Prevalence of Hyper- and Hypoglycemia Among Inpatients With Diabetes

A national survey of 44 U.S. hospitals

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The recent demonstration (1–3) of the benefits of intensive glycemic control in hospitalized patients has renewed interest in inpatient management of diabetes. Poor glycemic control is a marker for poor quality of hospital care (4), as well as an important safety issue: insulin is one of five medications most associated with inpatient medication errors (5,6). Moreover, many hospitals continue to solely rely on insulin "sliding scales" despite the limitations of this approach (7,8). To gain a broader understanding of the current quality of inpatient diabetes management, we analyzed the prevalence and management of hyper- and hypoglycemia among 999 patients with known diabetes treated in 44 hospitals across the U.S.

RESEARCH DESIGN AND METHODS — Data were derived from two sources: the University Health System Consortium (UHC) Diabetes Benchmarking Project and VHA, Inc. The UHC project collected inpatient and outpatient data in 2003 by standardized chart review of 274 patients aged ≥18 years with type 1 and type 2 diabetes (diagnosed by their outpatient physicians), who were admitted as inpatients to 1 of 29 academic medical centers located in 20 states. Chart reviewers identified the highest and lowest glucose values during hospital admissions and recorded the highest and lowest glucose results for the 2 days preceding and following the peak and nadir.

In 2003–2004, 15 member hospitals of VHA, Inc, an alliance that serves ~1,400 not-for-profit U.S. hospitals, performed baseline chart reviews on 725 general medical and surgical patients aged >18 years with a primary or secondary discharge diagnosis of diabetes (type not specified). Data on the admission diagnosis-related group, glucose tests (n = 18,097), and NPO status were recorded; 6 of the 15 hospitals also collected complete data on diabetes treatment (n = 296).

For both cohorts, we determined the prevalence of extreme glucose values (>200 or 250 mg/dl or <60, 50, or 40 mg/dl) and of persistent hyper- and hypoglycemia, defined as hyperglycemia >200 mg/dl or hypoglycemia <60 mg/dl for 3 consecutive days. We grouped insulin regimens into three categories: sliding-scale insulin alone, sliding scale with basal insulin, and basal alone. Basal insulin was defined as any long- or intermediate-acting or intravenous insulin. Because <5% of patients were on basal insulin without sliding-scale insulin, the latter two categories were combined into a single "treatment with any basal insulin" group. The prevalence of hyper- and hypoglycemia was compared between the two treatment groups using χ^2 tests. We also stratified analyses by severity of disease using the available indicators within each cohort, defined as *1)* diagnosis of type 1 diabetes, type 2 diabetes on outpatient insulin with or without oral hypoglycemic agents, or type 2 diabetes not on outpatient insulin (i.e., treated with oral hypoglycemic or diet and exercise) in the UHC cohort and 2) primary admission diagnosis code of diabetes in the VHA, Inc. cohort.

RESULTS — Prevalence of hyper- and hypoglycemia and treatment patterns are shown in Table 1. Hyperglycemia was common, with the majority of patients experiencing at least one value >250 mg/dl. Extreme values were more common in patients with type 1 diabetes and patients with type 2 diabetes who were on insulin as outpatients in the UHC cohort, as well as among patients who were primarily admitted for diabetes in the VHA, Inc. cohort. Persistent hyperglycemia was present in 38% percent of the UHC cohort and 18% of the VHA, Inc. cohort. While hospitalized, 16% percent of patients with type 1 diabetes and 35% of patients with type 2 diabetes on insulin as outpatients were treated with sliding-scale insulin alone; 41% of patients in both cohorts with hyperglycemia >200 mg/dl for 3 consecutive days were treated with sliding-scale insulin alone.

Hypoglycemia to <60 mg/dl was also common, with 12% of patients in the UHC cohort and 18% in the VHA, Inc. cohort experiencing at least one episode of glucose <60 mg/dl. Severe hypoglycemia (<40 mg/dl) and recurrent hypoglycemia (<60 mg/dl for 3 days) occurred in <5% of patients in both cohorts. Hypoglycemia was more common in patients with more severe diabetes and in the subset of patients treated with basal insulin.

