University of East Anglia | Norwich Medical School

Norfolk and Norwich University Hospitals NHS
NHS Foundation Trust

Therapeutic Advances and Technology in Inpatient Diabetes

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Who is This Strange Man?

- I qualified in 1991
- I trained in D&E and G(I)M in London
- I did general practice for 2 years
- I did ITU / anaesthetics for a year
- I did research at Mayo Clinic for 2 years on DHEA
- I have been in Norwich since 2004
- Currently my other roles include
  - Chair elect of the Association of British Clinical Diabetologists
  - Chair of the Specialist Clinical Exam in D&E
  - Chair of the Joint British Diabetes Societies for Inpatient Care
  - Immediate Past-President of the Endocrine Section of the Royal Society of Medicine

Standardisation

Operational productivity and performance in English NHS acute hospitals: Unwarranted variations

An independent report for the Dep
by Lord Carter of Coles

THE MID STAFFORDSHIRE NHS FOUNDATION TRUST PUBLIC INQUIRY

Chaired by Robert Francis QC

https://www.gov.uk/government/publications/productivity-in-nhs-hospitals
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/279115/0898_i.pdf

Targets - ICU

Year	Organization	Patient Population	Treatment Threshold (mmol/l / mg/dl)	Target Glucose (mmol/l / mg/dl)
2023	American Diabetes Association (ADA)	ICU patients	10.0 (180)	7.8 – 10.0 (140 – 180)
2018	Canadian Diabetes Association (CDA)	ICU patients	10.0 (180)	5.9 – 10.0 (106 – 180)
2012	Society of Critical Care Medicine (SCCM)	ICU patients	10.0 (180)	8.3 (150)
2011	American College of Physicians (ACP)	SICU/MICU patients	Do not use IIT to strictly control or normalize BG in MICU/SICU patients with or without Diabetes	7.8 – 11.0 (140 – 200)
2009	Surviving Sepsis Campaign (SSC)	ICU patients	10.0 (180)	8.3 (150)
2009	American Association of Clinical Endocrinologists (AACE)	ICU patients with acute coronary syndromes	10.0 (180)	7.8 – 11.0 (140 – 200)
2020	RSSDI	ICU	10.0 (180)	7.8 – 11.0 (140 – 200) 6.1 – 7.8 (110 – 140) in surgical patients

Targets – Acute Coronary Syndrome

Table 3. Summary of guidelines for the management of patients with acute coronary syndrome and diabetes

Society	Recommendations	Level of recommendation where available
AACE/ADA[31]	Target 7.8–10.0 mmol/L most non-critical patients.	Evidence level C
ACC/AHA[32]	Treat hyperglycaemia if >10.0 mmol/L and avoid hypoglycaemia.	Downgraded recommendation for use of insulin from class 1 to class II (evidence level B)
Canadian Diabetes Association[33]	Patients with acute MI and admission glucose >11.0 mmol/L may receive glycaemic control in the range of 7.0–10.0 mmol/L.	Grade C level 2
	Insulin may be required to achieve this target.	Grade D (consensus)
ESC/EASD[34]	Insulin based glycaemic control should be considered in ACS patients with significant hyperglycaemia (10.0 mmol/L) with the target adapted to possible comorbidities.	Recommendation class IIa, evidence level C
NICE[35]	Keep blood glucose levels below 11.0 mmol/L. Consider intravenous insulin as a method to achieve target.	
SIGN[36]	Patients with ACS and glucose >11.0 mmol/L should have immediate blood glucose control aiming for target of 7.0–10.9 mmol/L.	

AACE = American Association of Clinical Endocrinologists; ACC = American College of Cardiology Foundation; ADA = American Diabetes Association; AHA = American Heart Association; EASD = European Association for the Study of Diabetes; ESC = European Society of Cardiology; NICE = National Institute for Health and Care Excellence; SIGN = Scottish Intercollegiate Guidelines Network.

