

# In-Hospital Glucose Monitoring: Adequacy and Resource Management



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## Abstract

Adequate capillary glucose monitoring in the inpatient population is of crucial importance, as poor glucose control is associated to higher morbidity and mortality. In our experience, this practice does not always parallel clinical urgency, nor is it correlated to an immediate intervention leading to a treatment modification. We analyzed all capillary glucose data documented in the Electronic Medical Records of all hospitalized patients (excluding intensive care patients) during the first semester of 2015. Subsequently, a glucose monitoring protocol was devised, based on inpatient clinical characteristics, which we shared with medical and nursing staff with the aim of optimizing resources and standardizing measurement practices in our hospital.

All capillary glucose was analyzed in the first semester of 2016 after adopting the proposed protocol. Less hypoglycemic episode was founded. Sensitizing and educating staff on the topic of glycemia may lead to clinical improvements, potentially reducing the risk of infection, as well as reducing the duration of hospitalization and impacting clinical management positively in a comprehensive manner. An adequate and systematic utilization of capillary glucose data as decisional aid tool, eventually to be integrated with an 'alert' system, may become a valid pillar of support in the planning and improvement of inpatient care available to healthcare professionals.

**Keywords:** Glucose Monitoring, Hospitalization, Resource Management

## Introduction

According to the 2010 ISTAT report diabetes (type 1 and 2) is documented as primary or secondary diagnosis in 6% of the inpatient population [1]. The prevalence of diabetes can however significantly vary across different units. For instance, emergency ward inpatients display a higher prevalence of approximately 22-24% [2,3]. Another study conducted in 2014 in Italy suggests that approximately 23% of diabetic patients are hospitalized at least once a year compared to 11% of unaffected subjects [4]. Among health care expenditures attributable to metabolic disease the hospitalization of diabetic subjects produces the highest costs [5,6]. Hyperglycemias at admission, regardless of previous diagnosis of diabetes, is associated to higher morbidity and mortality across all areas of care [7,8]. Glucose monitoring in these patients or in patients at risk of developing hyperglycemias is therefore crucial. A recent metanalysis involving approx. 15 important studies confirmed that adequate blood glucose control (< 150mg/dl or 8.3mmol/L) featuring the use of specific protocols in the preoperative setting significantly reduced the risk of surgical infections [9] and that a radical intervention aimed at correcting hyperglycaemia in subjects at risk resulted in lower mortality and morbidity [10]. There are numerous studies and validated glucose managing protocols for the management of critical care patients (ranging from the DIGAMI study to

more recent observations in CRIT CARE). However, little is known about the management of diabetic patients in regular wards.

## Aim of Study

There is a lack of capillary glucose monitoring protocols for the management of hospitalized patients containing precise and strict instructions related to pathology (diabetes) and individual therapy in scientific literature. According to SID-AMD 2016 guidelines for patients in stable conditions, who are not receiving oral nutrition measurement intervals of indicatively 4 to 6 hours, are acceptable [11]. In contrast, patients feeding orally require measurements before meals and before sleep, as well as the possibility of adding postprandial and nightly measurements too. Intermittent, occasional measuring practices followed by insulin administration 'as required' in that moment (sliding scale) are to be avoided because considered inadequate and inefficient [12]. In all patients not considered diabetic but who are receiving treatments that entail a hyperglycaemic risk (such as high dosage steroids, enteral or parenteral nutrition, drugs like octreotide or immunosuppressant's) glucose monitoring must be recommended in order to potentially supply corrective insulin injections or to implement a basal-bolus scheme in case of persisting hyperglycaemias.

