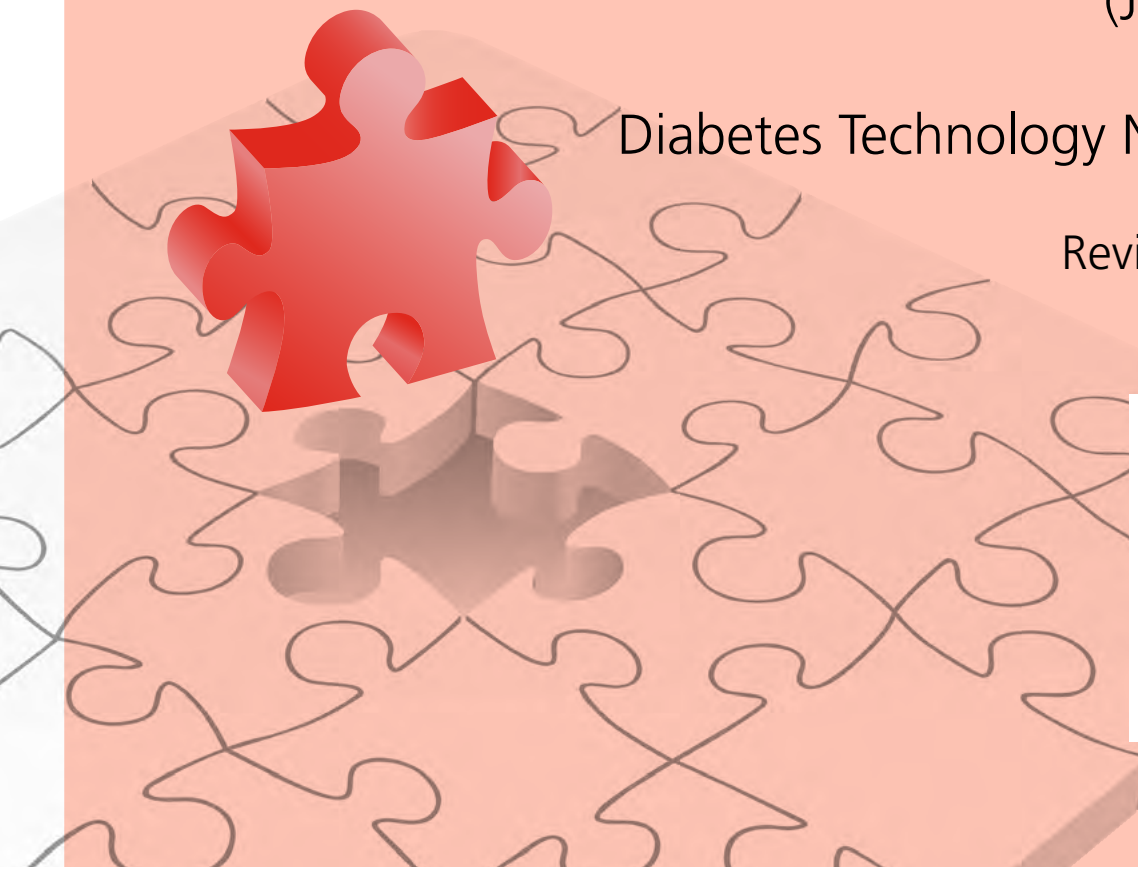
JBDS-IP Joint British Diabetes Societies for inpatient care

Using technology to support diabetes care in hospital:

A guideline from the
Joint British Diabetes Societies for Inpatient Care (JBDS-IP) Group
and
Diabetes Technology Network (DTN)

Revised March 2024



Association of British Clinical Diabetologists

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Management of adults with diabetes undergoing surgery and elective procedures: improving standards	*JBDS 03*
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These guidelines can also be accessed via the Diabetologists (ABCD) app (need ABCD membership to access the app)

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Statement for the JBDS-IP guidelines

JBDS guidelines have been developed to advise on the care process for people with diabetes currently under hospital care.

The guideline recommendations have been developed and reviewed by a multidisciplinary team led by the Joint British Diabetes Societies for Inpatient Care (JBDS-IP) group. People with diabetes have been involved in the development of the guidelines via stakeholder events organised by Diabetes UK.

It is intended that the guideline will be useful to clinicians and service commissioners in planning, organising and delivering high quality diabetes care. There remains, however, an individual responsibility of healthcare professionals to make decisions appropriate to the circumstance of the individual, informed by them and/or their guardian or carer and taking full account of their medical condition and treatment.

When implementing this guideline full account should be taken of the local context and in line with statutory obligations required of the organisation and individual. No part of the guideline should be interpreted in a way that would knowingly put staff, those with diabetes or anyone else at risk.

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All enquiries regarding this document should be addressed to the Joint British Diabetes Societies for Inpatient Care (JBDS-IP) group info@jbds-ip.org

Conflict of interest statement

AL has received payments for speaking and advisory boards from Insulet, Dexcom, Abbott Diabetes Care, Novo Nordisk, Sanofi and Institutional Research Support from Abbott Diabetes Care, Novo Nordisk. DF is the national lead for the UK diabetes care accreditation programme and has received speaker honoraria from AstraZeneca, Novo Nordisk, and Sanofi Diabetes. SM is appointed to the Board of Trustees at the Diabetes Research & Wellness Foundation and is in receipt of funds from Dexcom for an investigator-initiated research study. GR has received personal fees from Abbott Diabetes Care, Sanofi Aventis and Eli Lilly. PC has received personal fees from Abbott Diabetes Care, Dexcom, Diasend, Eli Lilly, Insulet, Medtronic, Novo Nordisk, Roche and Sanofi Aventis. KD has received speaker fees, travel or taken part in advisory boards for AstraZeneca, Sanofi Diabetes, Boehringer Ingelheim, Lilly, and Novo Nordisk. PA has no conflicts of interest.

Guideline Working Group

Dr Parizad Avari	Imperial College Healthcare NHS Trust
Professor Pratik Choudhary	University of Leicester
Dr Alistair Lumb	Oxford University Hospitals NHS Foundation Trust; Chair, Diabetes Technology Network (DTN)
Dr Shivani Misra	Imperial College London
Professor Gerry Rayman	East Suffolk and North Essex NHS Foundation Trust
Dr Daniel Flanagan	University Hospitals Plymouth NHS Trust
Professor Ketan Dhatariya	Norfolk & Norwich University Hospitals; Chair, Association of British Clinical Diabetologists

JDPS-IP Group

Dr Omar Mustafa	King's College Hospital NHS Foundation Trust, London; Chair, JBDS-IP
Dr Ahmed Al-Sharefi	South Tyneside and Sunderland NHS Foundation Trust
Dr Parizad Avari	Imperial College Healthcare NHS Trust, London
Elizabeth Camfield	Guy's and St Thomas' NHS Foundation Trust, London
Erwin Castro	East Sussex Healthcare NHS Trust
Dr Jason Cheung	Norfolk and Norwich University Hospitals NHS Foundation Trust, Norwich
Dr Umesh Dashora	East Sussex Healthcare NHS Trust,
Dr Parijat De	Sandwell and West Birmingham Hospitals NHS Trust
Professor Ketan Dhatariya	Norfolk & Norwich University Hospitals, Norwich; Chair, Association of British Clinical Diabetologists
Dr Daniel Flanagan	University Hospitals Plymouth NHS Trust
Dr Stella George	East and North Hertfordshire NHS Trust
Andrea K. Lake	Cambridge University Hospitals NHS Foundation Trust; Chair Diabetes Inpatient Specialist Nurse (DISN) UK Group
Dr Sue Manley	University Hospitals Birmingham NHS Foundation Trust
Philip Newland-Jones	University Hospital Southampton NHS Foundation Trust, Southampton
Professor Gerry Rayman	East Suffolk and North Essex NHS Foundation Trust, Ipswich
Klea Riley	Diabetes UK
Dr Stuart Ritchie	NHS Lothian
Professor Alan Sinclair	Director Foundation for Diabetes Research in Older People (fDROP) and King's College London
Esther Walden	Diabetes UK

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Foreword

This document is primarily written for specialist diabetes teams to make best use of current technology to support diabetes care in hospital. As teams are aware, there have been significant advances in diabetes care in recent years, including the development of technological solutions. Most of the research and development has focused on benefits seen outside of hospital, and while there has been some specific work looking at use of technology in hospital, this has mostly concentrated on safety rather than demonstrating improvements in care. Despite this, it seems reasonable to extrapolate from the evidence available, that devices developed to enhance diabetes care outside hospital will show similar benefits in hospital.

A survey of technology use in 102 UK hospitals has shown considerable variation in the use of all aspects of technology for diabetes management in hospital. For example, just over half of hospitals report using point-of-care glucose data for audit, quality improvement or clinical care, and continuous glucose monitoring may be continued on admission to hospital to aid self-management but is rarely used as a specific tool to improve diabetes management.

There is a need for clinical guidance defining how to safely use current devices when people with diabetes attend hospital. We need to define best practice for using wearable and information technology to monitor diabetes care and communicate between health professionals. We can also look forward to likely developments providing opportunities together with the potential risks.

Specific issues to address

There are two main areas; (i) use of devices to improve diabetes management (including insulin pumps and glucose sensors) and (ii) information technology. These two areas already interact. The combination of new technology together with a system to manage that information provide the opportunity for significant improvement in care of the person with diabetes but also present some novel challenges.

Target audience

These guidelines are aimed at all healthcare professionals to help identify and support people with diabetes manage technology safely in hospital.

Parizad Avari, Pratik Choudhary, Alistair Lumb, Shivani Misra, Gerry Rayman, Daniel Flanagan, and Ketan Dhatariya

Abbreviations / Glossary of Terms

CBG	Capillary blood glucose
CSII	Continuous subcutaneous insulin infusion
CGM	Continuous glucose monitoring (in the document refers to both real-time and intermittently scanned)
CPR	Cardiopulmonary resuscitation
CT	Computed tomography
DKA	Diabetic ketoacidosis
isCGM	Intermittently scanned continuous glucose monitoring
IV	Intravenous
EHR	Electronic health records
EPR	Electronic patient record
EPMA	Electronic prescribing and medicines administration
FRIII	Fixed rate intravenous insulin infusion
GIRFT	Getting It Right First Time
HCL	Hybrid closed loop
LIMS	Laboratory information management system
Looming hypoglycaemia - glucose between 4-6 mmol/L on CGM device	
LGS	Low glucose suspend
MRI	Magnetic Resonance Imaging
NaDIA	National Diabetes Inpatient Audit
NBM	Nil by mouth
NDISA	National Diabetes Inpatient Safety Audit
NHS	National Health Service
POCT	Point-of-care testing
PET-CT	Positron Emission Tomography and Computed Tomography
PLGS	Predictive low glucose suspend
rtCGM	Real-time continuous glucose monitoring
SC	Subcutaneous
T1D	Type 1 diabetes
T2D	Type 2 diabetes
TAR	Time above range >10mmol/L (%)
TBR	Time below range <4mmol/L (%)
TIR	Time in range 4-10mmol/L (%)
VRIII	Variable rate intravenous insulin infusion

1. Key Recommendations

1. Hospitals should have a written policy for the use of wearable technologies within the inpatient setting. These include:
    i. Continuous glucose monitoring (CGM)
    ii. Insulin pumps (continuous subcutaneous insulin infusion therapy)
    iii. Hybrid closed loop systems
2. Hospitals should have a policy for point-of-care testing (POCT) of networked glucose and ketone meters
3. Hospitals should routinely use the data from networked glucose and ketone meters to enhance inpatient diabetes care and should be regularly reviewed for audit/ quality improvement
4. People with diabetes should be involved with the development of relevant hospital policies
5. Hospital management should ensure electronic prescribing and medicines administration are available, as well as enabling the ability to integrate diabetes technology with electronic health records
6. The hospital should ensure relevant staff training in the use of diabetes technology
7. Policies on use of technology in hospital should undergo annual review and audit