Dhatariya K et al Clin Med 2020;20(1):21-27

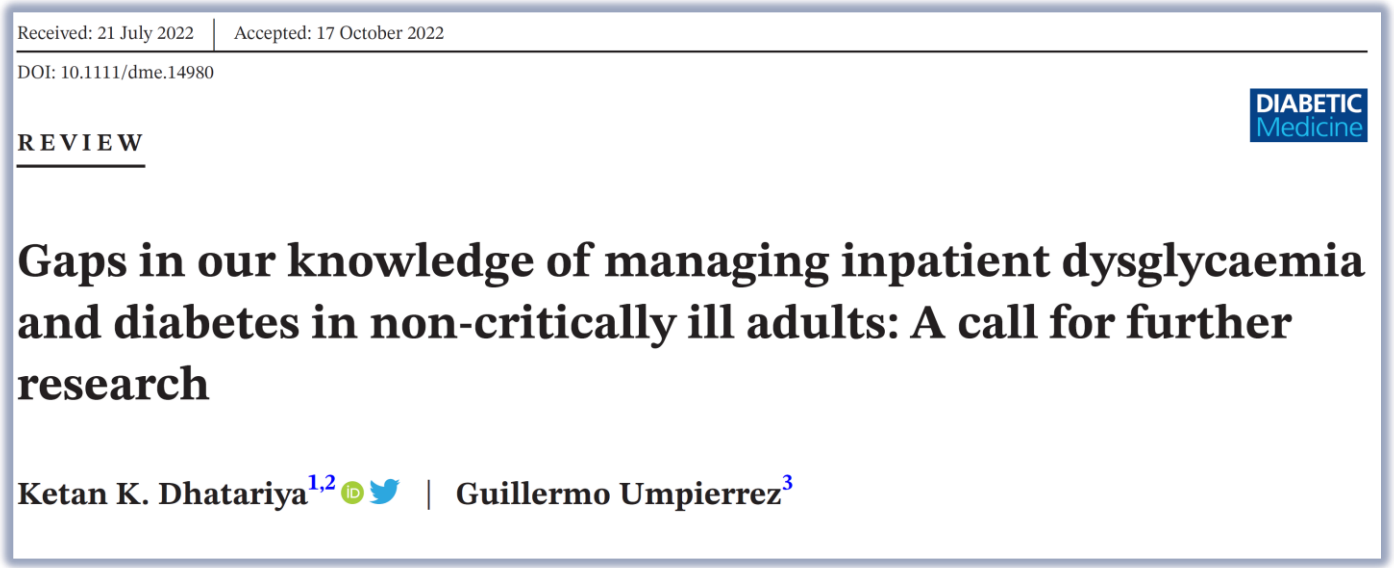
Targets – General Ward Patients

Organisation	Target Glucose (mmol/l / mg/dl)	Comments
JBDS	6.0 – 10.0 (106 – 180)	6.0 – 12.0 (106 – 215) acceptable 6.0 – 15.0 (106 – 270) for End of Life care
ADA / AACE	<7.8 (140) fasting <10.0 (180) random	Pre-meal glucose targets should generally be <7.8 (140) Random glucose levels <10.0 (180) Targets can be individualised depending on risk of hypoglycaemia and comorbidities

Dhatariya K et al www.endotext.org
Dhatariya K et al Textbook of Diabetes 6th Ed. In press

Areas of Uncertainty

- There are many areas of inpatient diabetes care where the optimal way of managing dysglycaemia remains unknown



