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Glycaemic control of hospitalised diabetic patients at the University Hospital Basel in 2002 and in 2005

Robert Thomann, Christoph Lenherr, Ulrich Keller

Division of Endocrinology, Diabetes & Clinical Nutrition, University Hospital Basel, Switzerland

Summary

Introduction: Hyperglycaemia has been shown to be detrimental in severely ill patients. Prospective randomized controlled trials in ICU patients demonstrated the benefit of near-normoglycaemia in reducing morbidity and mortality. Recommendations of professional societies (e.g., the American Diabetes Association) on glycaemic control in hospitalised patients have recently been published. It was therefore of interest to assess whether glycaemic control of diabetic subjects in our hospital adhered to these guidelines. No recent data are available on the glycaemic control of hospitalised diabetic patients in Switzerland.

Methods: Medical records of 580 hospitalised patients with type 1 and type 2 diabetes (290 from 2002, 290 from 2005) were extracted from the internal data base of the University Hospital Basel. The selection was based on the charts of successive admissions each month of the year. From these 290 records, 100 records were from the medical and surgical wards, respectively, and 30 from the medical ICU (MICU), 30 from the surgical ICU (SICU) and 30 from the coronary care unit (CCU), respectively. Thereby, the quality of glycaemic control was assessed within and between the wards.

Results: HbA1c of all diabetic patients with available measurements was 7.6 ± 1.8% (mean ± SD). HbA1c in medical wards was higher in 2005 than in 2002 (8.5 ± 1.9% vs 7.5 ± 2.8%; p = 0.014), and higher compared to surgical wards (8.5 ± 1.9 % vs 6.7 ± 1.1%; p <0.0001).

On admission 60% of the plasma glucose concentrations (PGC) in medical and surgical wards were above the recommended limit of 8 mmol/l (10.8 ± 7.5 mmol/l); in 63% of the measurements in the MICU, SICU and CCU the values were above 6.8 mmol/l. In 2005, PGC in medical wards on admission was higher than in surgical wards (13.5 ± 9.9 vs 9.4 ± 9.9 mmol/l, p <0.0001); in the MICU PGC was lower than in the SICU (9.7 ± 1.5 vs 19.5 ± 13.9 mmol/l; p <0.0001) and in the CCU (9.7 ± 1.5 vs 14.1 ± 12.1 mmol/l; p = 0.038).

PGC decreased on day 4 compared to admission in the medical wards in 2005 (p = 0.024). In the other wards PGC in 2005 failed to decrease during hospitalisation.

Conclusion: Most diabetic patients admitted to the hospital remained distinctly hyperglycaemic during hospitalisation. This was the case even in intensive care units, where equipment and staff for improved glycaemic control were available and where strict glycaemic control has recently been demonstrated to result in decreased complications, mortality and length of stay.

Key words: glycaemic control; plasma glucose concentration; HbA1c; ICU; wards

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Introduction

Diabetes mellitus is a chronic disease with increasing prevalence worldwide and with a large negative impact on the patients and the health care system. The prevalence in the German general population has been estimated to be 6.9%, and in the population of elderly subjects above 65 years 20 to 25% [1, 2]. Between 14.2 to 18.5% of the health care costs are used for diabetic patients [1, 3, 4].

Fifteen percent of hospitalised medical patients are diabetics according to previous reports [5, 6], however, few data exist on the quality of the glycaemic control in this setting. A comparison of data between England and the US showed similar HbA1c values in both countries (HbA1c 7.6% in England and HbA1c 7.1% in the US, respectively [7]). The available data show a similar picture for Switzerland [8].

