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Using Technology to Improve Diabetes Care in Hospital: The Challenge and the Opportunity

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Abstract

The past 10 years have seen a revolution in technology improving the lives of people with diabetes. This has implications for diabetes care in hospitalized inpatients. These technological developments have the potential to significantly improve the care of people with diabetes in hospital. Combining point of care glucose monitoring, electronic prescribing, electronic observations with electronic referral, and electronic health records allow teams to daily oversee the whole hospital population. To make the most of these tools as well as developing the use of pumps and glucose sensors in hospital, the diabetes team needs to work in new ways. To date, very little work has described how these should be combined. We describe how this technology can be combined to improve diabetes care in hospital.

Keywords
diabetes mellitus, hospital care, technology, electronic health record

Background

In the past 10 years, we have seen a revolution in the use of technology to improve the lives of people with diabetes. Although glucose sensors and insulin pump technology has been commercially available for over 20 years, it has only been more recently that we have seen improvements in reliability, accuracy, and ease of use, that have led to a rapid acceleration in the numbers of people using the equipment.[1] These devices are developed for use outside of hospital. There is a wealth of evidence showing that using an insulin pump and/or glucose sensor with appropriate training can improve glucose control, reduce hypoglycemia, and improve quality of life.[2] However, this evidence almost entirely excludes individuals who are acutely unwell or require hospital-based treatment. In parallel to developments in wearable technology, we have seen dramatic changes in the way clinical information can be shared and analyzed by the person with diabetes and health professionals. This has profound implications for diabetes hospital teams requiring a different way of working to provide optimal care.

As part of the training to use wearable technology, a person with diabetes will be taught how to manage their device in times of illness. This will not, however, cover any time in hospital as the assumption is that the team in hospital will have the required knowledge to appropriately manage diabetes control. It is an uncomfortable truth that this might not actually be the case for a significant proportion of hospital

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staff, whether they are dealing with elective or emergency admissions.[3,4] For those interested in improving the hospital care of people with diabetes the focus of the past few years has been ensuring that staff can safely recognize and manage the glucose sensor or insulin pump if a person with diabetes is admitted to hospital.[5-7] The technology has been seen as a challenge and potential risk that needs to be safely managed rather than an opportunity to improve care. The focus is now shifting to how these technologies can be used in hospital to improve care. We are starting to see specific evidence collected about how to best use these tools and guidance developed that emphasizes the potential benefits of the equipment.[8,9]

At the same time, as we have seen this dramatic change to diabetes care in the community, there has been a quiet but steady change in the importance attached to improving diabetes care in hospital. It is now accepted that hospitals should have a dedicated team whose role is to provide day-to-day care of people with diabetes admitted to hospital and provide training and support for the wider hospital team to improve standards of care.[10,11] In the past, hospitals have operated in isolation. Best practice in one hospital would often not be shared with neighboring hospitals. Even within a hospital, good care on one ward may not be mirrored in the ward next door.[12,13] The information technology revolution makes it much easier to measure standards of care and share best practice.

Tools that have been developed to improve communication within the hospital have potential benefits for the inpatient diabetes team. To best use these new tools, special consideration needs to be given to how the diabetes team in hospital can achieve benefit while minimizing risk. Inpatient diabetes care has, in the past, been reactive with inpatient teams having to wait for ward teams to ask for help. We often recognize that care could have been improved if the specialist team had been involved at an earlier stage. The use of systems that allow real-time information about patient care to be available from any computer within a hospital now mean 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, electronic prescribing and medicines administration, access to the hospital health record, 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. This can be provided remotely allowing more flexibility for the clinical staff. Lastly, it allows an electronic record of 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 summarized 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, and (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 2.[14,15]

Use of these tools can potentially save the diabetes team a great deal of time. There is also the risk of increasing the workload as we become aware of the need for specialist intervention for a much wider group of people with diabetes in hospital. This inevitably requires a larger diabetes team 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 a completely different way of working for the inpatient diabetes specialist team.

As is often the case a crisis will accelerate change. Covid-19 has had many negative impacts on people with diabetes and the staff looking after them. Much has been published about the consequences of the pandemic.[16] One of the positive impacts has been the forced change to increase our use of information technology to communicate remotely.[17,18] National/international meetings that, in the past, may take months to set up can now happen weekly or daily if required.[19] We can now be much more aware of what is happening in our neighbor's hospital and what is happening in the centers that are leading innovation and improvement. The past 20 years have seen a slow steady improvement in diabetes care in hospital.[12,13] This new ability to describe best practice and gather national data to support this should mean that the rate of improvement can now accelerate. The improvements that we are working toward within hospitals need to be matched by the ability to collect hospital data on a wider scale so that the standard improves uniformly across hospitals.