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DIABETIC Medicine

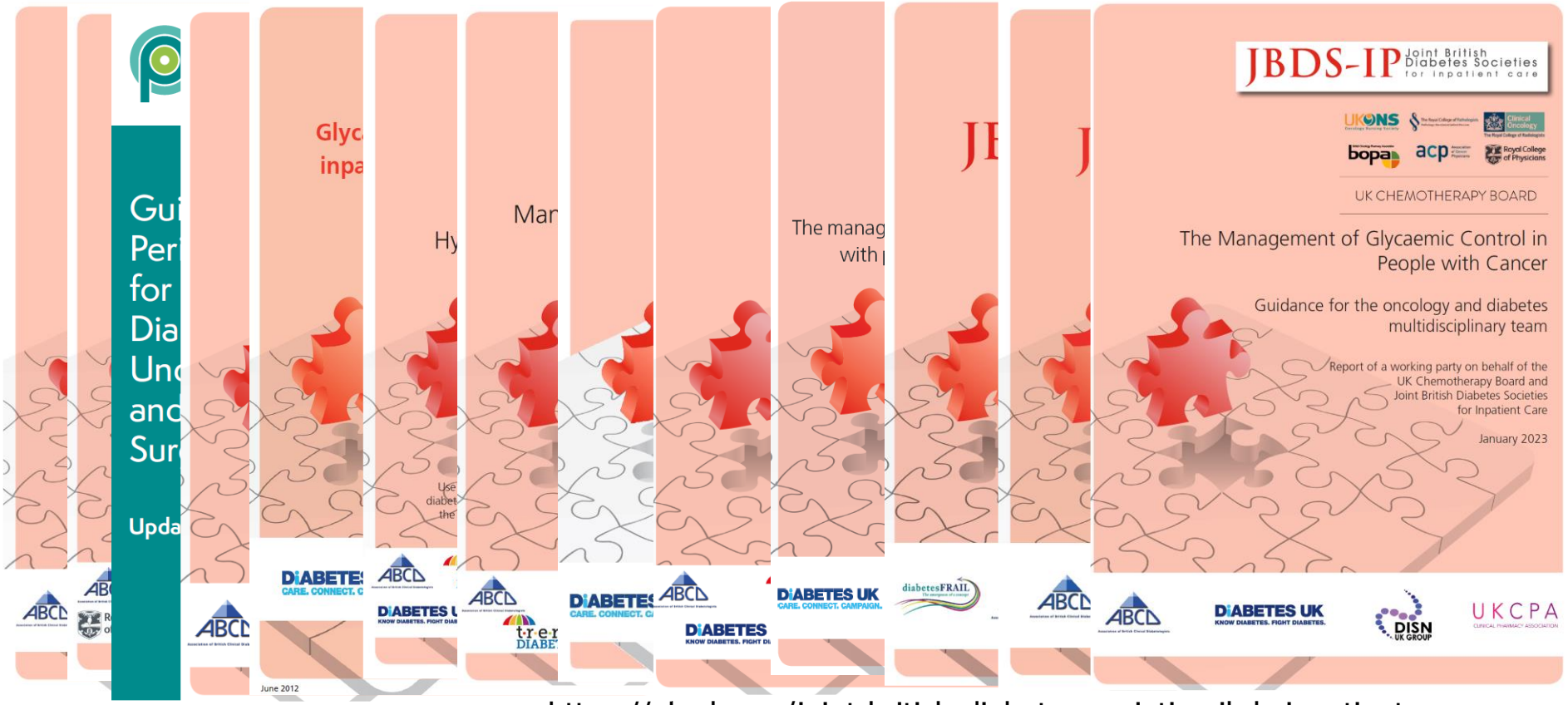
REVIEW

Gaps in our knowledge of managing inpatient dysglycaemia and diabetes in non-critically ill adults: A call for further research

Ketan K. Dhatariya[1,2] | Guillermo Umpierrez[3]