Recent studies demonstrated that hyperglycaemia on admission and during hospitalisation was associated with increased morbidity and mortality [9–11]. The data were particularly convincing in patients with myocardial infarction and with critical illness in both diabetic and non-diabetic subjects, especially in those without insulin treatment before hospitalisation and with a low baseline risk [5, 6, 12–14]. In addition, treatment of hyperglycaemia with insulin to achieve near-normoglycaemia lowered mortality in patients with acute coronary syndrome by about 30% [9, 12, 15]. Newest published data has raised concern about the benefit of near-normoglycaemia in intensive care patients, and it was concluded that it might be safer to use target plasma glucose concentrations (PGC) below 10 mmol/l in critically ill patients [16, 17]. PGC on admission was among the best predictors for outcome in diabetic patients with acute coronary heart disease, besides age, heart failure and diabetes duration [11, 15, 18]. Similarly, patients with stroke demonstrated a worse clinical outcome when hyperglycaemia was present on admission and persisted (>8 mmol/l) [19–23].

These observations lead to recommendations e.g., by the American Diabetes Association for the treatment of all hyperglycaemic patients during acute illnesses requiring hospitalisation [24].

Despite these publications there are no recent data available on the quality of glycaemic control of diabetic patients in Switzerland nor has it been assessed whether these reports have changed the management of hyperglycaemic patients in Swiss hospitals in recent years.

Therefore we evaluated the prevalence of diabetes mellitus and their glycaemic control in hospitalised patients at the University Hospital Basel in medical and surgical wards. We assessed HbA1c measurements in diabetic subjects and evaluated PGC measurements during hospitalisation from 2002 to 2005. Our hypothesis was that plasma glucose control changed during this period and more patients would be under insulin treatment in 2005.

Methods

Selection of the patients

Using the ICD-Codes for diabetes and the hospital internal data base there were a total of 4948 hospitalised diabetic patients in the two selected years; 290 patients were selected for 2002 and 290 for 2005 in the order of admission date and time. For each year there were 120 charts from the general internal medicine and 120 charts from the surgical wards (general surgery, visceral surgery, neurosurgery and heart/chest surgery), respectively. The first ten charts of successive patients admitted each month that fitted the inclusion criteria were selected, leaving 100 out of a total of 120 charts from each ward per year with complete data for analysis. For the intensive care units (medical ICU [MICU], surgical ICU [SICU] and coronary care unit [CCU]) a similar procedure (successive admission date and time each month) was used to select 30 patients of each unit for each year. The date of hospitalisation was evenly distributed over the whole year. The sample size for each group was proportional to the whole diabetic population within the ward but arbitrarily fixed to the upper limit of 100 and 30 respectively.

Included were only patients with type 1 or 2 diabetes mellitus with complete medical history. All other causes of diabetes or missing PGC on admission, missing medical information and PGC in intensive care unit patients below 8 mmol/l on admission were causes for exclusion.

Study design and parameters

Since HbA1c values were not always available we divided the diabetic patients into two groups depending upon whether HbA1c was recorded. For patients with measured HbA1c additional variables were analysed (see below). As there was no statistically significant difference between baseline characteristics of the two groups we formed no further subgroups during analysis. Data from 12 type 1 diabetic subjects were not further analysed because of the small number of patients.

For all diabetic patients gender, type of diabetes, age, body weight, BMI, duration of hospitalisation, PGC on admission, discharge from MICU, SICU or CCU, and therapy on admission and discharge were recorded. For patients with measured HbA1c additional data were collected, such as: PGC during the course of hospitalisation, CRP and white blood count on admission.

Duration of hospitalisation was defined as the time between admission and discharge from the ward or transfer to another clinic. Exceptions were patients who were transferred temporarily to the MICU/SICU or CCU; in these cases the time on the ICU was included. In the intensive care units only the days in the units were included.

HbA1c at the University Hospital Basel was measured using HPLC (high pressure liquid chromatography) and standardised according to NGSP. Measurements within the last four weeks before admission, on admission or during the hospitalisation were defined as current and used in the analysis. PGC was measured primarily at the bedside by nurses. PGC every third day was used for analysis. In case of missing values on the reference days only measurements within 24 hours before or after the reference days were analysed. In all cases the mean of all pre-prandial measurements per day was taken. All PGC values were measured on the wards bedside by nurses using Ascensia contour glucometer (Bayer®).

In diabetic patients in the ICU additional PGCs were analysed.