2. Summary recommendations for each chapter

Specific recommendations for each section are given at the start of the sections, as summarised:

Wearable diabetes technology

1. For any person with diabetes admitted to hospital, particularly T1D and insulin treated T2D, check whether they use any wearable technology
2. Determine whether the device is a continuous glucose monitoring system (real-time or intermittently scanned CGM) or an insulin delivery system (i.e. insulin pump)
3. If admitted unconscious, check for wearable diabetes technology (usually worn on the arm or abdomen, but may sometimes be on thighs/ buttocks)
4. Ensure the device (CGM/ insulin pump) is not inserted into area of generalized oedema or cellulitis

Continuous glucose monitoring:

5. If the person with diabetes can self-manage and are capable of using their technology device, they should be encouraged to do so as they do out of hospital
6. Currently, CGM can be used to augment capillary glucose testing in hospital but cannot replace it. If a sensor is being used in hospital, at least two capillary blood glucose (CBG) tests should be performed. Otherwise, routine point-of-care CBG testing should be done at the previously recommended frequency (i.e. before meals and at bedtime for those on a basal-bolus insulin regimen)
7. For in-hospital glycaemia, aim should be for no episodes of hypoglycaemia and to minimise hyperglycaemia
8. Glucose between 4.0-6.0mmol/L is indicative of looming hypoglycaemia so consider intervening, particularly if there is a downward CGM arrow
9. Alarms should be used to trigger a capillary glucose reading and consideration of intervention by ward nursing staff
10. If the person is due for a procedure or operation where it is agreed or planned to continue using their device, ensure it is on a different area of the body (contralateral side) so that it is not affected
11. Avoid placing CGM sensors on the abdomen in the prone individual, as increased pressure whilst lying on it may reduce sensor accuracy
12. Any CGM devices removed, should be labelled, stored in a safe place and documented
13. Diabetes inpatient teams are encouraged to maintain a supply of sensors available to support people in hospital who rely on these for self-management (although individuals are recommended to bring their own CGM supplies)

Insulin pump/ Continuous subcutaneous insulin infusion:

14. An insulin pump should be discontinued if there is any impairment to consciousness, or if the person with diabetes is acutely unwell and/or confused
15. If there is disruption of insulin delivery via subcutaneous insulin pump (for example, removal of pump or blocked cannula), ensure an alternative source of insulin is started immediately (intravenous or subcutaneous injections)
16. Any removed insulin pump devices, should be labelled, stored in a safe place and documented
17. All people using insulin pumps should be discussed with a member of diabetes specialist team

Hybrid Closed Loop:

18. Closed loop algorithms should be "disengaged" and switched to "manual" control in hospital
19. After discontinuation of auto-mode within the hybrid closed loop, the system may be used individually (as CGM only or insulin pump only) if criteria are met
20. For inpatients meeting the criteria to continue insulin pump and CGM therapy, continuing in closed loop mode may be considered but only under specific guidance from the diabetes team

Electronic prescribing and medicines administration

21. All hospitals should aim towards implementing electronic health records and EPMA
22. Specific training should be provided for EPMA systems, insulin prescriptions, as well as care bundles, such as DKA or HHS
23. Point-of-care glucose and ketone results should be integrated to in to EPR systems.

Point-of-care testing

24. Capillary blood glucose is the standard for glucose monitoring in hospital
25. Capillary blood ketone should be favoured over urine testing, due to their potential for increased accuracy and connectivity (urine ketones may lag behind blood ketones)
26. Provision and quality assurance (internal quality control in the ward environment and external quality assurance) of all POCT devices should be overseen by the Clinical Biochemistry Point-of-Care Committee
27. Staff training should be standard for the use of POCT devices including the identification of erroneous results and internal quality control
28. POCT devices should be implemented with end-to-end connectivity across device, middleware, laboratory information management system (LIMS) and electronic health records (EHR)

29. Inpatient diabetes teams should be supported to use data from networked POCT devices to prospectively identify harms and people at-risk, as well as retrospectively undertake quality improvement and benchmarking
30. Aim to include prompts for out-of-range blood glucose and ketones within EHR and make them available to healthcare professionals caring for people with diabetes

Information technology to support inpatient diabetes care

31. Inpatient teams should have access to a list of all people with diabetes in hospital
32. Inpatient teams should have the ability to maintain an electronic record of people with diabetes currently under their care
33. Data within this record needs to be auditable
34. There should be a system of electronic referral to the diabetes team
35. There should be an electronic system to monitor foot checks with referral to the inpatient foot multidisciplinary team as required
36. Inpatient teams should review lists of out of range glucose and ketone readings in order to aid prioritisation of people for review (for examples, recurrent hypoglycaemia or elevated ketones)
37. EPMA reduces diabetes related prescribing errors; prescribing information should be available to the diabetes team remotely
38. Routine observations such as blood glucose and ketones should be monitored electronically with action prompts for the ward teams if out of range
39. Using IT to perform regular audits of performance should be part of routine care delivery
40. Contribution to national electronic audits of inpatient care should be part of routine care delivery

Self-management protocols

41. If an individual normally uses an insulin pump or glucose sensor and is confident and capable of continuing with this in hospital, then hospital systems should enable this to happen
42. The diabetes team need to be available to closely support this process 7 days per week
43. Point-of-care capillary glucose measurements performed by the hospital team may be required in addition to the individual's own glucose recordings

3. Wearable diabetes technology

Summary of recommendations

1. For any person with diabetes admitted to hospital, particularly T1D and insulin treated T2D, check whether they use any wearable technology

2. Determine whether the device is a continuous glucose monitoring system (real-time or intermittently scanned CGM) or an insulin delivery system (i.e. insulin pump)

3. If admitted unconscious, check for wearable diabetes technology (usually worn on the arm or abdomen, but may sometimes be on thighs/ buttocks)

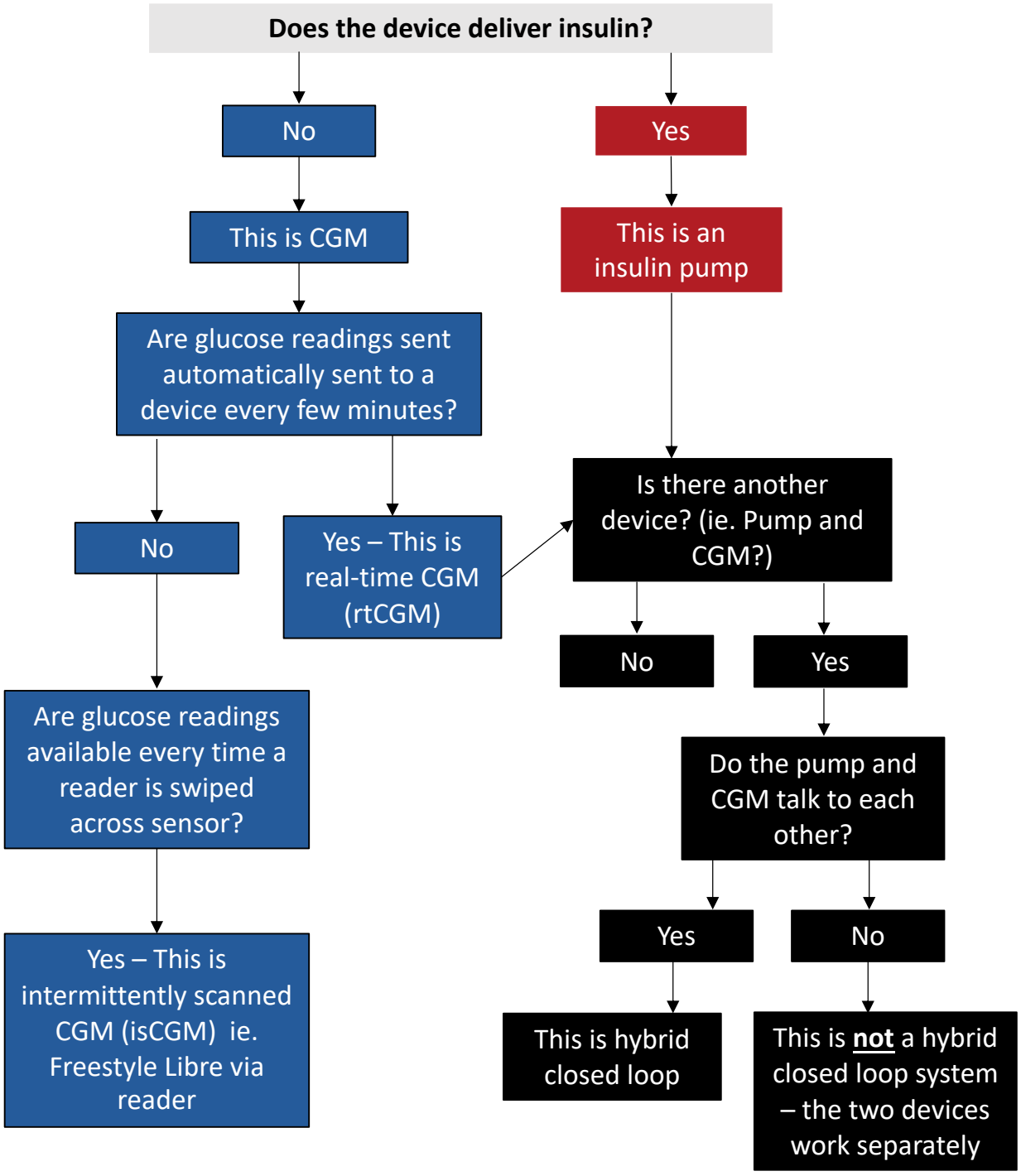
4. Ensure the device (CGM/ insulin pump) is not inserted into area of generalized oedema or cellulitis

Increasing numbers of people, particularly those with type 1 diabetes (T1D), are using wearable technology. It is important to be able to distinguish between the two main types: continuous glucose monitoring (CGM) and insulin pumps. CGM can be real-time or intermittently scanned continuous glucose monitoring, also known as flash glucose monitoring. These devices measure interstitial glucose, and through smart technology, transmit glucose levels to a reader or smartphone app.

Insulin pumps (also known as CSII: "continuous subcutaneous insulin infusion") are used by people with T1D to improve HbA1c and/or reduce the risk of hypoglycaemia. An insulin pump provides a continuous basal infusion of short acting insulin (the hourly rate typically varies over a 24-hour period), in combination with boluses of the same insulin at meals and drinks containing carbohydrates. Both basal and bolus insulin are delivered by the insulin pump, which infuses insulin a fine bore subcutaneous cannula.

For any person with diabetes admitted to hospital, particularly T1D and insulin treated T2D, check whether they use any wearable technology. If admitted unconscious, check for wearable diabetes technology (usually worn on the arm or abdomen, but may sometimes be on thighs/ buttocks). It is important for healthcare professionals to be able to distinguish between insulin delivery and glucose monitoring devices.

Figure 1: Identifying which diabetes technology is being used



Note: Some pumps are wireless (i.e. patch pumps) and may look similar to a CGM device. Some pumps display CGM readings on the device (ie. if working as a hybrid closed loop system) and should not be mistaken for CGM.
If in any doubt, please contact the diabetes team.