Dhatariya KK et al Diab Med 2023;40:e14980

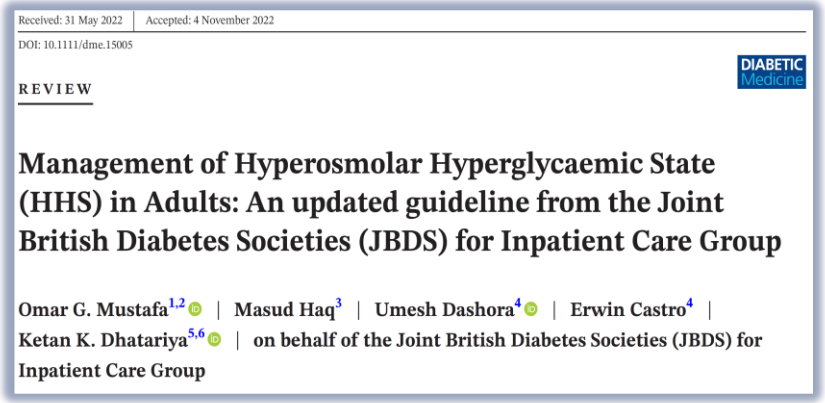
Standardisation



https://abcd.care/joint-british-diabetes-societies-jbds-inpatient-care-group

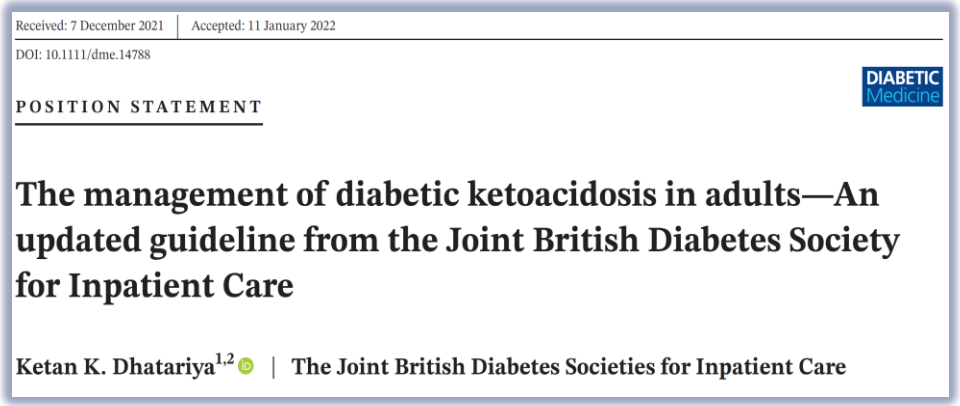
Therapeutic Advances

- These have all been updated and will be re-published in Diabetic Medicine in 2023


Received: 31 May 2022 | Accepted: 4 November 2022
DOI: 10.1111/dme.15005
DIABETIC Medicine
REVIEW

Management of Hyperosmolar Hyperglycaemic State (HHS) in Adults: An updated guideline from the Joint British Diabetes Societies (JBDS) for Inpatient Care Group

Omar G. Mustafa[1,2] | Masud Haq[3] | Umesh Dashora[4] | Erwin Castro[4] | Ketan K. Dhatariya[5,6] | on behalf of the Joint British Diabetes Societies (JBDS) for Inpatient Care Group


Received: 7 December 2021 | Accepted: 11 January 2022
DOI: 10.1111/dme.14788
DIABETIC Medicine
POSITION STATEMENT

The management of diabetic ketoacidosis in adults—An updated guideline from the Joint British Diabetes Society for Inpatient Care

Ketan K. Dhatariya[1,2] | The Joint British Diabetes Societies for Inpatient Care

- At EASD 2023 a new consensus document on the management of hyperglycaemic emergencies will be launched written by ADA/AACE/EASD/DUK

Mustafa OG et al Diab Med 2023;40:e15005
Dhatariya KK et al Diab Med 2022;39:e14788

Examples of Advance - HHS

Hyperosmolar Hyperglycaemic State (HHS) care pathway in adults

JBDS-IP Joint British Diabetes Societies for Inpatient care

Clinical features (all the below)