Antidiabetic therapy was divided into six groups: Diet, oral antidiabetics (OAD), long, middle and short acting insulin, a combination of OAD and insulin, and a combination of different long acting insulins, or insulin perfusor.

Statistical analyses

Statistica for Windows, version 6 (StatSoft Inc., Tulsa OK, USA) was used. Normally distributed variables were analysed with two-sided t-tests, and variables with a skewed distribution were ln-transformed for all analyses. Nominal data were analysed by Chi-Square test, non-parametric correlations with Spearman rank correlations, and for multi-group comparisons ANOVA with the Bonferroni correction was used. Results are presented as means ± SD.

Results

Prevalence of diabetes mellitus

Of 25,845 hospitalised patients in 2002, 2246 (8.7%) were diagnosed in the charts as having diabetes mellitus. In 2005 the prevalence increased to 10.2% (2702 of 26,401 hospitalised patients). This relative increase of 18% was statistically significant (p = 0.0007) and not associated with a difference of the mean age on admission (70.2 yrs in 2002 vs 70.0 in 2005).

Characteristics of the patients (tables 1 and 2)

Age, body weight and BMI were not significantly different between diabetic patients with and without HbA1c measurement. Therefore we pooled these two groups for further analyses.

There were more men than women.

Length of stay, HbA1c and plasma glucose concentration (table 3)

The length of hospitalisation was longer in 2005 than in 2002 in the medical wards (14.1 ± 9.5 vs 10.2 ± 7.0 days, p = 0.0006) and in the CCU (3.8 ± 2.5 vs 2.7 ± 1.3 days; p = 0.015). HbA1c on admission in the medical wards was lower in 2002 than in 2005 (7.5 ± 1.9% vs 8.5 ± 2.8% (p = 0.014).

The mean HbA1c in our study was 7.6% and thus in a majority of patients above the target level of <7% but concordant with recently published data from USA and England as well as from Switzerland [7, 18]. 56% of diabetic patients had a HbA1c above 7%, and 30% above 8%. In 72.4% of diabetic patients admitted to the MICU, SICU and CCU the HbA1c was above 6.5%. Diabetic patients on medical vs surgical wards and those on SICU vs surgical ward, and SICU vs MICU had significantly different HbA1c values (P = 0.0001, p = 0.0005, p = 0.026, respectively).

PGC on admission was not significantly different between 2002 and 2005 for all wards. It was higher on admission on medical than on surgical wards (2005: 13.5 ± 9.9 mmol/l vs 9.4 ± 9.9 mmol/l; p <0.0001). The same was true for surgical wards compared to SICU (p <0.0001 for both years) and for the MICU compared to SCIU (9.7 ± 1.5 vs 19.5 ± 13.9 mmol/l; p <0.0001) and compared to CCU (9.7 ± 1.5 vs 14.1 ± 12.1 mmol/l; p = 0.038).

On the MICU and CCU 65% and 75% of diabetic patients had PGC above 8 mmol/l on admission (n.s.), respectively. For the SICU the

Table 1

Characteristics of hospitalised patients with diabetes in 2002 and in 2005.