3.1 Continuous glucose monitoring (intermittently scanned and real-time)

Summary of recommendations

1. If the person with diabetes can self-manage and are capable of using their technology device, they should be encouraged to do so as they do out of hospital
2. At the current time CGM can be used to augment capillary glucose testing in hospital but cannot replace it. If a sensor is being used in hospital, at least two CBG tests should be performed. Otherwise, POC CBG testing should be done at the previously recommended frequency (i.e. before meals and at bedtime for those on a basal-bolus insulin regimen)
3. In-hospital glycaemia, aim should be for no episodes of hypoglycaemia and to minimise hyperglycaemia
4. Glucose between 4.0-6.0mmol/L is indicative of looming hypoglycaemia so consider intervening, particularly if there is a downward CGM arrow
5. Alarms should be used to trigger a capillary glucose reading and consideration of intervention by ward nursing staff
6. If the person is due for a procedure or operation where it is agreed or planned to continue using their device, ensure it is on a different area of the body (contralateral side) so that it is not affected
7. Avoid placing CGM sensors on the abdomen in the prone individual, as increased pressure may reduce sensor accuracy
8. Any CGM devices removed, should be labelled, stored in a safe place and documented
9. Diabetes inpatient teams are encouraged to maintain a supply of sensors available to support people in hospital who rely on these for self-management (although individuals are recommended to bring their own CGM supplies)

Within the outpatient setting, continuous glucose monitoring (CGM) is rapidly replacing capillary blood glucose testing. It is not yet standard care in hospital, but it seems highly likely that it will become so in the near future. There are several potential advantages to the use of CGM in hospital over POCT finger-prick CBG monitoring:

- The diabetes team could monitor glucose fluctuations in more detail to improve advice and guidance
- The use of alarms to warn the person with diabetes and ward team of the risk of out-of-range glucose, particularly hypoglycaemia
- Less discomfort for the individual, facilitating more frequent glucose monitoring. A particular advantage in some situations such as during enteral feeding
- Reduced risk to the ward team to needle stick injury
- In the future, closed loop systems are likely to enhance glucose management in hospital

There are, however, a few current barriers to the routine use of CGM in hospital:

- Lack of familiarity of ward staff with the technology
- Concerns about accuracy in some situations, for example diabetic ketoacidosis (this is an absence of evidence rather than evidence of a problem)
- An inability of the diabetes specialist team to monitor CGM remotely in hospital
- CGM not integrating with current EHRs
- A reliance on the person with diabetes having capacity to self-monitor and provide appropriate readings, whilst being unwell

Providing these barriers can be overcome, the potential advantages of CGM in hospital are significant. Where individual teams can safely overcome the barriers to CGM use and provide assurance that readings are sufficiently accurate during the hospital admission, then CGM can be used in place of finger-prick glucose. For this document we have assumed that most hospitals cannot currently provide this. The advice given here is therefore a pragmatic approach that can be used today. At the time of writing this guidance, use of CGM within the hospital setting is rapidly evolving.

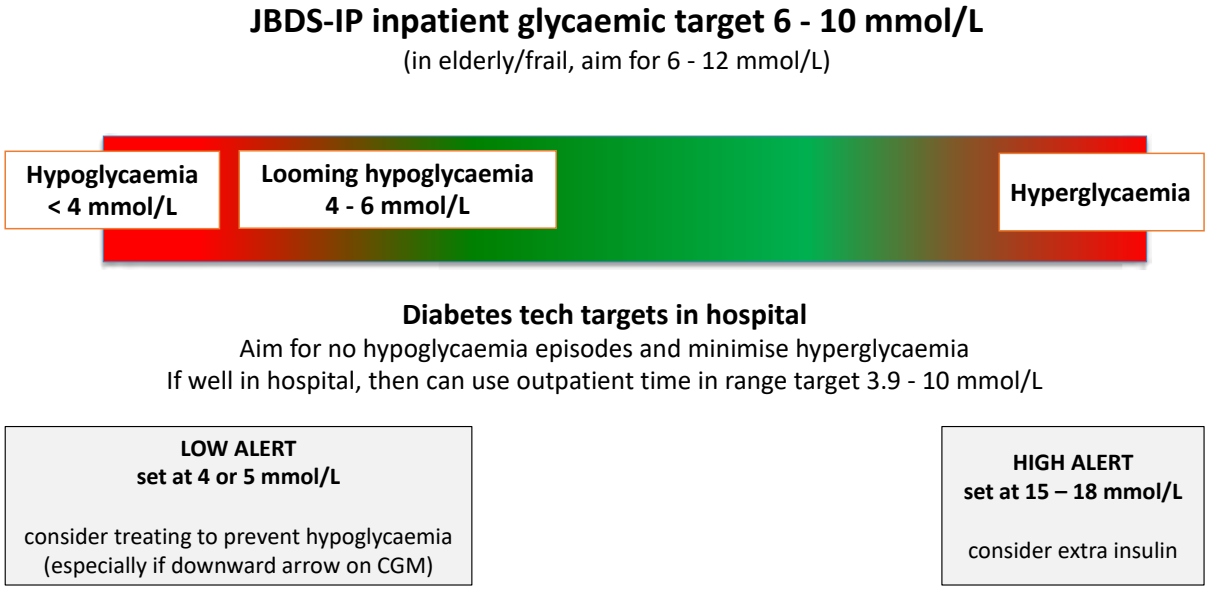
For the purposes of this document, the term "CGM" refers to both real-time continuous glucose monitoring (rtCGM) and intermittently scanned continuous glucose monitoring (isCGM), unless specified. Glucose refers to interstitial glucose, unless specified as capillary blood glucose.

3.1.1 Glycaemic targets in hospital

Glycaemia in hospital is likely to change hour by hour, and day by day, whilst people are unwell, therefore it is difficult to meaningfully use the concept of "time in range" in that situation. The consensus view is that avoiding hypoglycaemia is the priority, with the secondary aim of avoiding significant hyperglycaemia (Figure 2: Glycaemic parameters and targets for people with diabetes in hospital).

- Aim should be for no hypoglycaemia in hospital and to minimise hyperglycaemia
- Usual JBDS-IP glycaemic targets in hospital are 6.0 – 10.0 mmol/L, which apply for the acutely unwell person
- For some individuals who are well in hospital, then the outpatient target of 3.9 – 10.0 mmol/L may be acceptable (for example, in otherwise fit, well adults awaiting elective surgical procedures)
- Targets should therefore be individualised and the reasons why targets in hospital differ from the outpatient setting should be discussed with the individual
- If glucose is between 4.0 – 6.0 mmol/L and CGM arrow(s) are trending down, this is indicative of looming hypoglycaemia. A small carbohydrate snack (4-8 grams) can arrest the fall to hypoglycaemia. Other interventions may include adding glucose to an intravenous infusion or simply rechecking blood glucose levels sooner than planned.

Figure 2: Glycaemic parameters and targets for people with diabetes in hospital



3.1.2 Alarms and alerts in hospital

People using CGM may have individualised alarms, and if the person is able and willing to self-manage, alarm settings may be kept as in the outpatient setting.

Although target glucose levels in hospital are 6.0 – 10.0 mmol/L (in elderly frail, aim for 6.0 – 12.0 mmol/L), it may also be useful to change the alarm setting thresholds to avoid the burden of high alarm frequency. We suggest alarms to be used as safety nets to require action, and are set at which intervention would be necessary on safety grounds, rather than efficacy.

If CGM is being used to alert the medical team, the settings can be programmed as:

- HIGH ALERT: set at 15 – 18 mmol/L – consider extra insulin
- LOW ALERT: set at 4 – 5 mmol/L – consider treating to prevent hypoglycaemia (especially if downward arrow on CGM)

Some people using CGM may usually have the alarms switched off. If the system is being used to alert the medical team, it must therefore be ensured the alarms are switched on.

As clinical teams gain more experience, and it becomes possible to link these systems with hospital electronic health records, we expect their use to increase. At present, the alarms should be used to trigger a capillary glucose reading and consideration of intervention by the ward nursing staff according to clinical advice.

3.1.3 Capillary glucose monitoring whilst the individual wears CGM

Due to the risk of inaccuracy during acute illness, capillary blood glucose should be checked at least twice daily for people using CGM in hospital, irrespective of whether the device needs calibration. On admission to hospital, it should be explained to the person with diabetes that regular CBG monitoring is necessary for safety reasons, and for alerting staff to out of range results. Nursing staff should also be aware to perform additional CBG testing in case of any concerns of discrepancy with symptoms.

3.1.4 Discrepancies between CGM and CBG readings

A discrepancy may be observed between CGM and CBG readings. JBDS-IP define an acceptable difference as being within ±20% of the absolute difference between CGM and CBG glucose levels if CBG is >5.6mmol/L; or within ±1.1mmol/L of the absolute difference between CGM and CBG glucose if CBG is ≤5.6mmol/L. This is based on the definition for the reference standard for integrated CGM (iCGM) devices, also known as %20/20 rule.

- If the discrepancy is significant, more frequent CBG monitoring advised is for next few hours (depending on clinical need)
- For CGM devices that can be calibrated (e.g. Dexcom G6) consider calibration with point-of-care glucose using a blood glucose meter, and use if accurate. If the discrepancy persists, remove the sensor, and replace

Appendix 1: Situations to always check outlines some situations in which people using CGM in hospital should be advised to check capillary blood glucose before treatment decisions (rather than using sensor glucose). Reasons for ensuring capillary glucose checks are performed in hospital include that these are quality assured, and that point-of-care glucose results may be linked to safety systems and to the diabetes team.

- As per manufacturer guidance, ensure CGM devices are not inserted into an area of generalized oedema or cellulitis
- If the patient is due for a procedure or operation, ensure the sensor is on a different area of the body (contralateral side) so that it is not affected. Lying/ pressure on the sensor may cause erroneous results

3.1.5 Documentation of glucose readings in hospital

Currently most CGM data are not integrated with hospital electronic health records, therefore healthcare professionals need to be mindful of how data are documented. Due to the influx of glucose readings available from CGM devices, we recommend a minimum standard of documentation. This includes: fasting, pre-meals and before bed readings; any episodes of hypoglycaemia and hyperglycaemia, triggered through alarms. Documentation should also include the method through which glucose values have been obtained.

Diabetes teams receiving automated alerts from CBG monitoring should be mindful that until CGM systems are integrated with electronic health records they will not be directly alerted to out of range values as with point-of-care glucose systems.

Diabetes teams can review historic data through appropriate sensor online platforms (Appendix 2: Reviewing CGM data).

3.1.6 The person with diabetes wearing CGM in hospital

Unless incapacitated or acutely unwell, most people using CGM in a medical or surgical ward are safe to remain on CGM if admitted to hospital (Figure 3: Recommendations for use of CGM in the hospital setting). Due to the possible risk of inaccuracy during acute illness, capillary blood glucose should be checked at least twice daily for people using CGM in hospital, irrespective of whether the device needs calibration.

The CGM sensor device can be left in (unless the duration of illness is longer than the manufacturer's guidance on sensor wear). See Section "CGM and insulin pump use in special situations".

- Ensure CGM device is not inserted into area of generalized oedema or cellulitis
- CGM glucose readings should not be used whilst on VRIII/FRIII
- If the patient is due for a procedure or operation, ensure the sensor is on a different area of the body (contralateral side) so that it is not affected

If the person using CGM in hospital is having an episode of hypoglycaemia, they should inform nursing staff. Point-of-care capillary blood glucose should be performed to corroborate the result, and treated as per local guidance.