1) Marked hypovolaemia
2) Osmolality ≥320 mOsm/kg
3) Marked hyperglycaemia (≥30 mmol/L)
4) Without significant ketonaemia (≤3.0 mmol/L)
5) Without significant acidosis (pH ≥7.3) and bicarbonate ≥15 mmol/L

A mixed picture of HHS and DKA occurs relatively frequently

Aims of therapy

1) Improvement in clinical status and replacement of all estimated fluid losses by 24 hours
2) Gradual decline in osmolality: drop of 3-8 mOsm/kg/hr
3) Blood glucose: aim to keep to 10-15 mmol/L in the first 24 hours
4) Avoid hypoglycaemia and hypokalaemia
5) Prevent harm: VTE, osmotic demyelination, fluid overload, foot ulceration

Criteria for resolution of HHS:
Holistic assessment of the following:

1) Clinical and cognitive status is back to the pre-morbid state
2) Osmolality <300 mOsm/kg
3) Hypovolaemia has been corrected (urine output ≥0.5 ml/kg/hr)
4) Blood glucose <15 mmol/L

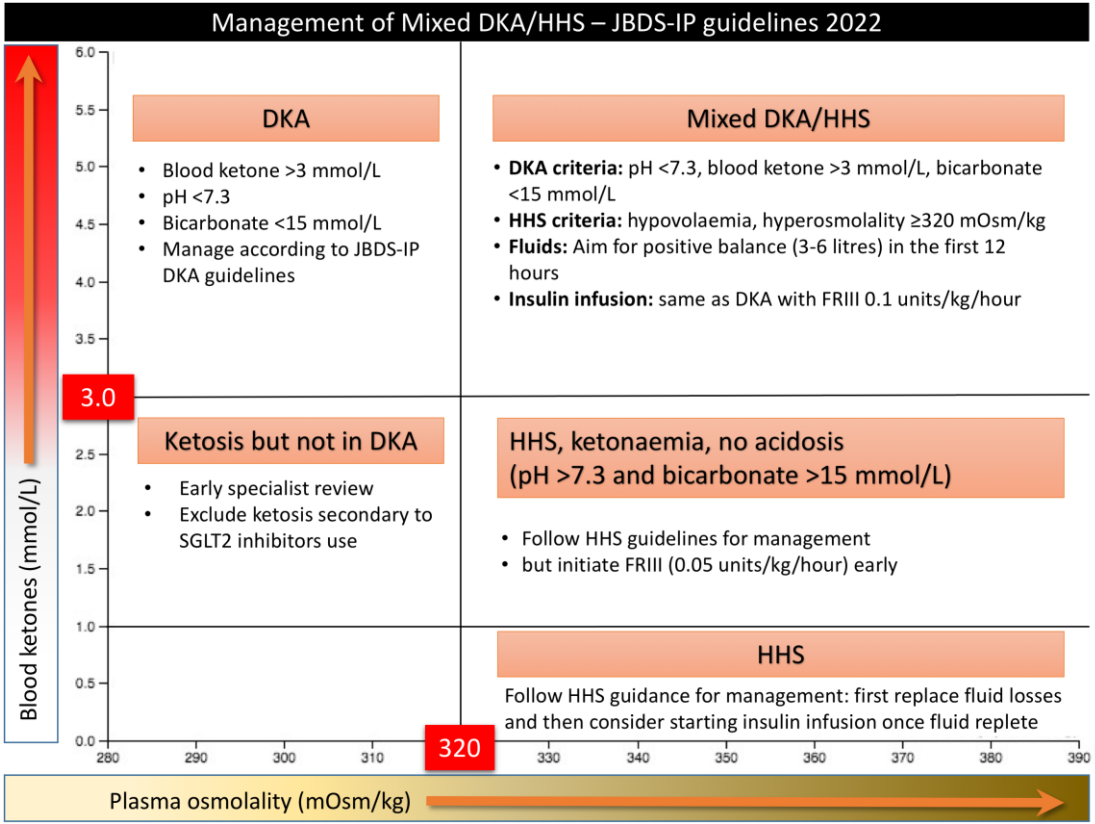
Theme \ Time	0-60 minutes	60 minutes - 6 hours	6-12 hours	12-24 hours	24-72 hours
Clinical assessment and monitoring					
Clinical status / NEWS	ABCDE approach, History/Examination, NEWS, cardiac monitoring, urine output Establish adequate intravenous lines (preferably 2 large bore IV cannulas) Discuss with outreach/ICU team early if there are markers of high severity **(see Table 1 overleaf)**			Check for continuing improvement	Expect steady recovery, patient eating and drinking, and biochemistry as it was prior to HHS Ongoing management of the precipitating cause(s) Replacement of all estimated fluid losses by 24 hours Individual BG target 6-10 mmol/L
Precipitating cause(s)	Assess for precipitating cause(s): sepsis, diabetic foot infection, treatment omissions, vulnerable adult, vascular event (myocardial infarction, stroke)			Ongoing management of the precipitating cause(s)	
Osmolality (VBG/blood) **Measure/calculate (2xNa$^+$) + Glucose + Urea** **Aim for gradual decline of 3-8 mOsm/kg/hr**	Check every hour for 6 hours Until the urea is available, calculate using (2 x Na$^+$ + glucose). Recalculate osmolality once urea is available, and then use (2 x Na$^+$ + glucose + urea)		Check every 2 hours	Check every 4 hours (if no clinical improvement then check every 2 hours)	
How to interpret osmolality results	**Check Figure 1 overleaf**	**Check Figure 1 overleaf**	**Check Figure 1 overleaf**	**Check Figure 1 overleaf**	