		2002				2005			
		All diabetics		Patients with HbA1c values available		All diabetics		Patients with HbA1c values available	
		n	mean ± SD	n	mean ± SD	n	mean ± SD	n	mean ± SD
Medical	Age (years)	100	73.6 ± 10.9	58	72.6 ± 10.0	100	71.7 ± 10.5	76	72.4 ± 9.8
wards	Body weight (kg)	76	78.7 ± 18.6	52	78.1 ± 16.8	91	79.7 ± 15.8	73	79.6 ± 15.9
	BMI (kg/m^2)	57	28.6 ± 7.7	38	27.9 ± 6.3	76	28.1 ± 5.3	58	28.2 ± 5.5
Surgical	Age (years)	100	69.0 ± 12.5	30	68 ± 14.1	100	69.8 ± 10.9	40	69.9 ± 11.3
wards	Body weight (kg)	96	80.4 ± 20.0	29	79.5 ± 18.0	100	84.3 ± 22.0	40	85.6 ± 19.0
	BMI (kg/m^2)	83	28.8 ± 6.7	26	27.8 ± 6.8	87	29.8 ± 8.0	39	29.0 ± 6.4
MICU	Age (years)	30	71.7 ± 11.5	18	72.3 ± 12.4	30	66.9 ± 14.0	18	65.4 ± 14.1
	Body weight (kg)	30	81.2 ± 12.9	18	82.3 ± 11.8	30	80.6 ± 20.0	18	84.8 ± 23.6
	BMI (kg/m^2)	29	27.9 ± 4.5	18	29.5 ± 4.2	27	28.4 ± 6.7	17	29.8 ± 7.8
SICU	Age (years)	30	66.2 ± 9.5	13	66.4 ± 7.9	30	70.1 ± 9.5	18	69.3 ± 7.6
	Body weight (kg)	25	80.2 ± 22.1	12	83.1 ± 25.1	25	78.8 ± 15.3	16	83.1 ± 14.4
	BMI (kg/m^2)	19	28.8 ± 7.5	11	28.8 ± 8.6	18	26.2 ± 3.1	11	26.1 ± 3.4
CCU	Age (years)	30	70.4 ± 9.3	20	69.7 ± 9.3	30	70.5 ± 10.5	18	71.8 ± 11.4
	Body weight (kg)	27	76.6 ± 15.8	19	77.0 ± 15.1	28	82.9 ± 16.2	17	83.7 ± 16.9
	BMI (kg/m^2)	23	29.1 ± 5.2	17	29.6 ± 5.1	26	29.4 ± 5.1	15	29.3 ± 5.7

MICU, SICU and CCU means: medical intensive care unit, surgical intensive care unit and coronary care unit
Mean ± SD (Standard Deviation)
N: number of diabetic patients; +: Comparison of all patients to patients with available HbA1c measurements within the same year
: Comparison of all patients in 2002 vs in 2005; +/: p <0.05; ++/**: p <0.01; +++/***: p <0.001

Table 2

Admission diagnoses of all patients (2002 and 2005) in % of total (one patient may have several diagnoses).

	Medical wards	Surgical wards	MICU	SICU	CCU
CV-Disease	48	41	92	28	79
Metabolic disease	14	0	3	16	8
Pulmonary disease	10	0	0	22	5
Neurological disease	9	5	0	7	0
Infections	6	5	0	7	0
Cancer	5	19	5	0	0
Accidents	0	6	0	0	0
Gastrointestinal disease	0	17	0	11	5
Haematological disease	0	0	0	7	0
Others	8	7	0	2	3

Table 3

Comparison of length of hospitalisation, HbA1c and plasma glucose on admission and during hospitalisation, between 2002 and 2005.