CONCLUSIONS — Over one-quarter of hospitalized Americans have diabetes (9). While disruptions in outpatient regimens and intercurrent illness and medication changes may cause hyper- and hypoglycemia during hospitalization, the availability of frequent monitoring, skilled nursing care, and glucose-

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Abbreviations: UHC, University Health System Consortium.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

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Table 1—*Prevalence of hyperglycemia, hypoglycemia, and mode of insulin replacement in two large national samples of inpatients with diabetes*

	UHC cohort, 29 hospitals					VHA, Inc. cohort, 15 hospitals			
	Total, $n = 274$	Type 1, $n = 37$	Type 2 on insulin, $n = 113$	Type 2, not on insulin, $n = 124$	P	Total, $n = 725$	Diabetes primary dx, $n = 113$	Other primary dx, $n = 559$	P
Prevalence of hyper- and hypoglycemia									
Prevalence of hyperglycemia (%)									
Single value >200 mg/dl	77	92	92	60	<0.001	76	96	74	<0.001
Single value >250 mg/dl	60	76	71	42	<0.001	59	92	54	<0.001
Three consecutive days >200 mg/dl	38	41	37	19	0.003	18	19	19	0.9
Prevalence of hypoglycemia (%)									
Single value <60 mg/dl	12	27	15	5	<0.001	18	28	15	0.008
Single value <50 mg/dl	7	22	7	2	<0.001	10	15	9	0.03
Single value <40 mg/dl	3	11	1	2	0.002	5	7	4	0.2
Three consecutive days <60 mg/dl	3	8	4	0	0.02	5	3	6	0.1
Mode of insulin replacement						VHA, Inc. subset with treatment data, 6 hospitals			
Treatment (%)						$n = 296$	$n = 57$	$n = 239$	
Sliding scale alone	41	16	35	52	0.001	45	56	42	0.13
Any basal insulin	32	70	43	10	<0.001	32	37	31	0.42
No insulin	28	13	21	37	0.002	23	7	27	0.001
Treatment modality, patients with persistent hyperglycemia (glucose >200 mg/dl × 3 days) (%)									
Sliding scale alone	41				0.36*	41			0.34*
Any basal insulin	53				<0.0001*	59			<0.0001*
No insulin	6				<0.0001*	0			<0.0001*
Treatment modality, patient with glucose <60 mg/dl (%)									
Sliding scale alone	12				0.001*	46			0.98*
Any basal insulin	70				<0.0001*	50			0.004*
NPO (nothing by mouth)	N/A					42			0.46*
Prevalence of hypoglycemia (glucose <60 mg/dl) among patients on basal insulin (%)	26				<0.0001*	25			0.004*

Data are percentages. The total number in each cohort is given, followed by the number in each group stratified by severity of diabetes, using available data in each cohort. UHC is stratified into patients with type 1, type 2 on insulin with or without oral hypoglycemics, and type 2 on oral or diet therapy (not on insulin, based on outpatient regimen); VHA, Inc. is stratified into those with and without a primary admission diagnosis code of diabetes by DRG. **P* values are for comparisons between the patients receiving and patients not receiving the specified treatment. Data are shown for patients receiving treatment. Prevalence of hyperglycemia and hypoglycemia was greater in patients treated with basal insulin. dx, diagnosis; N/A, not available.

lowering medications should limit hyper- and hypoglycemia in the hospital setting. Our survey of a broad cross section of 44 academic and community hospitals revealed that among 999 inpatients with diabetes, marked, persistent hyperglycemia was very common and often treated by sliding-scale regimens alone, while severe hypoglycemia was rare.

Hyperglycemia is associated with increased mortality (10,11); improved control has been proven to reduce mortality in several populations. Severe hypoglycemia, a complication that partially drives undertreatment of hyperglycemia, is avoidable with appropriate management (12). Since the early 1990s, it has been known (17,18) that sliding-scale insulin protocols in the absence of a basal insulin are associated with wide glycemic variations. Consensus guidelines (4,13,14) and individual experts (15,16) suggest that optimal management of inpatient glycemia should include basal insulin with prandial insulin coverage, rather than sliding scales alone.

In our analysis of data from 2003, sliding scales were prescribed as the sole treatment in 41% of the UHC cohort and 45% of the VHA, Inc. cohort. Sliding-scale insulin alone may be transiently appropriate as a dose-finding strategy or in patients with type 2 diabetes not on outpatient insulin, but it was not appropriate in the 16% of patients with type 1 diabetes and probably not for the 35% of patients with type 2 diabetes on outpatient insulin (4,19,24). Hypoglycemia <60 mg/dl was more common in patients on

basal insulin, but only one-quarter of patients on basal insulin experienced hypoglycemia.

It is noteworthy that hyperglycemia on 3 consecutive days was prevalent in both cohorts but was not treated with basal insulin in 50% of UHC patients and 40% of VHA, Inc. patients. Confounding by indication and underdosing may explain persistent hyperglycemia in patients who were treated with basal insulin. Persistent hyperglycemia or hypoglycemia may have been underestimated in the UHC cohort, since data were only collected for 2 days before and after the most extreme value.

This analysis of 44 U.S. hospitals reveals persistent shortcomings in inpatient diabetes management. Inpatient diabetes care delivery may require systematic changes in order to meet current standards.

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