Blood glucose (BG) **(Aim for 10-15 mmol/L in the first 24 hours)**	Check every hour Fall in BG should be up to 5.0 mmol/L per hour **(check Figure 2 overleaf for details)**		**Check every hour** **(check Figure 2 overleaf for details)**	**Check every hour** **(check Figure 2 overleaf for details)**	
Interventions					
Intravenous fluid (0.9% saline) **(In IV line 1)** **(caution in HF/CKD/BW <50 kg)**	1 litre over 1 hour (caution in HF/CKD/BW <50 kg)	Aim for 2-3 litres positive balance by 6 hours	Aim for up to 6 litres positive balance by 12 hours	Reassess fluid balance to plan fluids replacement for the next 12 hours	Can be stopped if patient is eating and drinking
Insulin infusion **(FRIII 0.05 units/kg/hr using Actrapid®)** **(In IV line 2)**	Use DKA guidelines if ketonaemia (>3.0 mmol/L) or ketonuria (≥2+) Start FRIII if ketonaemia (>1.0 - ≤3.0 mmol/L) or ketonuria (<2+)	Only commence if positive fluid balance and BG plateaued on repeated measurements (>2 occasions)		Rate may need adjustment by another 1 unit/hr to achieve BG target 10-15 mmol/L	VRIII if not eating and drinking Otherwise convert to subcutaneous insulin
Glucose infusion: 5% or 10% @ 125ml/hr **(In IV line 2)**	Not required at this stage	Only initiate if BG <14 mmol/L		Continue infusion at 125 ml/hr	Can be stopped if patient is eating and drinking
Potassium (avoid hypokalaemia)	Senior review / ICU outreach if potassium <3.5 or >6.0 mmol/L	**Check Table 2 overleaf for potassium replacement guidelines**	**Check Table 2 overleaf for potassium replacement guidelines**	**Check Table 2 overleaf for potassium replacement guidelines**	Check U&Es daily
Assessments and prevention					
Prevent harm	VTE prophylaxis (low molecular weight heparin) Assess for complications e.g. fluid overload, cerebral oedema, osmotic demyelination (deteriorating conscious level)				VTE prophylaxis until discharge Daily feet checks
Prevent hypoglycaemia	Glucose 5% or 10% at 125 ml/hr if BG <14 mmol/L				Target BG 6-10 mmol/L
Prevent foot ulceration	Daily foot checks				Daily foot checks
Refer to the inpatient diabetes team early. **Escalate management if there is clinical deterioration.**					Review by inpatient diabetes team before discharge