3.1.7 Stopping and restarting CGM

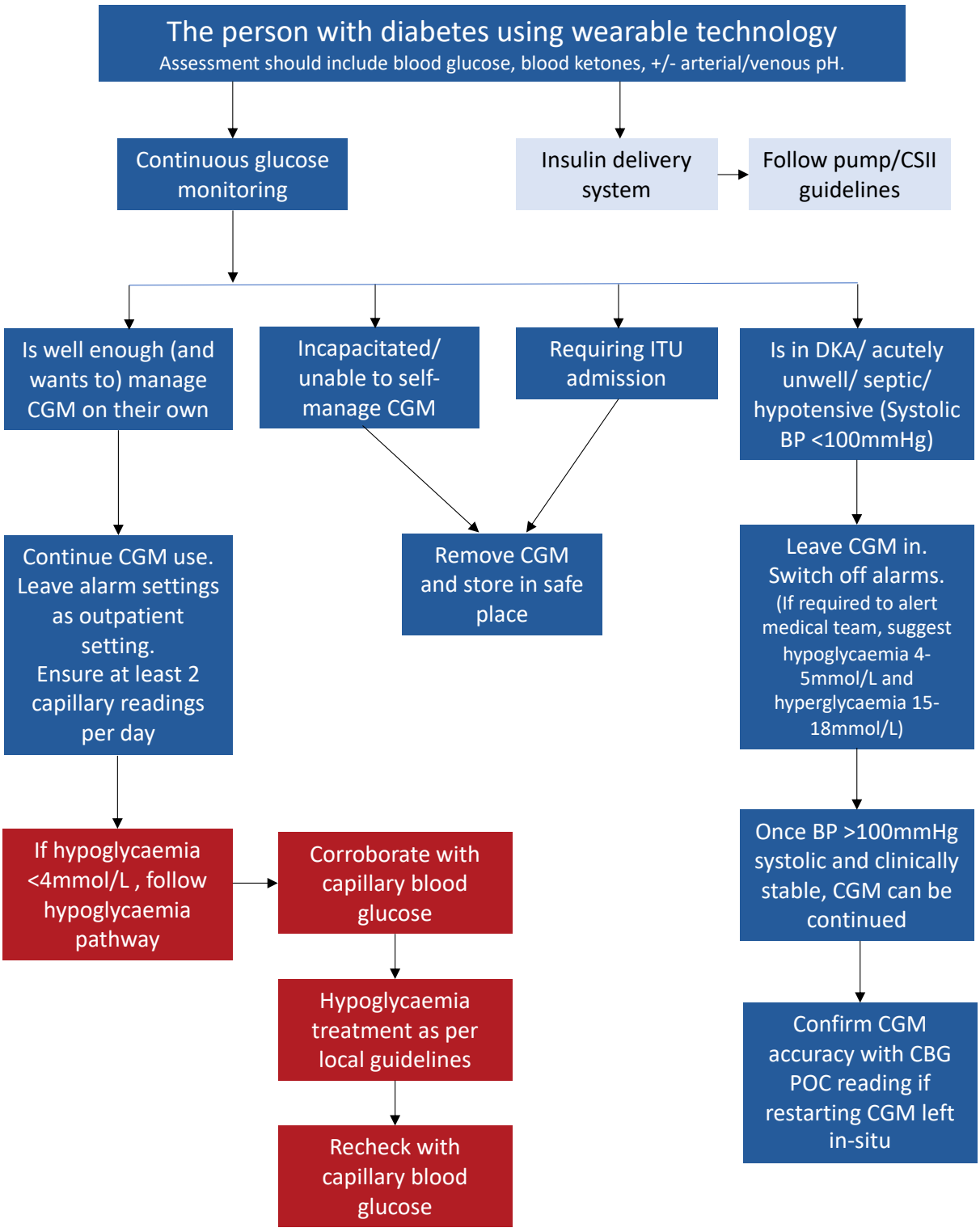
The person with diabetes is ideally best placed to remove the sensor, with the phone app or receiver to be informed of sensor session ending. If this is not possible, the sensor may be removed and safely stored.

As some sensors have the transmitter attached, we recommend any devices removed, be labelled and stored in a safe place and documented. This should ensure that the relatively expensive transmitter is not discarded. Even though the implantable sensor (Eversense) is not available in many parts of the world, including the UK, the surface transmitter can be removed and reapplied at a later date.

For healthcare professionals familiar with the diabetes technology, the disposable sensors can be safely disposed of. For healthcare professional unfamiliar with the technology devices, due to the cost of diabetes wearable technology, we suggest they should be safely stored until they get input from the diabetes team.

For restarting CGM, the person with diabetes is ideally best placed to restart this as they will have received training and will be experienced in this process.

Figure 3: Recommendations for use of CGM in the hospital setting



3.2 Insulin pumps/ Continuous Subcutaneous Insulin Infusion therapy (CSII)

Summary of recommendations

1. Insulin pump should be discontinued if there is any impairment to consciousness, or the person with diabetes is acutely unwell and/or confused
2. If there is disruption of insulin delivery via subcutaneous insulin pump (for example, removal of pump or blocked cannula), ensure an alternative source of insulin is started immediately (intravenous or subcutaneous injections)
3. Any removed insulin pump devices, should be labelled, stored in a safe place and documented
4. All people using insulin pumps should be discussed with a member of diabetes specialist team

Insulin pumps, also called continuous subcutaneous insulin infusion (CSII) systems are small portable devices that deliver a continuous infusion of rapid acting insulin subcutaneously. They have the advantage of delivering pre-programmed variable rates throughout the day to mimic physiological "basal" insulin delivery. There is also a "bolus" feature that is used to give additional doses of insulin based on preset insulin-to-carbohydrate ratios and insulin sensitivity factors. These boluses are usually initiated by the individual to provide insulin to cover food intake with carbohydrates at mealtimes and snacks, as well as to correct hyperglycaemia.

On acute admission to hospital, a considered decision, involving the person with diabetes, should be made as to whether the person can continue to safely use their pump (Figure 4: Recommendations for use of insulin pumps in hospital). The key criteria for insulin pump continuation include:

(1) The individual is medically stable, willing, and capable of self-management, and

(2) The treating clinician's familiarity with the insulin pump, appropriate hospital policies/ guidance on insulin pump use and inpatient diabetes management teams to support.

A full list of prerequisites for safe use and contraindications of insulin pump can be found in Appendix 3 (Requisites for safe perioperative use of CSII) and Appendix 4 (Contraindications to insulin pump therapy in hospital).

Insulin pumps are expensive and we recommend any devices removed, should be labelled, stored in a safe place and documented.

Shortly after admission, inpatient diabetes teams and/or the outpatient diabetes service should be involved in helping with insulin adjustment and pump settings as well as in coordinating care after hospital discharge. Specialist support is not usually available out of hours and may not be available at weekends - this lack of a 24/7 diabetes team and infrastructure to support in majority of UK hospitals remains a challenge to effective implementation within usual inpatient care.

Note: errors in insulin pump management can potentially result in severe hypoglycaemia, hyperglycaemia or DKA that may not be caught by typical hospital safe-guards, such as pharmacy review or scheduled point-of-care testing. Therefore, continued use of insulin pumps in the inpatient setting needs to be carefully considered.

Individuals continuing with insulin pump therapy in hospital should follow local hospital self-management policies. People continuing pumps or hybrid close loop systems in the acute care setting should be provided with a detailed information sheet and hospitals may wish to consider introducing a hospital pump policy, in addition to self-management policies already in place. An example used in the US has been published by Galindo et al (2020).

3.2.1 What can go wrong

People on insulin pump therapy do NOT usually take any long-acting insulin so if there is any interruption to insulin delivery (e.g. if the cannula is blocked or dislodged), hyperglycaemia and then ketoacidosis can develop very quickly. In these situations, the problem must be identified and rectified, e.g. by re-siting the cannula, changing the tubing, or starting alternative insulin such as an intravenous infusion. Technical problems with the pumps can occur; the pump manufacturing companies offer round-the-clock telephone support and are typically able to provide a replacement pump within 24 h if required. All individuals using pumps are advised to retain a supply of their pre-pump insulin pens for use in an emergency situation, for example, in case of pump failure or damage (See "Appendix 5: Starting basal insulin from insulin pump therapy ").

3.2.2 Practical recommendations: Insulin pump in the person able to self-manage

Unless incapacitated, most people admitted to hospital using insulin pumps, who are physically and mentally able to continue to use their pumps, are safe to remain on insulin pump therapy if admitted to hospital (they will have received extensive training). It is important to note that a significant proportion of medical staff will be unfamiliar with this technology. Specialist diabetes staff are required to be available to give advice and guidance if required.

If the individual is unable or unwilling to manage the pump, unable to safely demonstrate pump settings, and/or no specialist advice is immediately available, the pump should be removed and a conventional intravenous insulin infusion or a subcutaneous basal-bolus insulin regimen started.

It may not be possible for hospitals to have all the necessary insulin pump supplies, since each device model will have different components that a hospital would not typically have on formulary, therefore the individual or family need to be able to provide the necessary pump supplies, such as infusion sets and insulin reservoirs. If supplies are not available, then insulin pump therapy will need to be discontinued whilst in hospital.

On admission, rapid acting insulin used in the pump reservoir should be prescribed for use in an insulin pump (either on the parenteral section of the drug chart or on the electronic record). For electronic insulin pump order sets, hospitals should alert the medical team on how to deal with pump discontinuation.

Individuals should be made aware of differing glucose targets in hospital, as it likely differs from outpatient goals.

Insulin pumps are expensive and steps should be taken to ensure they are not lost when a patient is admitted to hospital. The pump should only be adjusted by its owner (who has received extensive training) or a member of the diabetes team in possession of the correct knowledge and skills.

3.2.3 Discontinuing/restarting insulin pumps

If the decision is made to discontinue the insulin pump on admission, individuals should be transitioned to a subcutaneous insulin injection regimen consisting of basal and bolus insulin, or continuous IV insulin infusion. Similarly, if an individual's medical condition changes during the hospital admission, and any concerns or a contraindication arises, insulin pump therapy should be discontinued. Examples include administered medications or analgesia which may impair consciousness or cause confusion or development of renal injury or hepatic failure resulting in uraemia or encephalopathy.

Appendix 5 (Starting basal insulin from insulin pump therapy) and Appendix 6 (Restarting insulin pump therapy from basal IV/SC insulin) summarise guidance for transferring individuals on CSII to/from subcutaneous insulin.

3.2.4 Hypoglycaemia whilst on an insulin pump

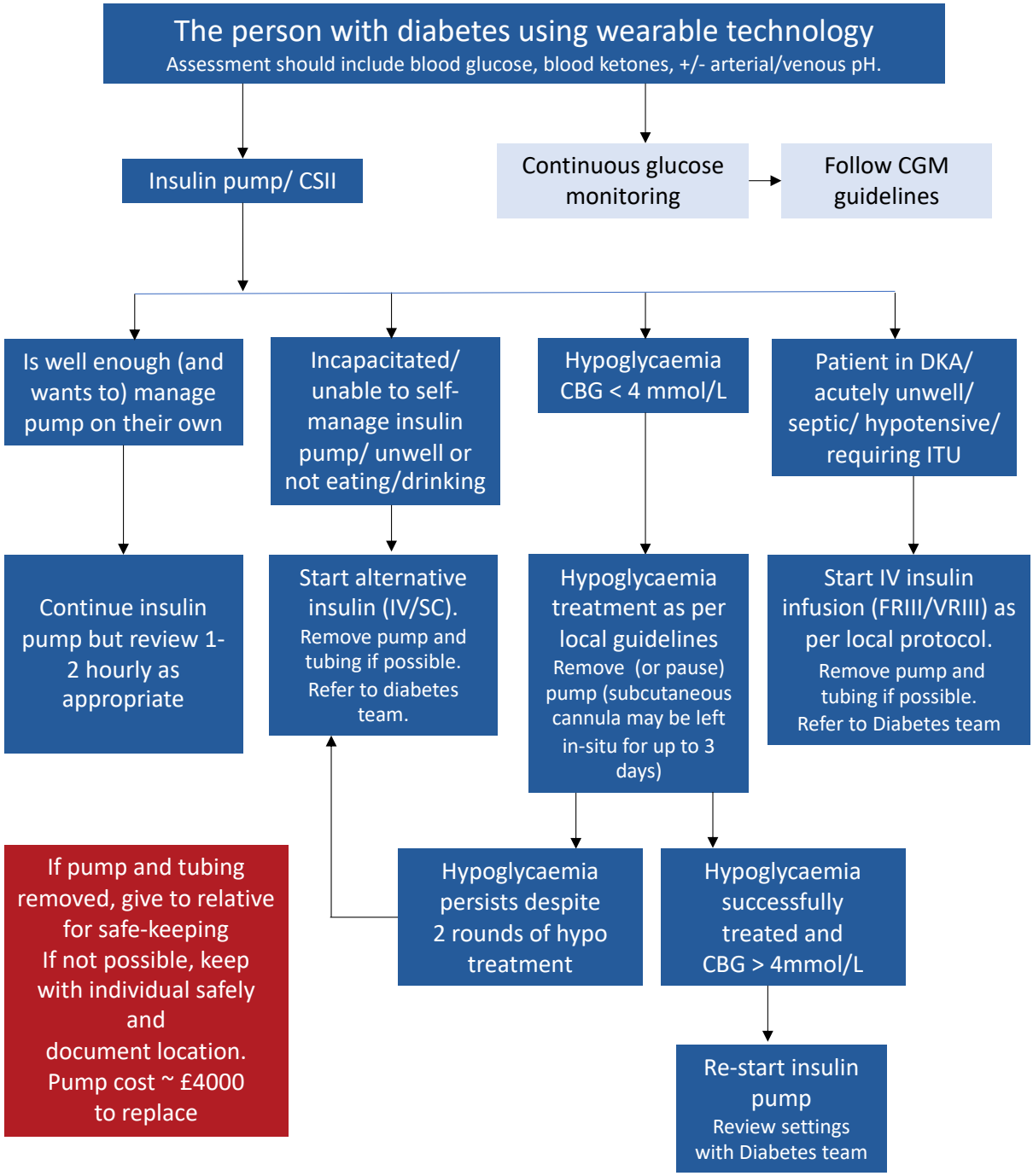
If able to manage their pump:

Treat hypoglycaemia with 15g rapid acting carbohydrates (e.g. dextrose tablets). Unlike people on long-acting insulin, follow-up with long-acting carbohydrates is not usually needed. Pump infusion rates may need adjustment, especially if there is a history of recurrent hypoglycaemia: consult diabetes team.