Nevertheless, in daily clinical practice the completion of capillary glucose measurements depend on the demands of a ward (available resources and type of inpatients), which can be highly variable (medical vs. surgical wards; acute vs. subacute; arrangements with medical staff vs. competence of nursing staff) and does not necessarily match actual clinical needs, nor does it correlate with an immediate intervention leading to a treatment modification. The presence of hypoglycemia's and hyperglycaemias does not always result in immediate therapeutic actions leaving the hospitalized patient exposed to the risks of glycaemic variability before therapy is eventually adjusted. The lack of a universally shared protocol for the adequate metabolic management of patients results in an underestimation of the problem, the above-mentioned repercussions as well as wasteful use of resources. The aim of our study was to hence to conceive a glucose monitoring protocol based on inpatient characteristics, and to share it with all medical, nursing and paramedical hospital staff with the aim of optimizing and homogenizing the collection of these data. We further attempted to evaluate the impact of protocol implementation on the total number of measurements performed and, considering the crucial importance of glycaemia, on the number of total hypoglycemia's and hyperglycaemias.

**Materials and Methods**

Humanitas Research Centre is a highly specialized hospital with 747 beds, of which 651 ordinary beds distributed across 15 wards. From January 2015 all admitted patients are managed via Electronic Medical Records (*wHospitalTM*). Vital parameters, including capillary glucose measurements are reported in a specific section of the records. A standard measuring system (ACCU-CHECK Aviva→ Roche) is used for capillary glucose measurements across all wards, the system itself being validated by a centralized control protocol. We collected all capillary glucose values from patient records between 1<sup>st</sup> January and 30<sup>th</sup> June 2015 in all wards, excluding intensive care and sub-intensive care areas. The frequency of hyperglycaemias and hypoglycaemias was established, using cut off values of >250 mg/dl and <70 mg/dl respectively. We further determined how many of the patients had a recent glycated haemoglobin measurement available.

**Table 1:** Interventional protocol tailored to inpatient characteristics.

In-patients glucose monitoring (except intensive care areas)			
Non diabetic subject treated with steroids	Fasting capillary glucose and post prandial	07:00 AM 03:00 PM	Every other days
Diabetic subject in oral treatment	Fasting capillary glucose post prandial and before evening meal	07:00 AM 03:00 PM 07:00 PM	Every other days
Diabetic subject insulin treated	3 times daily before meals	07:00 AM 07:00 AM 07:00 PM	Every days
frail/high risk subject insulin treated	strict capillary glucose monitoring	07:00 AM 12:00 AM 03:00 PM 07:00 PM 10:00 PM	Every days

An interventional protocol tailored to inpatient characteristics was subsequently proposed, establishing the number of blood glucose measurements to be performed according to the following criteria (Table 1). Non-diabetic subject treated with steroids check fasting capillary glucose once in the morning and 2 hours after lunch on alternate days (7 am and 3 pm). Diabetic subject treated with oral hypoglycemic drugs check fasting capillary glucose once in the morning, 2 hours after lunch and before dinner on alternate days (7 am - 3 pm - 7 pm). Diabetic subject treated with insulin check capillary glycaemia daily, 3 times a day before meals. Diabetic frail/high risk subject treated with insulin perform strict capillary glucose monitoring (7 am- 11 am- 15 pm- 19 pm- 22 pm). Glucose measurement whenever symptoms compatible with insurgence of a hypoglycemic episode present. After gaining approval from the hospital management committee, the protocol was shared with all medical and nursing staff across wards during a series of formative courses. The protocol was subsequently introduced throughout our hospital, taking effect in all wards starting from admission and being managed directly by the nursing staff.

Six months after the implementation of the protocol capillary glucose data were once again analyzed, using glucose measurements collected during this period, with particular attention for values of hypoglycemia's and hyperglycaemias and evaluation of satisfaction in the staff responsible for protocol implementation. A two-sample t test with stable variance was used to compare the mean number of hypoglycemic and hyperglycemic episodes, as well as to inspect the proportion of patients with hypo/hyperglycaemias amongst the patients with at least one available glucose measurement; a two-sample test for proportions was used. Both tests were carried out using the STATA software.