Abbreviations: ABCDE= Airway, Breathing, Circulation, Disability, Exposure; BG=blood glucose; BW=body weight; CKD=chronic kidney disease; FRIII=fixed rate intravenous insulin infusion; HF=heart failure; hr=hour; ICU=intensive care unit; IV=intravenous; kg=kilograms; NEWS=national early warning score; U&Es=urea and electrolytes; VBG=venous blood gas analysis; VRIII=variable rate intravenous insulin infusion; VTE=venous thromboembolism

@JBDSIP October 2022

Mustafa OG et al Diab Med 2023;40:e15005

Examples of Advance - HHS



Mustafa OG et al Diab Med 2023;40:e15005

Criteria for Resolution of HHS

- Clinical and cognitive status is back to the pre-morbid state
- Osmolality <300 mOsm/kg
- Hypovolaemia has been corrected (urine output ≥0.5 ml/kg/h)
- Blood glucose <270mg/dL (15 mmol/L)

Mustafa OG et al Diab Med 2023;40:e15005

Technology – Point of Care Testing

- A (rapid) chemical analysis of blood, urine or other body fluid at the bedside or away from the laboratory
  - Capillary glucose
  - Capillary or urine ketones (breath and continuous ketone monitoring are on their way)
  - Other analytes (e.g. venous blood gases)

- They allow for rapid diagnosis and aid clinical decision making in real time

Misra S et al J Diabetes Sci Technol 2023: In press

Technology – Point of Care Testing

- Methodology must be validated
- Equipment and methodologies must be quality assured
- Networked meters have several advantages

Misra S et al J Diabetes Sci Technol 2023: In press

Technology – CGM

- Usually a tool for self management in the outpatient setting
- May be useful in inpatient settings – but:
  - Nursing and non-specialist staff need training
  - Need equipment to download the device in real time (e.g., wifi)
  - Lots of things may affect the readings – dehydration, temperature, rapid changes in glucose or tissue perfusion, etc.
  - Time in range is irrelevant in hospital, but avoidance of hypoglycaemia is paramount

Korytkowski MT et al J Clin Endocrinol Metab 2022;107(8):2101-2128
Avari P et al J Diabetes Sci Technol 2023: In press

Technology – Pumps and Closed Loops

- Where people can self manage they should be allowed to do so
- A few studies have shown better glycaemic control when a pump / closed loop is used, with less hypoglycaemia

Avari P et al J Diabetes Sci Technol 2023: In press
Pelkey MN et al Endo Practice 2023;29(1):24-28

Technology – Pumps and Closed Loops

- Decisions to be made on admission
  - The individual is medically stable, willing, and capable of self-management
  - The treating clinician's familiarity with the CSII
  - Appropriate hospital policies/guidance on CSII use
  - Inpatient diabetes management team support

Avari P et al J Diabetes Sci Technol 2023: In press

Inpatient CGM and CSII/HCL – Areas of Uncertainty

- CGM/CSII management
  - In the well person
  - In the unconscious or incapacitated individual
  - In the septic, unwell individual
  - During hyperglycaemic emergencies
  - On the ITU
  - During radiological investigations (e.g. MRI)
  - In the peri-operative period
  - During labour
  - During a cardiac arrest

Avari P et al J Diabetes Sci Technol 2023: In press

In Summary

- There are incremental changes being made as new data become available
- The biggest changes will be in the use of technology in the inpatient setting
- There are big gaps on how best to manage various aspects of inpatient diabetes – YOU can help fill those gaps!

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