If unconscious/incapacitated:

Initial treatment of hypoglycaemia is as standard hospital policy. If persistent hypoglycaemia occurs, remove cannula and pump. Once normoglycaemic, re-start insulin, either CSII if the person with diabetes is alert and able to self-manage, or alternative regimen (see below); this is needed to prevent the development of ketoacidosis.

Figure 4: Recommendations for use of insulin pumps in hospital



3.3 CGM and insulin pump use in special situations

CGM	Insulin pump
In the septic, unwell individual	
• Do not use CGM in those acutely unwell or haemodynamically unstable • Revert to standard point-of-care CBG monitoring • CGM devices may be left in-situ • Once stabilised with systolic BP>100mmHg and individual able to self-manage, CGM may be continued on ward • Reassess and confirm CGM accuracy before using the sensor	• Do not use subcutaneous insulin pump in those acutely unwell or haemodynamically unstable • Stop insulin pump, remove and store in safe place • Replace with intravenous (VRIII) or multiple daily insulin injections
During hyperglycaemic emergencies	
• Do not use CGM during hyperglycaemic emergencies • CGM devices may be left in situ • Do not use CGM readings whilst on VRIII/ FRIII • Capillary blood glucose monitoring should be performed to adjust insulin infusions	• Do not use subcutaneous insulin pump during hyperglycaemic emergencies • Insulin pump should be removed and replaced with intravenous insulin as per local protocol (FRIII/VRIII) • Do not restart insulin pump until reasons for the hyperglycaemic emergency have been determined and pump equipment has been checked
In ITU	
• CGM should not be used in the ITU setting	• Insulin pump should not be used in the ITU setting
Radiological investigations	
• MRI – All CGM devices should be removed (except the implantable Eversense sensor) • CT – Can be either removed or covered with a lead shield	• MRI – Insulin pump should be temporarily suspended and removed* • CT – Can be either removed or covered with a lead shield • FDG-PET – No bolus insulin via pump <4 hours prior to procedure. Basal insulin can be continued through pump (discuss in advance with Radiologist) • X-rays – no need to remove the pump

CGM	Insulin pump
During Elective Surgery and/or Procedures	
• CGM may be used to guide capillary or blood gas glucose monitoring • CGM Should not be used to base treatment decisions • CGM sensor should be situated away from the operative site and the diathermy pad(s) • Do not use in event of intra-operative hypotension or haemorrhage Minor procedures (e.g. OGD/colonoscopy) • CGM can be continued	Major surgical procedures (>1 missed meal): • Stop insulin pump, remove and store in safe place • Ensure alternative strategy for insulin delivery appropriate for major surgery (VRIII) Minor procedures (no more than 1 missed meal with/ without sedation eg OGD/colonoscopy) • Can continue using insulin pump** • Only a Teflon® cannula should be used (steel needles contraindicated due to hypothetical risk of diathermy conduction) • During fasting, standard basal rates may be continued • Insulin pump should be situated away from the operative site and the diathermy pad(s) • Ensure VRIII prescription and basal insulin is prescribed in case of pump failure Further guidance and checklists found in Appendix 7: Wearable technology during elective procedures and UK Centre for Perioperative Care guidelines: https://cpoc.org.uk/guidelines-resources-guidelines-resources/guideline-diabetes
During pregnancy and labour	
• Can be used safely during pregnancy and labour delivery • Do not use to guide maternal VRIII • Ensure sensor is moved to the arm prior to caesarean section, so does not interfere with the operative field	• Can be used safely during pregnancy and labour delivery • If the mother-to-be (or partner) does not feel confident managing the insulin pump during labour, or if blood glucose not appropriately controlled, then VRIII should be started instead. • Consider starting VRIII if two consecutive blood glucose levels are above the target range (7.0 as per NICE or 8.0 mmol/L as per JBDS-IP guidance) https://abcd.care/resource/jbds-09-use-variable-rate-intravenous-insulin-infusion-vriii-medical-inpatients • After delivery, revert to pre-pregnancy basal infusion rates to minimise risk of hypoglycaemia
Pacemakers	
• There is an absence of data on use of pacemakers with CGM and more needs to be known with regards to safety, accuracy and compatibility	
Cardiac arrest	
• CGM devices should ideally be removed for external DC cardioversion (but do NOT delay CPR) • Do not use CGM glucose to guide treatment of hypoglycaemia in cardiac arrest	• Insulin pump should ideally be removed for external DC cardioversion (but do NOT delay CPR)

* Pumps can be safely suspended/removed for up to an hour at a time without needing alternative insulin. A correction bolus may be needed on reconnecting the pump.

**Prerequisites for safe perioperative use must be met.

3.4 Hybrid closed loop systems/ Automated insulin delivery systems

Summary of recommendations

1. Closed loop algorithms should be "disengaged" and switched to "manual" control in hospital
2. After discontinuation of auto-mode within the hybrid closed loop, the system may be used individually (as CGM only or insulin pump only)
3. For inpatients meeting the criteria to continue insulin pump and CGM therapy, continuing in closed loop mode may be considered but only under specific guidance from the diabetes team

Some rtCGM systems, when used with an appropriate insulin pump, have the facility for the sensor glucose to trigger suspension and resumption of insulin delivery. Low-glucose suspend (LGS) and predictive low glucose suspend (PLGS) systems are the simplest forms of a closed-loop system. Insulin suspension can be triggered without requiring any confirmation from the individual, when sensor glucose is predicted to reach a low threshold if sensor glucose keeps falling at the same rate (PLGS) or when sensor glucose reaches a low threshold (LGS). The aim of such systems is to avoid, or limit the duration of, hypoglycaemia.

Latest hybrid closed-loop systems aim to minimize hypoglycaemia and hyperglycaemia and maintain glucose levels within a target range through the use of a computerized algorithm to adjust the basal rate of insulin and administer corrective bolus doses. They are called "hybrid" systems as, unlike fully closed-loop systems, the person with diabetes is still required to manually program insulin boluses with meals.

Note: NOT all systems with CGM and a pump are hybrid closed loop systems and these may work separately.

Insulin suspension may not be used to treat hypoglycaemia because it does not work quickly enough.

3.4.1 In-hospital use of hybrid closed loop systems

There are limited data and guidance on real-world use and safety of hybrid closed loop systems in the hospital setting.

In someone who is well, and may be in hospital for a short elective procedure or investigation, it may be appropriate to let the hybrid closed loop continue to control their glucose.

In someone who is unwell, insulin requirements can change rapidly from day to day and so JBDS-IP recommend closed loop algorithms are "disengaged" and systems are switched to "manual" mode in the hospital setting. This allows the individual with support from their diabetes team to adjust insulin pump settings, including glucose target range, insulin sensitivity factor, and basal rates.

Further challenging scenarios for hybrid close loop systems in hospital, include medications such as glucocorticoids, which may cause severe insulin resistance and uncontrolled hyperglycaemia, presenting a challenge for hybrid close loop algorithms. Other challenging scenarios include nausea and vomiting in people on hybrid close loop systems, and during periods of parental or enteral nutrition through nasogastric/ percutaneous endoscopic gastrostomy (PEG) feed. In these scenarios we recommend closed loop algorithms to be "disengaged".

Individuals would need to meet the self-management criteria as for normal continuation of their insulin pump in hospital. It is important to recognise that individuals may need adjustment in their basal rates when switched to standard insulin pump mode or basal insulin, and a review of glycaemia, pre-admission basal rates, and number of automated insulin suspensions should be made. It is worth noting that some hybrid close loop systems, such as Omnipod 5, may not provide specific details on basal patterns, but report the total amount of insulin given in the day. In such situations, conversion to multiple daily injections can be done through estimation from total daily insulin or weight calculations (Appendix 5: Starting basal insulin from insulin pump therapy).

For inpatients meeting the criteria to continue insulin pump and CGM therapy, continuing in closed loop mode is only recommended under specific guidance from the diabetes team.

After discontinuation of auto-mode within the hybrid closed loop, the system may be used individually (as CGM only or insulin pump only). Continued use of these systems should be determined on a case-by-case basis, with shared decision making with individuals.

3.4.2 Hybrid closed loop in surgery

There are increasing case reports of using hybrid closed loop systems in surgery, but these should only be used with the anaesthetist working in close collaboration with the diabetes inpatient teams, with close monitoring and a clear plan and knowledge of using these systems

4. Electronic prescribing and medicines administration

Recommendations

1. All hospitals should aim towards implementing electronic health records and EPMA
2. Specific training should be provided for EPMA systems, insulin prescriptions, as well as care bundles, such as DKA or HHS
3. Point-of-care glucose and ketone results should be integrated to in to EPR systems

There are rapidly expanding numbers of electronic prescribing and medicines administration (EPMA) systems available. Although every system is different there are many common features. In general terms the major advantage of these systems is improvement in safety for the person receiving medications. There are also potentially advantages in reducing the time required to deliver care. This is particularly true for the diabetes team who should be able to review remotely a person's glucose readings in the context of medication prescribed and administered. Although this cannot replace the need to visit the person with diabetes, it does allow for a more focused approach to identify the people who would most benefit from a visit in person.

Potential benefits associated with EPMA use:

For pharmacy	• Reduction in prescribing errors through use of mandatory fields such as allergies and sensitivities and decision support (for example ensuring that insulin is prescribed in units) • Saving in time as a medication chart does not need to be transported to pharmacy or the pharmacist visit the ward to view the chart • Legible prescribing saving time and preventing errors • A clear record and auditable trail of what medication has been given and when
For the ward team	• Provides a legible prescription that is available to the whole clinical team • Ward team can be supported at a distance by other specialists such as pharmacy • Regular ward level audits of diabetes medication prescription and administration can be established • Other examples of decision support include: - Links to protocols for use on VRIII, DKA and HHS when intravenous insulin is being prescribed. - Alert sent to the diabetes team when intravenous insulin is prescribed. - Links to e-learning module on safe use of insulin for any insulin prescription - Limiting the prescription of short acting insulin to mealtimes and correction doses - Alerts if medication needs reviewing_

For the diabetes team	• Records and medication can be viewed at a distance from the ward, enabling diabetes specialist time to be focussed on those individuals who will benefit most • Enables certain groups of people with diabetes to be identified (eg. if admitted with diabetic ketoacidosis) • Matching individual glucose levels to the dosing and timing of diabetes medication should be easier as the specific time that the medication is administered is recorded. • As real time audits of ward level data on prescription and medication errors are available it is possible to plan specific training for areas that require it.
For the person on the ward with diabetes	• Safer care • A more responsive service • Reducing prescription errors • Potential improvement in the speed of the discharge process

Challenges associated with EPR/EPMA

Challenges include that EPR/EPMA systems are complex and take time to learn. One of the major issues is integrating glucose data (from CGM systems) in to EPR. Additionally, some EPR/EPMA systems remain hybrid with electronic recording of prescriptions, but data recorded separately on paper charts; a fully electronic system removes complexity, will be safer and is preferred. Specific training is required and will differ with each system. All clinical staff need to have the skills required to safely use the system. This in itself can result in medications being prescribed late or prescribed in error.