		2002		2005	
		n	mean ± SD	n	mean ± SD
Medical wards	Length of stay (d)	100	10.2 ± 7.0	100	14.1 ± 9.5 ***
	HbA1c (%)	58	7.5 ± 1.9	76	8.5 ± 2.8 *
	PGC on admission (mmol/l)	100	11.3 ± 6.3	100	13.5 ± 9.9‡
	PGC on day 4 (mmol/l)	29	9.0 ± 3.2 ++	34	9.9 ± 3.6 +
	PGC on day 8 (mmol/l)	40	8.6 ± 3.6	63	8.6 ± 2.5
	PGC on day 15 (mmol/l)	17	8.5 ± 3.7	33	6.6 ± 1.3
Surgical wards	Length of stay (d)	100	15.1 ± 9.0	100	13.6 ± 9.2
	HbA1c (%)	30	7.2 ± 1.5	40	6.7 ± 1.1
	PGC on admission (mmol/l)	100	9.1 ± 3.7	100	9.4 ± 9.9#
	PGC on day 4 (mmol/l)	13	7.8 ± 2.5	25	9.2 ± 2.6
	PGC on day 8 (mmol/l)	23	8.3 ± 2.4	34	8.0 ± 1.9
	PGC on day 15 (mmol/l)	8	8.4 ± 2.8	13	8.6 ± 2.7
MICU	Length of stay (d)	30	4.3 ± 4.1	30	3.1 ± 1.3
	HbA1c (%)	18	7.2 ± 1.2	18	6.9 ± 1.2
	PGC on admission (mmol/l)	30	10.7 ± 2.9	30	9.7 ± 1.5†
	PGC on day 4 (mmol/l)	10	7.7 ± 1.8 ++	5	8.5 ± 1.1
	PGC at discharge (mmol/l)	30	8.9 ± 3.4	30	9.8 ± 3.6
SICU	Length of stay (d)	30	3.2 ± 2.3	30	3.5 ± 2.0
	HbA1c (%)	13	8.3 ± 2.0	18	8.4 ± 2.4
	PGC on admission (mmol/l)	30	16.8 ± 8.9	30	19.5 ± 13.9
	PGC on day 4 (mmol/l)	4	9.8 ± 2.4	4	13.0 ± 4.5
	PGC at discharge (mmol/l)	30	8.8 ± 2.1	30	10.3 ± 2.8 *
CCU	Length of stay (d)	30	2.7 ± 1.3	30	3.8 ± 2.5 *
	HbA1c (%)	20	7.5 ± 1.3	18	8.3 ± 3.2
	PGC on admission (mmol/l)	30	14.2 ± 4.7	30	14.1 ± 12.1∞
	PGC on day 4 (mmol/l)	5	8.0 ± 1.2 ++	8	9.0 ± 1.8
	PGC at discharge (mmol/l)	30	8.8 ± 3.3	30	8.5 ± 2.4

Abbreviations see table 1; PGC: plasma glucose concentration;
*: Comparison 2002 vs 2005 within the wards; +: Comparison of PGC on admission vs during course vs discharge;
#: Comparison of PCG on admission in the surgical wards vs SICU; †: Comparison of PCG on admission in the MICU vs CCU;
‡: Comparison of PCG on admission in the medical vs surgical wards; ∞: Comparison of PCG on admission in the MICU vs SICU;
*/+: p <0.05, **/++: p <0.01, ***/+++: p <0.001, #/†: p <0.001; ‡/∞: p <0.0001

respective prevalence was 56% (n.s.). In 63% of the measurements in all three ICUs the values were above 6.8 mmol/l.

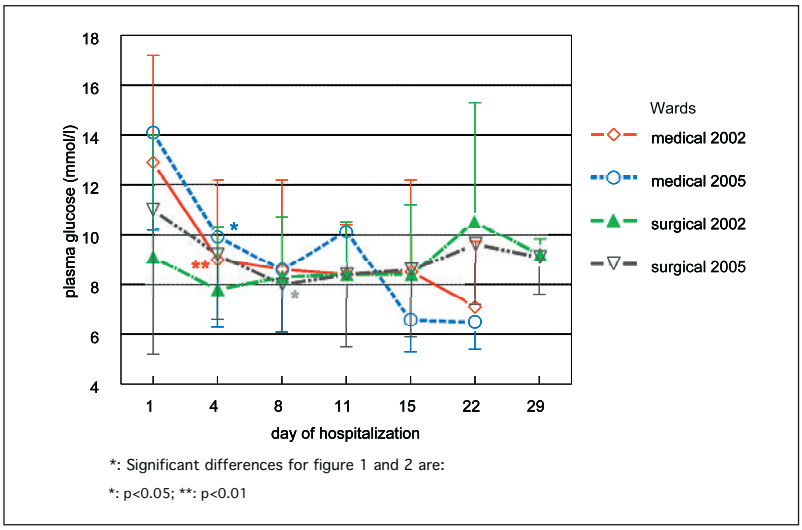

Figure 1

Plasma glucose concentration in patients of medical and surgical wards during hospitalisation in 2002 and in 2005. Abbreviations see table 1.

Plasma glucose concentrations during the stay and on discharge showed a decrease of PGC during the first four days of hospitalisation in 2002 and in 2005 (p = 0.006, resp. p = 0.024; fig. 1). In both years PGC in the MICU and SICU remained unchanged until discharge (fig. 2). PGC at discharge from the SICU was higher in 2005 than in 2002 (10.3 ± 2.8 mmol/l vs 8.8 ± 2.1 mmol/l, p = 0.021).