Current State

When discussing the use of technology to improve diabetes care in hospital the focus has often been on the use of wearable technology. This aspect of inpatient diabetes care is dealt with by Avari et al elsewhere in this journal [link reference]. But there are other areas particularly related to information technology that may have similar if not greater impact on diabetes care. Each of these systems is briefly discussed below:

Point of Care Monitoring of Glucose and Ketones

Blood glucose and ketone monitoring within hospital uses similar technology to the personal glucose meters that individuals use at home.[20] The difference has been that to meet laboratory quality assurance standards the meters need to be regularly calibrated.[21] Commercial suppliers have developed systems to allow remote quality assurance. Using

cloud-based technology the systems upload readings centrally as they are performed. A side benefit to this is the ability of the diabetes team to review bedside glucose and ketone measurement in real time. An inpatient diabetes ward round can therefore start by reviewing all values throughout the hospital and identify individuals with readings that are above or below the required range. Individuals that require closer monitoring, for example, those requiring enteral feeding and insulin therapy, can be viewed and a decision made about whether further input is required. This is a very different model to a reactive ward round were only those patients identified by the ward staff are reviewed. These systems are now widespread use and intuitively are significantly improving inpatient glucose control although there are few published data supporting this.[22,23]

Electronic Prescribing and Medicines Administration

These systems are designed to enhance the prescribing ordering and administrations of medicines. They are now in widespread use.[24-26] They have highlighted the issue of prescribing and administering insulin at mealtimes as there is a time prescribed and a time stamp when the insulin is recorded as being given. If used in conjunction with the record of capillary glucose values, this can be used to improve glycemic control.[27,28] The systems can help with decision support as well as coaching/training. A disadvantage is that the record is not visible to the person with diabetes. Specific consideration needs to be given to how the system can be used to enhance self-management of diabetes in hospital. Use with rapidly changing insulin doses can be problematic.[29,30]

Glucose and Ketone Monitoring Within Electronic Observations

Paper charts recording vital observations, such as blood pressure, pulse, and oxygen saturation are a familiar part of the clinical record for every patient in hospital. This is usually combined with a paper record of glucose and ketone values when relevant. These paper records are now being replaced by electronic capture of this information. This has several advantages; the data are available in real time for multiple system users (and do not get lost). Results that are outside of acceptable limits can have flags with advice on appropriate action and links to guidelines. The results can be linked to electronic prescribing with prompts to review, for example, insulin doses. Out of range results can be flagged to the inpatient diabetes team to allow proactive management.[31-35]

Electronic Health Records

An electronic health record (EHR) combines the replacement of the hospital paper notes with an ability to link with several other electronic system. These systems may be developed in house by the hospital team or there are a number of commercial products available. The functions above may be included in the package as well as links to other systems, such as radiology, laboratory results, and patient administration systems. 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 EHR. Most will combine the functions described above with the ability to record diabetes-specific outcomes (eg, details of foot ulceration and a preventative care plan). A challenge of switching to an EHR is that the functionality may not exactly mirror the individual systems that they are replacing. Clinical care can be challenging in the transfer period and careful thought given to ensure that care standards are maintained. Remote point of care glucose monitoring is unlikely to be part of the EHR package and may be challenging to incorporate directly.[36-38]

Wearable Technology in Hospital

There are linked papers dealing with wearable technology in this journal (Avari refs). It is briefly included here in the context of the other systems discussed. 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 2 main types: continuous glucose monitoring (CGM) and insulin pumps (continuous subcutaneous insulin infusion—CSII). CGM can be real-time or intermittently scanned CGM, also known as flash glucose monitoring. These discrete devices measure interstitial glucose levels, and through smart technology, transmit glucose levels to a reader or smartphone app. Its use has been associated with improved glycemia, reduced fear of hypoglycemia and improved quality of life.[39-41]

CSII is used by people with T1D (and also insulin-deficient individuals with type 2 diabetes mellitus) to improve glucose control and/or reduce the risk of hypoglycemia. CSII involves a continuous basal infusion of short-acting insulin (the hourly rate typically varies over a 24-h period), in combination with meal-time boluses of the same insulin. Both basal and bolus insulin are delivered by the insulin pump, which infuses insulin through a catheter attached to a fine bore subcutaneous cannula. Systems that combine CGM with an insulin pump are now commercially available (hybrid closed loop) and are increasingly used in the community.