Specific training is required for individuals in the safe use of insulin. It is still possible to prescribe insulin incorrectly using electronic systems (eg selecting the incorrect insulin, delivery device or dose).

Prescribing in dynamic situations (eg DKA/HHS/ enteral feeding) can become cumbersome and require specific training. It is possible to mitigate some of this risk by building the necessary information into the local protocol for managing the condition.

Individuals that are self-administering insulin at mealtimes, may result in discrepancies on timings recorded on EPMA. Staff need to witness the administration and then record that it has been given. Care needs to be taken that the insulin is not recorded as given but the individual has not taken the medication.

Issues for the person with diabetes

Using the knowledge and experience of the person with diabetes is essential in supporting good glucose management when they become unwell. Where previously a medication chart and observation chart with glucose values might be readily available at the bedside this is not always the case if the information is stored electronically elsewhere on the ward. This problem is relatively easy to address if attention is given to ensuring that staff and the patient communicate effectively and are clear about what medication is being given and how this is influencing glucose levels. This can be a new area of frustration for people admitted to hospital with diabetes particularly if the ward has limited skills in managing diabetes.

Areas for future development

Overall, these systems have obvious and immediate benefits for people with diabetes and the diabetes team. There are some specific challenges around implementation of the systems and then some specific areas of increased risk due to the complexity of use. Diabetes teams need to adjust protocols and procedures to make best use of EPMA and reduce the associated risk. Overall EPMA should allow better oversight of everyone in hospital with diabetes and allow better use of limited specialist time.

It is likely that with time best practice in using specific systems will be shared between different hospitals using those systems, and that system-specific challenges will be addressed by providers. A more uniform approach to electronic prescribing would allow national data collection to be developed as an automatic process. This should result in an improvement in care across the UK.

As most hospitals now have networked central monitoring of glucose values an immediate advantage of these systems is the ability to cross-reference glucose readings with the prescription record. As these systems develop closer linkage should be possible. For example, an alert on the electronic prescription to review the medication if glucose values are persistently above or below set parameters.

The ability to build training into the prescription system should improve insulin safety. Advisory or mandatory training can be linked to the individual's ability to prescribe specific medication such as insulin.

5. Clinical use of point-of-care testing

Point-of-care testing (POCT) technologies are a key method of analysing blood, urine or other body fluid at the bedside or away from the routine laboratory. POCT measurements help facilitate decision making around diabetes management, but beyond this, have huge potential to drive improvements for inpatient safety, as well as enable rapid diagnosis or clinical decision-making on the basis of results obtained in real-time.

Recommendations

1. Capillary blood glucose is the standard for glucose monitoring in hospital
2. Capillary blood ketone should be favoured over urine testing, due to their potential for increased accuracy and connectivity (urine ketones may lag behind blood ketones)
3. Provision and quality assurance (internal quality control in the ward environment and external quality assurance) of all POCT devices should be overseen by the Clinical Biochemistry Point-of-Care Committee
4. Staff training should be standard for the use of POCT devices including the identification of erroneous results and internal quality control
5. POCT devices should be implemented with end-to-end connectivity across device, middleware, laboratory information management system (LIMS) and electronic health records (EHR)
6. Inpatient diabetes teams should be supported to use data from networked POCT devices to prospectively identify harms and people at-risk, as well as retrospectively undertake quality improvement and benchmarking
7. Aim to include prompts for out-of-range blood glucose and ketones within EHR and make them available to healthcare professionals caring for people with diabetes

5.1 Point-of-care glucose measurements

When selecting a POCT glucose device, consideration should be given to the method of glucose analysis as there may be specific interferents, for example compounds in dialysate fluid may interfere with some methods; a full description of assays and considerations for inpatient use, has been reviewed (Rajendran and Raymond, 2014).

Connectivity via interfacing software (middleware) of data derived from the POCT device to LIMS and electronic health records is a necessary component of the quality framework that, at a basic level, ensures data integrity, recording and linkage. Thus organisations where this chain of linkage is 'broken' may be at higher risk of clinical incidents, for example hospitals with paper-based notes and POCT devices that are not connected to LIMS may require practitioners to hand-write results from the device into notes, which leaves no digital record and has a much greater potential for human error. Thus total connectivity of the device to LIMS to EHR, or in some cases to LIMS and EHR independently, via middleware, is to be encouraged.

5.2 Using networked POCT measurements to drive clinical effectiveness

There are two key ways in which glucose measurements in the electronic health record can be used:

1) Identify people in hospital in real-time who have extreme glucose values for example hyper- or hypoglycaemia. Proactively searching these individuals could then lead to input from dedicated diabetes inpatient teams. Glucose thresholds may be set to suit each hospital trust. Monitoring and responding to glucose and ketone measurements over the whole hospital is a key role of the diabetes specialist team and should be part of routine work.

2) Retrospective audit - In England, for example, all hospitals are mandated to submit data on inpatient diabetes harms such as inpatient severe hypoglycaemia (National Diabetes Inpatient Safety Audit: https://digital.nhs.uk/data-and-information/clinical-audits-and-registries/national-diabetes-inpatient-safety-audit). Interrogation of glucose readings and ketone readings could facilitate identification of inpatients experiencing harms or indeed excursions in glucose measurements retrospectively. These data could then be used to benchmark against audit standards but also reviewed serially to drive improvements as part of an audit cycle, in a given local service.

Challenges

There is considerable variation in the clinical use of glucose and ketone point-of-care tests across the UK. Although most hospitals will have networked glucose meters the results are not always accessible to the diabetes specialist teams. Even if data are available the team may not have time to make use of the information. The challenge will be to provide the same level of oversight for every patient in every hospital.

Conclusion

POCT technologies remain a critical component of the management of people with diabetes in hospital. The need for appropriate infrastructure to support implementation of these devices is paramount. Connectivity that ensures POCT measurements are recorded in electronic health records and/ or laboratory information management systems is a requisite for ensuring appropriate governance but beyond this offer the ability to use these data to drive improvements. As we look forward to how POCT technologies can drive improvements in inpatient diabetes care, such systems will become an inevitable standard of care, but the resource, infrastructure and staffing to embed these as a standard will be necessary.

6. Information technology to support inpatient diabetes care

Recommendations

1. Inpatient teams should have access to a list of all people with diabetes in hospital
2. Inpatient teams should have the ability to maintain an electronic record of people with diabetes currently under their care
3. Data within this record needs to be auditable
4. There should be a system of electronic referral to the diabetes team
5. There should be an electronic system to monitor foot checks with referral to the inpatient foot multidisciplinary team as required
6. Inpatient teams should review lists of out of range glucose and ketone readings in order to aid prioritisation of people for review (for examples, recurrent hypoglycaemia or elevated ketones)
7. EPMA reduces diabetes related prescribing errors; prescribing information should be available to the diabetes team remotely
8. Routine observations such as blood glucose and ketones should be monitored electronically with action prompts for the ward teams if out of range
9. Using IT to perform regular audits of performance should be part of routine care delivery
10. Contribution to national electronic audits of inpatient care should be part of routine care delivery

Information technology refers to using various systems; for example, telecommunications and computers to store, retrieve, and send information. Advantages include faster access to clinical information, the ability to rapidly compile information about an individual and provide care remotely. There is an ability to monitor and therefore reduce medical errors and to gather audit data to continuously improve services. This wealth of new clinical information that is now available can only be translated into improved health care if there are trained individuals in place to make use of the data. The information technology revolution makes it much easier to measure standards of care and share best practice.

The use of systems that allow real time information about patient care to be available from any computer within a hospital, now means that the diabetes team can monitor care for a much wider group of people. Systems include electronic observations, electronic monitoring of point-of-care glucose and ketone measurements, EPMA, access to the EHR and the previous medical history from primary care. Telephone or paper-based referral to the diabetes team can now be replaced with an instant electronic message and potentially a much faster response.

Education and training of ward teams to improve diabetes care is an important role of the specialist team. Where undertaken electronically, this can be provided remotely, allowing more flexibility for the clinical staff, as well as a record of the diabetes team input to be available to the whole team at any time and the standard of care to be continuously monitored.

The benefits of these systems can be summarised as;

1. Improved speed and reliability of communication between health professionals and the person with diabetes
2. The ability to automatically record and collate outcomes and therefore improve
3. The ability to coach health professionals with specific comments based on the results. Research papers have tended to focus on the third of these, but the greatest immediate gains probably lie with the first two

Use of these tools can potentially save the diabetes team a great deal of time. They will also increase the workload as we become aware of the need for specialist intervention for a much wider group of people with diabetes in hospital. Increased efficiency but also an increased workload may mean a larger diabetes team is needed to manage the work that has now been identified. The technology described above is currently available. The guidance on how the diabetes team can best use these tools is not. To make the most of these new tools requires different ways of working for the inpatient diabetes specialist team.

6.1 Electronic health records (EHR)

An electronic health record (EHR; also known as electronic patient record or EPR) stores medical and nursing information, and may also link to systems such as those storing radiology and laboratory results and patient administration systems. These systems may be developed in house by the hospital team or there are several commercial products available. Several of the commercial products were initially developed as hospital billing systems and may have the advantage of flagging specific conditions such as diabetes or recording diabetes emergencies such as diabetic ketoacidosis. There are specific advantages for the diabetes team in using an electronic health record. Most will combine the functions described above with the ability to record diabetes specific outcomes (for example details of foot ulceration and a preventative care plan).

Current challenges

Switching to an EHR can be challenging as the functionality may not exactly mirror the individual systems that they are replacing. Remote point-of-care glucose monitoring is unlikely to be part of the EHR package and may be challenging to incorporate directly. Careful thought needs to be given to ensure that care standards are maintained during the transfer period. The transfer to an EHR requires time to plan and implement, and diabetes teams are currently stretched by volumes of work and workforce shortages. This is hopefully a short-term problem but there is the potential for larger teams to get better and smaller teams to get left further behind using outdated working practices. This can be addressed by developing national standards and ensuring that hospitals are appropriately supported to meet the standards.

7. Self-management protocols

Recommendations

- If an individual normally uses an insulin pump or glucose sensor and is confident and capable of continuing with this in hospital, then hospital systems should enable this to happen
- The diabetes team need to be available to closely support this process 7 days per week
- Point-of-care capillary glucose measurements performed by the hospital team may be required in additions to the individual's own glucose recordings

Being admitted to hospital is often a time when it is difficult to keep glucose readings in range. The stress effect of illness combined with poor appetite make optimal glycaemic management difficult. For a person with diabetes who is using current technology such as an insulin pump and glucose sensor to optimally manage their diabetes, the effect can be magnified. Although they may have significant expertise in managing their diabetes, self-management can be taken away by clinical staff who have less experience in using this technology. This tension is best dealt with by a hospital self-administration or self-management policy. Careful thought needs to be given to how this is linked to the EPMA system and EHR. For example, inpatient safety systems usually involve glucose readings from an organisation's own networked glucose meters, and readings not taken using these meters (such as from an CGM system or a person's own meter) will there bypass these systems. Until CGM data integrate with the EHR, a suitable compromise may be for the individual to continue to use their wearable technology while glucose testing is also performed using the hospital system.