**Discussion of Results**

In the period analyzed before the introduction of our protocol (first semester of 2015) 3440 subjects underwent at least 1 capillary glucose measurement, of which 46% had more than 4 daily measurements taken (retrospective evaluation). Among the subjects who underwent monitoring, 1649 hypoglycemic episodes (<70 mg/dl) were detected in a total of 706 subjects and 9666 hypoglycemic episodes (>250 mg/dl) in a total of 1424 patients (Table 2). The protocol was implemented from 1st January 2016. During the first semester of that year 3713 subjects were monitored, however the percentage of subjects undergoing more than 4 daily measurements dropped to 38%. The frequency of hypoglycemic episodes was of 974 in 438 subjects, while 7266 hyperglycaemias were observed in 1020 subjects (Table 3).

**Table 2:** Altered glucose values in first semester 2015.

Number of subjects undergoing monitoring	3440
Number of subjects with value <70 mg/dl <70 mg/dl	1649
Number of subjects with value <70 mg/dl	706
Number of subjects with value >250 mg/dl	9666
Number of subjects with value >250 mg/dl	1424

**Table 3:** Altered glucose values in first semester 2016.

Number of subjects undergoing monitoring	3713
Number of value <70 mg/dl	974
Number of subjects with value <70 mg/dl	438
Number of subjects with value >250 mg/dl	7266
Number of subjects with value >250 mg/dl	1020

The reduction in percentage of patients with glucose measurements >250 mg/dl or <70 mg/dl out of those with an available capillary glucose measurement was found to be statistically significant ( $p < 0.0001$ ). The mean number of hypoglycemic episodes per patient was slightly reduced (2.22 vs. 2.34), but statistically insignificant ( $p = 0.2244$ ). On the contrary, the mean number of hyperglycaemic episodes rose (7.1 vs. 6.8) in a statistically significant fashion ( $p = 0.0019$ ). Nursing staff were interviewed to evaluate the level of satisfaction related to the implementation of the protocol (mainly dissatisfied, indifferent, very satisfied) and 84% declared to be very satisfied (data not shown).

### Conclusion and Potential Areas of Improvement

Adequate metabolic management of hospitalized diabetic patients constitutes a critical aspect of care and must be kept in consideration as such [13,14]. Several clinical parameters are used as predictive outcomes in hospitalized patients, but glycaemia cannot be currently considered one of them [15,16]. In our hospital capillary glucose monitoring in different wards was previously not governed by a universal protocol and, except for intensive care areas, measurements were frequently not followed by therapeutic attempts aimed at avoiding or reversing potentially dangerous glucose value excursions in the hospitalized subject (glycaemic variability). In absence of precise guidelines concerning capillary glucose monitoring in the hospital setting also the inadequate utilization of hospital resources, in terms of both materials and workforce, cannot be corrected. Following the introduction of a capillary glucose monitoring protocol, hence also a metabolic control tool, a slight incrementation in glycaemic measurement practices has been observed, as well as a statistically non-significant reduction in hypoglycaemic episodes.

Conversely, a statistically significant incrementation in hyperglycaemias was encountered due to the lack of specialist interventions (such as consultations and/or protocols for the adaptation of therapy) to tackle these elevated blood glucose levels, most likely in previously unknown cases (iatrogenic diabetes?). The creation of a shared protocol, accompanied by the correct training of staff, can result in the optimization of resources without negatively impacting the clinical outcome of a patient. We believe that sensitizing and educating staff on the topic of glycemia may lead to clinical improvements, potentially reducing the risk of infection, as well as reducing the duration of hospitalization and impacting clinical management positively in a comprehensive manner. The intro-

duction of a 'warning' signal triggered by severe hypoglycaemias or hyperglycaemias inside patient electronic medical records, for the responsible consultant to access, is currently underway. The Diabetology team will also receive these notifications to achieve a faster and more adequate clinical response to metabolic alterations in hospitalized subjects.

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