There were few episodes of mild hypoglycaemia (none on the MICU, SICU and CCU in both years, three episodes on the medical and surgical wards in 2002, two on medical wards and one on the surgical wards in 2005) and no incidence of severe hypoglycaemia (PG <2.2 mmol/l).

Antidiabetic therapy on admission

Fewer patients were treated with diet only on medical wards in 2005 compared to 2002 (15 vs 31; p = 0.012), more patients were under insulin combination therapies (20 vs 5 under single insulins; p = 0.003). On surgical wards in 2005 more patients were under oral antidiabetic medication alone than in 2002 (67 vs 50; p = 0.022). In

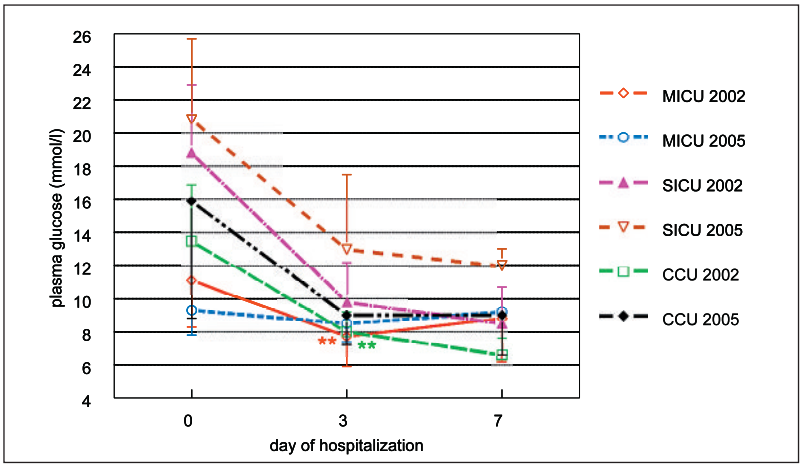

Figure 2

Plasma glucose in medical and surgical ICU patients and in the CCU during hospitalisation in 2002 and in 2005.

contrast, there were less patients admitted to the SICU under oral medication alone in 2005 compared to 2002 (8 vs 43; p = 0.009).

Fewer patients admitted to medical compared to surgical wards were on oral antidiabetics only (79 vs 117; p <0.0001), and more patients admitted to medical compared to surgical wards were on insulin combination therapy (25 vs 8; p = 0.004).

Antidiabetic therapy at discharge

Comparison between the two years of assessment showed that in 2002 less patients were treated with diet alone than in 2005 (3% vs 31%; p <0.0001) or oral antidiabetic agents on medical wards (28% vs 46%; p = 0.013), while in 2005 more patients were under insulin with or without oral agents (p = 0.008 and p <0.0001).

In surgical wards in 2005 less patients were under diet only compared to 2005 (10% vs 23%; p = 0.022) but more under oral antidiabetic agents than in 2002 (67% vs 45%; p = 0.028). There were no significant differences in insulin or combination therapies.

Antidiabetic therapy at discharge compared to admission

In 2005 more diabetic patients in the medical wards were treated with insulin at discharge compared to admission (69% vs 52%; p = 0.021), in the MICU (20 vs 10; p = 0.020) und in the CCU (21 vs 11; p = 0.020), and medical ward patients were more frequently changed to insulin during hospitalisation than surgical patients (17% in medical vs 3% in surgical wards; p = 0.002).

Discussion

The present study is the first to examine the quality of glycaemic control of diabetic patients in a large Swiss hospital. The data demonstrate that a major proportion of the patients had undesirably high plasma glucose levels on admission and during the course of hospitalisation, and the quality of glycaemic control did not improve between 2002 and 2005 despite published reports indicating that hyperglycaemia in diabetes prolongs hospitalisation and increases costs.