Unless the individual is incapacitated or has presented with a diabetes emergency, then, it should be possible to continue the use of insulin pump therapy or CGM. Ward staff are unlikely to have expertise in the use of these technologies. This emphasizes the importance of have a 7-day specialist diabetes service to ensure the appropriate use of the

equipment. Guidelines have been developed for the use of this technology in the perioperative period.[42] As in other areas of inpatient diabetes care, there are few data that show that these tools improve glucose control of improve outcomes for people with diabetes in hospital. If they can be used to maintain similar levels of glucose control to when the individual is at home, then, it can be assumed that there has been benefit.

National Monitoring of Quality of Diabetes Care in Hospital

There will always been 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 then 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; this is a paper-based snapshot bedside audit (the National Diabetes Inpatient Audit [NaDIA]),[12,13] which is conducted during a specified week in September on a week day chosen by each diabetes team during which aspects of care, including medication errors, inappropriate use of insulin infusions, harms, such as in-hospital hypoglycemia, hospital-acquired diabetic ketoacidosis, and foot lesions are assessed. This involves the team visiting every inpatient with diabetes to examine their notes, and prescription and observation charts. The data are submitted to National Health Service (NHS) Digital for analysis and presentation in a national report. The first NaDIA report revealed significant deficiencies in care and alarming rates of hypoglycemia 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 their previous years' data. This process, which has been ongoing over the last 10 years, has resulted in significant reductions in medication errors, and inpatient hypoglycemia 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, it 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. A key technology to deliver improvements in inpatient glycemia is the use of web-based glucose meters with alerts directing the user to act on out-of-range results and to provide ready access for the inpatient diabetes team to these out-of-range results. The NaDIA has been an important lever in increasing the use of these devices.

Despite its significant contribution to improving inpatient diabetes, it is recognized that NaDIA is labor-intensive and costly. Going forward, the National Diabetes 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 hypoglycemia from web-linked glucose. The intention is to make these data available to hospitals on a monthly or quarterly dashboard for internal as well as national comparison. This should be a very powerful driver of change.

In England, the Getting It Right First Time (GIRFT) is another important initiative that has a focus on improving inpatient care for people with diabetes.[43] The GIRFT diabetes program involves visiting all hospitals in England to assess their diabetes services. It has resulted in a considerable leveling up of staffing and the use of technologies in inpatient care, such that, today over 90% of services now have access to web-linked glucose meters and every hospital has an inpatient diabetes specialist nurse, whereas in 2010, 30% did not.

Inpatient diabetes care is a rapidly evolving speciality. Services in need for improvement that often involves investment in staffing and also technologies should be supported to attain best practice. In England, the GIRFT program with investment from NHS England is intended to help these services. Supporting this another important initiative is the accreditation of diabetes inpatient services. The Royal College of Physicians, Diabetes U.K. and the Joint British Diabetes Society are currently piloting this in a number of hospitals in England and Wales. 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. This is a U.K. perspective and parallel work has been undertaken in a number of other countries. An example from the United States is the Joint Commission for advanced inpatient diabetes certification.[44] 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.

Current challenges. Although these systems improve communication within the diabetes team and with other health professionals at the moment, they do not improve communication with the person with diabetes. As previously, it may be necessary to modify the systems that are being developed out of hospital to communicate with the person in hospital. Nothing can replace the need to actually visit the person with diabetes on the ward, but this will not be possible if there are potentially 300 people in hospital on any given day. There is a need for an interim step where the person with diabetes can be spoken to either by telephone or video link.

Using the system described above require a change in practice. This requires time to plan and implement the change at a time when diabetes teams are overwhelmed by volumes of work and staff absence. 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.

Being admitted to hospital is often a time when glucose control deteriorates. The stress effect of illness combined with poor appetite make optimal glycemic control difficult. For the individual 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, control 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 electronic prescribing and medicines administration (EPMA) system and EHR. There is also the danger that the individual may not be performing capillary glucose values on the hospital system and therefore not visible to the specialist diabetes team. Until CGM data are available to the diabetes team, a compromise probably requires the individual to continue to use their wearable technology while also performing glucose testing using the hospital system.

Abbreviations

CGM, continuous glucose monitoring; CSII, continuous subcutaneous insulin infusion; EHR, electronic health record; EPMA, electronic prescribing and medicines administration; GIRFT, Getting It Right First Time; NaDIA, National Diabetes Inpatient Audit; NDISA, National Diabetes Safety Audit; NHS, National Health Service; T1DM, type 1 diabetes; T2DM, type 2 diabetes.

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