Although EHR systems improve communication within the diabetes team and with other health professionals, they do not improve communication with the person with diabetes. Although nothing can replace the need to visit the person with diabetes on the ward, efforts can be made to review whether that will be in person or remotely. There is a need for an interim step where the person with diabetes can be spoken to either by telephone or video link.

Self-management of insulin pumps (continuous subcutaneous insulin infusion (CSII)) during hospital admission)

Insulin pumps may be used by people with T1D to optimise glycaemia, with users undergoing detailed education and training by the diabetes specialist team.

Principles of self-management of insulin pumps by inpatients

- Inpatients using insulin pumps should self-manage if well enough to do so
- If the person with diabetes is not well enough to self-manage the pump or is unconscious/ incapacitated the pump should be discontinued and a variable rate intravenous insulin infusion should be commenced immediately
- An insulin pump should NEVER be discontinued without immediate substitution of rapid-acting insulin via an alternative administration route. The person using insulin pump therapy should already have an alternative basal/bolus insulin regimen in the event of pump failure
- Insulin pumps should only be adjusted by the patient or a member of the diabetes team
- If an insulin pump is discontinued it should be stored safely until the person with diabetes is ready to recommence the pump. The place of storage should be documented
- If the person with diabetes is not able to self-manage but continued intravenous insulin is not necessary, the diabetes specialist team should be asked to advise on a subcutaneous insulin injection regimen
- The altered tissue perfusion in diabetic ketoacidosis (DKA) affects insulin absorption, making insulin pump therapy unreliable. The insulin pump should be temporarily discontinued in people with diabetes presenting in DKA: remove the cannula and detach the pump. For further management, follow standard DKA protocol
- When an insulin pump is recommenced the intravenous insulin infusion should not be discontinued until a mealtime bolus dose of has been given via the pump
- All people with diabetes admitted to hospital using an insulin pump should be referred to the diabetes specialist team

Pump management for procedures requiring a period of starvation:

- Continuous infusion of subcutaneous insulin via a pump is designed to maintain stable blood glucose during the fasting state
- Procedures requiring the individual to be nil by mouth for a limited period (no more than one missed meal) may be manageable with a pump
- Plans for continued use of the pump during an elective procedure should be discussed and agreed with the patient before admission
- People with an insulin pump should not require overnight admission prior to the procedure

Continuous glucose monitoring

The issues that arise are very similar to those associated with insulin pump therapy. The general principles described for insulin pump therapy apply here. If the person with diabetes is capable and comfortable to continue using the device, then they should be allowed to do so. There is still a requirement to perform regular capillary glucose tests on a quality-controlled hospital device to meet clinical governance standards.

If a person with diabetes attends hospital wearing one of these devices, then they should continue to use it if capable. At the current time routine capillary glucose and ketone testing will need to be performed in parallel by the ward team.

Electronic prescribing and medicines administration (EPMA)

Self-administered medications need to be prescribed in a specific format to allow for variable doses of insulin being given and for insulin to be given at times that are different to the standard medication rounds. Both prescribers and those recording administration need to be specifically trained in this aspect of their hospital's electronic system. The inability of clinicians to use an electronic system must not be allowed to prevent an individual self-administering medication. The inpatient diabetes specialist team should have the opportunity to input into developing appropriate processes for medication self-administration, and may then be trained to provide specific support and training to other staff.

Systems need to be able to record the specific dose of insulin given at each injection. The timing that the dose was administered also needs to be recorded. This is especially important for short acting insulins that should be given at mealtimes as these are unlikely to correspond with the timing of other medicines being administered. Ensuring that short-acting insulins are given at mealtimes is particularly important for avoiding hypo- and hyper-glycaemia.

Most systems will not allow people with diabetes to directly enter information. There is potential for adverse events if the information relating to timing and dose of insulin is not sought from the person with diabetes and entered in a timely way.

Hospital insulin safety groups need to specifically focus on electronic prescribing systems to ensure that they are contributing to improved insulin self-administration and safety as focussed diabetes specialist input may be required particularly when systems are being introduced.

8. National datasets to improve diabetes care

There will always be differences in the levels of care provided between hospitals. These differences can be reduced by developing national guidelines for the various aspects of diabetes care in hospital. Individual hospitals need the ability to measure themselves against those standards and compare themselves with national benchmarks. In England and Wales, a national audit of inpatient care was introduced in 2010, Scotland are currently introducing a similar process.

This paper-based snapshot bedside audit (the National Diabetes Inpatient Audit (NaDIA) reviewed aspects of care including medication errors, inappropriate use of insulin infusions, harms such as in-hospital hypoglycaemia, hospital acquired diabetic ketoacidosis and foot lesions. This involved the team visiting every inpatient with diabetes to examine their notes, prescription and observation charts. The first NaDIA report revealed significant deficiencies in care and alarming rates of hypoglycaemia and diabetic ketoacidosis. Subsequent audits provided a national overview of year-on-year change but importantly were used by teams to benchmark themselves against other hospitals as well as against previous years' data. This process has resulted in significant reductions in medication errors, inpatient hypoglycaemia and hospital acquired foot lesions. Another benefit of this annual surveillance is that it brings diabetes teams together to discuss the issues encountered during the audit of their hospital which require attention and importantly raises the profile of inpatient diabetes care with other teams as well as hospital management. Many teams have found the audit useful in supporting business cases for investment into staff and weekend working. NaDIA also collected data on the use of technology in supporting inpatient diabetes care. Since its inception there has been an increase in services using electronic patient records and electronic prescribing. The NaDIA, a paper-based audit, has been an important lever in increasing the use of these devices. It is currently paused in England and Wales. The challenge will be to deliver similar or enhance national audit using information technology to reduce the work required in undertaking a bedside audit.

Despite its significant contribution to improving inpatient diabetes, it is recognised that NaDIA is labour intensive and costly. Going forward, the National Diabetes Inpatient Safety Audit (NDISA) is exploring means of extracting data from electronic patient records, electronic prescribing records, electronically collected harms such as hospital acquired diabetic foot lesions ulcers (from analysis of tissue viability pressure ulcer data) and frequency of severe hypoglycaemia from web-linked glucose. The intention is to make this data available to hospitals on a monthly or quarterly dashboard for internal as well as national comparison. This should be a powerful driver of change.

In England the Getting It Right First Time (GIRFT) programme is another important initiative which has a focus on improving inpatient care for people with diabetes. The GIRFT diabetes programme involves visiting all hospitals in England to assess their diabetes services. This has resulted in a considerable levelling up of staffing and the use of technologies in inpatient care.

Inpatient diabetes care is a rapidly evolving speciality. Services in need for improvement, not only require investment in staffing, but also technologies, and should be supported to attain best practice. In England, the GIRFT programme with investment from NHS England, is intended to help these services. Supporting this is another important initiative, the Diabetes Care Accreditation Programme (DCAP; https://www.dcap.org.uk/). The Royal College of Physicians and Diabetes UK launched the DCAP in May 2023. DCAP, the first of its kind in diabetes, aims to improve inpatient care by setting quality standards and measuring how services perform against these. The Programme is open to all hospitals across the UK. With respect to technology, use of electronic records, systems to identify all inpatients with diabetes and web-linked glucose devices will be part of the assessment. Importantly self-management of diabetes treatments and guidance on the use of wearable technologies during the inpatient stay will also form part of the assessment

9. Supporting information

The guidance provided in this document is based on the work of an expert panel supported by input from the wider JBDS-IP and DTN group. The evidence used is summarised in five papers recently published by the group; the references for these papers are given below. The evidence provided by a national survey of technology use in hospital has been essential in developing this document. This survey was distributed widely, and responses were received from 42 organisations across the UK representing 104 hospitals. Some of the key findings are summarised below (percentages reported are the proportion of those who responded to the question):

* Specialist diabetes support with knowledge of diabetes technology was available in all organisations on weekdays in normal working hours at least some of the time, but majority of organisations do not have this specialist support available out of hours on weekdays (64.3%) or at weekends (53.7%)

* Only 16.7% of organisations have a specific policy in place for the inpatient use of CGM, although 91.4% of organisations without a policy will permit CGM use in specific circumstances. The most common scenarios where CGM will be used are labour, delivery and the postpartum period (41%) and in the perioperative period for elective surgery (35.9%)

* The main benefits of CGM use include empowerment of people with diabetes (96.2%), having more information to guide treatment decisions (73.1%), the ability to review data remotely (65.4%) and the prevention of hypoglycaemia (65.4%)

* The main concerns about CGM use in hospital are staff unfamiliarity with devices (100%) and concerns about accuracy (64.7%) as well as clinical governance concerns including worries about indemnity (47.1%)

* In contrast 64.3% of organisations have a specific policy for the use on insulin pumps or hybrid closed loop (HCL) systems in hospital, and the vast majority (93.3%) would permit their use in hospital in specific circumstances

* 80% of organisations reported benefits of using pumps and HCL systems in hospital including empowerment of people with diabetes and improved glycaemia. The main challenges were staff unfamiliarity with devices and the chance that this would bring them into conflict with people with diabetes

* Only 40.5% of organisations have an automated system to flag people with diabetes on admission, and only 28.6% have a system which can flag those at increased risk of harm

* 73.1% of organisations have an electronic system for referral to the diabetes specialist team. The majority (65%) report benefits from these systems, with the main challenges being IT limitations

* 85.7% have networked blood glucose meters but the data are used for audit, quality improvement or clinical care in only 58.3% of these. All organisations have bedside capillary ketones meters, but only 76.3% have these linked in a network

* 92.9% have some form of electronic record, but only 51.3% have a single system which combines information from multiple domains, and only 47.6% have a specific diabetes database

9.1 Insights from the national diabetes technology survey

1. Implement national guidance for the use of technology in hospitals, including specific guidance for the use of CGM in hospital settings

2. Ensure that support is available for people with diabetes to make use of wearable technology in hospital

3. Consider regional or national helplines to support hospitals who do not have specialist support available in person outside normal working hours

4. Optimise information sharing between GP and hospital record systems

5. Use collected information to identify people with diabetes on admission to hospital, including specific flags for those at high risk

6. Optimise use of data from networked glucose and ketone meters

7. Ensure data is used for audit and quality improvement

10. Audit standards

The technology used in this document is primarily there to assist in providing good care in hospital. It is therefore part of a process rather than an outcome. The technology described can greatly assist in measuring quality of care rather than being something that is measured itself. For example, EPMA systems can produce automated monthly reports of prescribing or administration errors relating to insulin use. Electronic health records can produce automated reports that then feed into national audits comparing quality of care (an example being the national audit of diabetic ketoacidosis). There are also some specific audits of safety aspects of technology that should be measured. The list below is illustrative but not exhaustive.

Table 1: Audit standards

	Audit standard
Safe use of wearable technology on admission to hospital: • Percentage of ward staff that can recognize an insulin pump or glucose sensor • Percentage of staff that can access guidelines for the use of wearable technology • Percentage of staff that are aware of what to do if an individual is admitted acutely unwell using wearable diabetes technology. Audit of clinical incidents relating to safe use of wearable technology in hospital	100% 100% 100%
Audit of staff training in the prescribing and administration of insulin: • Percentage of relevant staff that have completed mandatory training. • Percentage of staff that successfully completed a test of safe prescribing	100% 80% 70%
All hospitals should be completing patient satisfaction questionnaires at regular intervals. Ability to use their wearable technology should be part of this audit	N/A
Organisations should have a diabetes database that supports electronic data identification (and submission where appropriate) for national diabetes audits	-

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Appendix 1: Situations to always check CBG

Situations to ALWAYS check fingerstick CBG whilst using a CGM device:
• To confirm hypoglycaemia AND monitor recovery from hypoglycaemia
• If symptoms do not match sensor glucose (e.g., if symptoms of hypoglycaemia are present but the sensor glucose reading is normal)
• If the sensor reading seems unlikely in the circumstances
• If the sensor reading is unreliable or obviously erroneous (e.g. no reading, or no arrow)
• If required for calibration
• During and after exercise (e.g. after extensive physio session)
• When following 'sick day rules' or 'rules for management of unexplained hyperglycaemia'

Appendix 2: Reviewing CGM data

Some people will automatically be sharing glucose data from their CGM sensor with the diabetes team, which enables the diabetes team to remotely monitor the individual's glucose levels. On some devices, it is possible to review glucose data using the "history" function on the device to review glucose levels over the last 7-90 days. This allows the clinician to understand the person's usual glycaemia. However, as these systems require sensors to be linked, this may not always be possible in the acute setting.