The reason for the relatively low prevalence of diabetes mellitus of 8.7% in our study compared to 16% found by Johnson et al. [25] remains unclear. It can not be ruled out that this figure was influenced by patient selection in a University hospital. In agreement with data from Germany and the USA we found an increase in the prevalence of diabetes mellitus between 2002 and 2005 of more than 5% per year [2, 26].

Diabetic patients in the surgical wards were hospitalised remarkably longer than in medical wards and in a British hospital [27]. Compared to medical wards their stay was 1.9 days longer and compared to the British hospital [27] their hospitalisation was 6.2 days longer.

In agreement with Hirsch et al. the length of hospitalisation in diabetic patients in our study was longer than that in non diabetic patients [28]. In 2002 (2005) diabetic patients in medical wards stayed 0.7 (4.8) days and in surgical wards 5.6 (4.1) days longer than non diabetic patients. One possible reason for the longer stay in hospital was the fact that more patients in medical wards were on insulin at discharge, requiring more time for instruction and for PGC stabilisation.

Although HbA1c measurements are standard for medical care in diabetic patients HbA1c values were available in only 60% of all patients in 2005; in surgical wards this number was significantly lower.

With a mean PGC of 10.8 mmol/l, 60% of all diabetic patients in medical or surgical wards were above the desired maximal PGC of 8 mmol/l. In the MICU, SICU and CCU 63% of the patients were above this maximal value. This finding was consistent with published data [29]. Glycaemic control did not improve between 2002 and 2005.

In the MICU mean PGC on admission was significantly lower compared to the SICU (8 mmol/l higher) or CCU (4 mmol/l higher). In contrast, PGC on admission was 3.2 mmol/l higher in medical compared to surgical ward patients. The latter may be an expression of the severity of illnesses or the higher age of patients in medical wards.

Plasma glucose concentration during hospitalisation remained virtually unchanged, both in 2002 and in 2005. Near-normoglycaemic glucose concentrations were seldom reached. In the medical and surgical wards 63% of the patients had PGC values above 8 mmol/l on day four (mean PGC: 9.5 mmol/l). In the intensive care units a startlingly 98% of all diabetic patients were above 6.8 mmol/l (mean PGC: 8.7 mmol/l). A possible explanation for

this phenomenon may be lack of awareness of the problem by the treating physician on regular wards, the fear of hypoglycaemia with higher doses of insulin and lack of standardisation of s.c. insulin algorithms on medical and surgical wards.

Despite evidence from several large randomized trials demonstrating the benefit of near-normoglycaemic PGC in surgical and medical ICU patients using insulin perfusors [30], few patients in the intensive care units were treated with insulin perfusors; in the SICU not a single diabetic patient received an intravenous insulin infusion during his stay.

The recently published NICE-SUGAR study reporting adverse effects of aggressive normoglycaemic therapy in ICU patients yielded contrasting findings to the landmark study conducted by van den Berghe et al. Differences between the studies were for example: nutrition, plasma glucose range/aim for the conventional group and also different PGC levels achieved (smaller differences in the NICE-SUGAR study between the intensive and conventional group). In the meta-analysis by Wiener et al. including 15 out of 34 studies with more than 30% diabetic patients reported that the benefit of normoglycaemia was less than that in non-diabetics. These study results are difficult to translate into daily practice [5, 6, 16, 17], and it may be that the benefit is smaller than previously thought. Nevertheless, hyperglycaemia over 10 mmol/l should be avoided [24].

Our study has several limitations that could influence the results. Firstly, the retrospective design and the small number of patients included could lead to a selection bias. The lack of PGC during hospitalisation in patients without HbA1c on admission could lead to an overestimation of the quality of glycaemic control.

To summarise, the present report observed that the majority of diabetic patients were hospitalised with elevated PGC and HbA1c values without distinct improvement during hospitalisation. Especially high PGC values were observed in MICU, SICU and CCU patients in whom there is evidence available that near-normoglycaemia decreases morbidity and mortality.

Correspondence:
Prof. Ulrich Keller
FMH Endokrinologie-Diabetologie
Missionsstrasse 24, CH-4055 Basel
ulrich.keller@unibas.ch

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