on intravenous insulin, document hourly blood glucose readings on the intravenous insulin chart

Ensure insulin is also prescribed "as per insulin chart" on the drug Kardex

Date	Ketones Time	Blood Glucose (mmol/L) Before Breakfast	Before Lunch	Before Teatime	Before Bed	Before Breakfast Type & Units	Prescribed by/ Time Given by/ Time	Before Lunch Type & Units	Prescribed by/ Time Given by/ Time	Before Teatime Type & Units	Prescribed by/ Time Given by/ Time	Before Bed Type & Units	Prescribed by/ Time Given by/ Time	Hypoglycaemia Time / Treatment
7/9	18:00 0.4	9.4 Time 07:00	15.1 Time 12:00	18.9 Time 18:00	11.5 Time 22:00	HUMULIN M3 20 UNITS	AA 07:00	UNITS		HUMULIN M3 20 UNITS	AA 18:00	UNITS		
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		
8/9	18:00 0.1	8.7 Time 07:00	16.6 Time 12:00	20.4 Time 18:00	11.8 Time 22:00	HUMULIN M3 20 UNITS	AA 18:00	UNITS		HUMULIN M3 20 UNITS	AA 18:00	UNITS		
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		
		Time	Time	Time	Time	UNITS		UNITS		UNITS		UNITS		

Interpretation Three - Answers

Chart Three – This chart demonstrates a patient on a basal bolus regimen who is having high capillary blood glucose readings before bed. As the capillary glucose is greater than 14, the nursing staff have also checked ketones at this time. The ketones are satisfactory. A high blood glucose before bed suggests that the dose of rapid-acting insulin at dinner time was insufficient. Therefore, this should be increased. In this situation, I would increase the dinner time Novorapid to 8 units, with the expectation that this would reduce the evening blood glucose by 4-6mmol/L

Chart Four – This chart demonstrates a patient on a mixed insulin regime, who is having hypoglycaemia before dinner time. The blood glucose at lunchtime is also at the lower limit of the acceptable range. In this scenario, the nursing staff have treated the hypoglycaemia, resulting in an improvement in the patient's blood glucose. Low capillary blood glucose at lunchtime and teatime suggests that the morning mixed insulin dose is too high. Therefore, this dose should be reduced by 10-20%. In this case, I would reduce the morning insulin to 26 units to prevent further hypoglycaemia.

As an additional note, once the hypoglycaemia has been corrected, and provided the patient has had a good evening meal, you would give them there normal dose of insulin at dinner time. Withholding this dose would result in hyperglycaemia later.

Chart Five – This chart demonstrates a patient on a basal bolus insulin regime, who is having episodes of hypoglycaemia in the morning. Again, the nursing staff have treated the hypoglycaemia resulting in an improvement in the blood glucose. The long-acting insulin, in this case lantus, is the insulin in a basal bolus regime that maintains a satisfactory blood sugar overnight. If a patient is having hypoglycaemia in the morning, this suggests that the long-acting insulin dose is too high, Therefore, I would reduce this dose by 10-20%, and reduce it to 25 units. Again, the hypoglycaemic episode in the morning should not result in the morning dose of Novorapid being withheld provided that the hypo has been treated and the patient is eating. Withholding insulin could result in a dangerous hyperglycaemia after breakfast.

Chart Six - This chart demonstrates a patient on a mixed insulin regime who is having high blood glucose readings at lunchtime and dinner time. Again, the nursing staff have checked ketones at dinner time, and the ketone levels are safe. The highs at lunch and dinner time suggest the morning dose of mixed insulin is too low. Therefore, the morning dose should be increased by 10-20%, and I would increase the morning dose to 24 units.

Conclusion

Well done on completing this case. I hope that you have found it informative. If you have any questions, please contact …

Dr Sophie Horrocks, Sophie.horrocks@nhslothian.scot.nhs.uk
Dr Toby Merriman, Andrew.Merriman@nhs.scot

Thank you for completing this long case. As these cases are new intervention, we would really value your feedback.

We would be very grateful if you could complete the feedback form accessed from the QR code below.