Importantly, automated uploading of data is only available for people who have registered for these platforms; and is not available for those who use a reader (who can upload data intermittently by plugging the reader into an appropriate internet connected device).

Examples of platforms to review data include, but are not limited to:

- Dexcom data linked to Dexcom Clarity (https://clarity.dexcom.eu/professional/)
- Freestyle Libre data linked to Libre view (https://www.libreview.com/)
- Medtronic pump or CGM data linked to Carelink (https://carelink.minimed.com/)
- Glooko (https://glooko.com/)

Appendix 3: Requisites for safe perioperative use of subcutaneous insulin pumps (all conditions must be met)

Requisites for safe perioperative use of subcutaneous insulin pumps (all conditions must be met)
• The person with diabetes should be seen preoperatively by a registered health care practitioner who is knowledgeable about the perioperative use of insulin pumps
• Documentation of discussions and decisions made with the person with diabetes
• Multidisciplinary agreement that continued use of insulin pumps is appropriate
• Provision of an information leaflet for people in hospital
• Ability to communicate with medical teams
• Short fasting period (for example no more than one missed meal)
• Elective or expedited surgery
• Optimal preoperative HbA1c <69mmol/mol where safe to achieve
• Ability to site pump away from the site of proposed surgery
• Ability to avoid positioning the insulin pump between the earthing plate and the diathermy
• Use of a Teflon® cannula (and **not a steel cannula**)
• Sufficient Teflon® consumables
• Ability to monitor CBG or via blood gas regularly (i.e. every 60 minutes) and to monitor capillary blood ketones
• Ability to replace subcutaneous insulin pump with variable rate intravenous insulin infusion (VRIII) if necessary

Appendix 4: Contraindications to insulin pump therapy in hospital

Contraindications to insulin pump therapy use in hospital
• Impaired level of consciousness or confusion
• Critical illness requiring intensive care/ high dependency care
• Diabetic ketoacidosis or hyperosmolar hyperglycaemic state
• During MRI
• Psychiatric illness or suicidal ideation
• The individual is unable to use hands and/or physically manipulate pump due to medical condition
• The individual is unwilling to participate in diabetes self-management, or share pump manage-ment decisions with hospital clinical staff
• Lack of pump supplies or mechanical pump malfunction
• Lack of trained healthcare providers or available diabetes specialists to supervise pump therapy
• Medical team decision for health and safety of the individual

Adapted from Umpierrez GE et al, Diabetes Care. 2018;41(8):1579-1589 and Yeh et al. Curr Diab Rep. 2021;21(2):7.

Other situations where there is limited safety data to allow continued use of insulin pumps:

- During major surgery
- As part of hybrid closed loop systems in hospital

Appendix 5: Starting basal insulin from insulin pump therapy

Starting basal insulin from insulin pumps (e.g. people who are unable to self-manage their pump)

Starting basal-bolus insulin regimen

- This is for people with T1D who are unable to self-manage their insulin pump, but do not have unstable blood sugars, are not in a hyperglycaemic emergency and are not nil by mouth (NBM)
- A basal bolus regime is preferable to VRIII
- **Nb:** The insulin in an insulin pump is very short acting and therefore alternative insulin must be started immediately (i.e. within 1 hour) to avoid risk of ketoacidosis.
- Choice of basal insulin for the hospital admission should ideally include Lantus or Levemir. Ultra-long acting insulins (Degludec or Glargine U-300) may be more challenging when switching back to insulin pump therapy given their longer duration of action

Calculate Total Daily Dose (TDD)

Method 1 Pump Total Daily Dose	**Method 2 Person's weight**
(eg. 7 day average) Information can be obtained by individual or diabetes specialist nurse	Weight: kg x 0.5

Basal and Bolus Insulin Dosing

Basal Rate	**Bolus (mealtime) insulin**
(TDD x 0.5)	(TDD x 0.5 / 3)
• Prescribe 50% of the TDD as once daily Lantus (or can be divided in to twice daily Levemir)	• For meal-time insulin (Novorapid/ Humalog/ Fiasp): 50% of TDD/3 plus a safety adjustment (e.g. minus 30%) to minimise risk of hypoglycaemia. • Titrate doses according to response • If the person is able to carbohydrate count, prescribe a variable rapid-acting insulin dose for self-adjustment

Example:

- E.g. A person's average pump insulin TDD for last 7 days is 48 units/day
- 50% of 48 units = 24 units as once daily Lantus insulin (or 12 units as twice daily Levemir insulin)
- 50% of 48 units/3 = 8 units of Novorapid with each meal: after safety adjustment = 6 units

Abbreviations: CSII, continuous subcutaneous insulin infusion; NBM; nil by mouth; TDD, total daily dose; T1D, type 1 diabetes; VRIII, variable rate intravenous insulin infusion.

Adapted from Diabetes Technology Network (DTN) UK Best Practice Guidelines for managing continuous subcutaneous insulin infusion (CSII, or 'insulin pump') therapy hospitalised patients

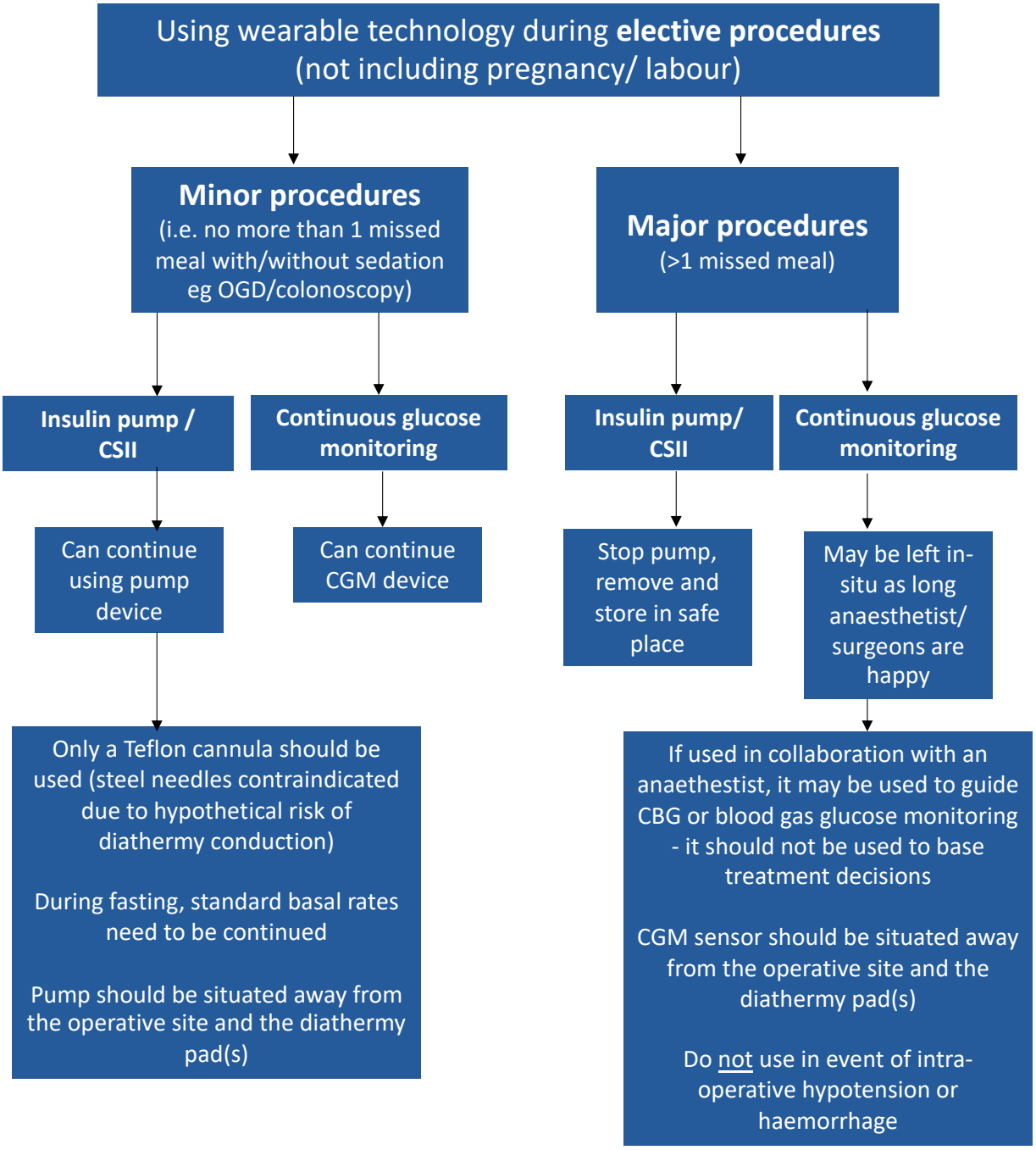
Appendix 6: Restarting insulin pump therapy from basal IV/ SC insulin

Restarting insulin pump therapy from basal IV/ SC insulin		
Insulin pump total daily dose (TDD) calculation		
Method 1 Pre-Pump Total Daily Dose Pre-pump TDD x 0.75	**Method 2 Person's weight** Weight: kg x 0.5	
Clinical considerations on pump TDD: • Average values from methods 1 and 2 • Problematic hypoglycaemia: consider lower estimated TDD • Hyperglycaemic, elevated HbA1c, or pregnant, consider higher estimated TDD		
Pump Dose adjustment		
Basal Rate (Pump TDD x 0.5)/ 24hrs	**Carbohydrate Ratio (I:C) ratio** 400/TDD	**Insulin Sensitivity Factor (ISF)** 130/TDD
• Start with one basal rate, adjust according to glucose values over basal rate testing • Add additional basal according to need (e.g. Dawn phenomenon	• e.g. TDD 35units = 400/35 = 11.4, I:C ratio 1 unit:11g • Most adults require 1 unit:8-15g • Acceptable post prandial rise is ~3mmol/L • Adjust based on low fat meals with known carbohydrate quantity	• Correction insulin dose should bring glucose back to target range in 4-5 hours
Pump restart from basal SC insulin		
• Individual inserts new cannula performs a fixed prime and re-starts insulin pump. • The individual may need to temporarily reduce background insulin infusion rate (e.g. drop to a 70% temporary basal rate for 12-24hrs) while long acting subcutaneous insulin is still active, with increased glucose monitoring required (ideally use CGM). • No further subcutaneous insulin doses should be required once insulin pump restarted. • Capillary blood glucose should be checked 1-2 hours after insulin pump re-started		
Pump restart from IV insulin		
• Individual inserts new cannula performs a fixed prime and re-starts insulin pump (there is no need to wait until a meal) • Wait 60 minutes before discontinuing IV insulin		

Abbreviations: ISF, insulin sensitivity factor; IV, intravenous; SC, subcutaneous; TDD, total daily dose.

Adapted from Evans K. Clin Med (Lond). 2013 Jun;13(3):244-7 and Diabetes Technology Network (DTN) UK Best Practice Guidelines for managing continuous subcutaneous insulin infusion (CSII, or 'insulin pump') therapy hospitalised patients

Appendix 7: Wearable technology during elective procedures



Further guidance and checklists can be found in the Appendix and UK Centre for Perioperative Care
https://www.cpoc.org.uk/guidelines-resources-guidelines-resources/guideline-diabetes