From the Diabetes Unit, The Medical Services and Department of Surgery, Massachusetts General Hospital, Boston, Massachusetts; and the Solomon A. Berson Research Laboratory, Veterans Administration Medical Center, Bronx, New York.

Address correspondence and reprint requests to Dr. L. Axelrod, Diabetes Unit, Bulfinch 4, Massachusetts General Hospital, Boston, MA 02114.

REFERENCES

1. Service FJ: *Hypoglycemic Disorders: Pathogenesis, Diagnosis, Treatment.* Boston, MA, Hall, 1983
2. Bauman WA, Yalow RS: Hyperinsulinemic hypoglycemia: differential diagnosis by determination of the species of circulating insulin. *JAMA* 252:2730–34, 1984
3. Bauman WA, Merkle LN, Rachman RA, Mitsuto SM: Hypoglycemia in a diabetes nurse care coordinator. *Diabetes Care* 7:88–91, 1984
4. Bauman WA, Yalow RS: Differential diagnosis between endogenous and exogenous insulin induced refractory hypoglycemia in a nondiabetic patient. *N Engl J Med* 303:198–99, 1980

An Unusual Case of Insulin Overdose

Subcutaneous injection of both intermediate-acting and regular insulin has been reported in cases of intentional insulin overdose (1). Systemic complications of cerebral damage, hypokalemia, pulmonary edema, hypertensive crisis, and respiratory insufficiency have been noted, although the outcome is generally not fatal. Although intravenous injection of rapid-acting insulin has been reported in intentional overdose, we report what we believe to be the first case of intravenous injection of intermediate-acting insulin in an intentional overdose situation.

A 49-yr-old White man with a history of chronic intravenous drug abuse, depression, and insulin-dependent diabetes mellitus had attempted suicide twice previously. Forty-five minutes before arrival at the emergency room, the patient willingly injected himself intravenously with 150–250 U of NPH insulin (beef-pork species) in a vein on the dorsum of the right foot.

In the emergency room, he reported light-headedness and was agitated. Serum glucose was 45 mg/dl, and simultaneous fingerstick glucose monitoring at bedside (Accucheck, Boehringer-Mannheim, Indianapolis, IN) was 40 mg/dl. He was given a 50-g i.v. bolus of dextrose and begun on a continuous 10% dextrose infusion in the emergency department.

Physical examination on admission to the intensive care unit revealed a confused, slightly combative male with sinus tachycardia of 124 beats/min. Supine blood pressure was 144/80 mmHg. Respirations were 24/min and unlabored. The rest of the examination was unremarkable.

Hourly bedside glucose monitoring was begun with additional doses of 25-g i.v. boluses of dextrose. Over the next 14 h, 415 g i.v. of dextrose were needed to maintain blood glucose levels. The following day his fasting serum glucose was 255 mg/dl, and no neurological abnormalities were noted. Intravenous dextrose was discontinued 35 h after admission, and insulin therapy was reinstituted. Laboratory results revealed an initial total insulin level of 1389 μU/ml, with a free-insulin level of 378 μU/ml (Nichols Institute, San Juan Capistrano, CA). Total insulin levels after 18 h were 1105 μU/ml, and free-insulin levels were 123 μU/ml. Insulin antibodies were positive at a 1:2 dilution, with an insulin-binding capacity of 1.0 μU/ml.

Subcutaneous NPH insulin has been shown to have onset of action at 2–4 h, peak effect at 8–14 h, and duration of 20–29 h (2). Individual variability may be in part due to the slow release of insulin from subcutaneous tissue, to the levels of proteases, and to the presence of insulin antibodies that act as a buffer. In this patient, the insulin-binding capacity of 1.0 mU/ml is similar to that determined in insulin-treated diabetes without immunological insulin resistance (2,3).

We are unaware of previous reports of the pharmacokinetics of intravenous injection of NPH insulin in humans. Animal experiments indicate intravenously injected NPH insulin results in rapid splitting of insulin from the carrier, with the preparation behaving like regular or unmodified insulin (J. H. Anderson, personal communication).

Linear extrapolation of our data suggests a $t_{1/2}$ of ~14 h. Several interesting observations could be made based on our data. *1*) Compared with animal studies, where NPH insulin is rapidly degraded and acts very much like regular insulin when it is injected intravenously, in this patient, intravenous NPH insulin had a prolonged duration of action. It may be speculated that a difference in animal and human serum protease activity may exist. *2*) No adverse reactions were noted from the protamine suspension in the intermediate-acting insulin injected intravenously into our patient.

Although significant elevations of free-insulin levels have been noted after subcutaneous injection of NPH insulin (3), at least one article failed to show a significant increase in free-insulin levels under similar conditions (4). We were able to demonstrate clear-cut elevation of free-insulin levels after an intravenous bolus of a large dose of intermediate-acting insulin.

Management of intravenous insulin overdose emphasizes the need for prompt early measurement of serum glucose, preferably by bedside techniques, and correction of early hypoglycemia. Long-term management over the next several hours hinges in part on dosage taken and the presence of insulin antibodies that would tend to cause a prolongation of insulin action. Clinical management of intravenous NPH insulin overdose requires the awareness of prolonged clinical duration of action, which in this patient persisted for up to 18 h after injection.

ACKNOWLEDGMENTS: We gratefully acknowledge the support of Dr. Delroy Stutzman, Division of Medicine, Lutheran General Hospital, for allowing us to be involved in the care of his patient. We also thank Leona Orth for secretarial assistance.

EDWARD HSI, MD
PHILLIP L. WERNER, MD, FACP

From the Section of Endocrinology, Department of Medicine, Lutheran General Hospital, Park Ridge, Illinois.

Address correspondence and reprint requests to Dr. Phillip L. Werner, Lutheran General Hospital, 1775 Dempster Street, Park Ridge, IL 60068.

REFERENCES

1. Arem R, Zoghki W: Insulin overdose in eight patients: insulin pharmacokinetics and review of the literature. *Medicine* 64:323–32, 1985
2. Haskar R, Chou M, Field JB: Time action characteristics of regular and NPH insulin in insulin-treated diabetics. *J Clin Endocrinol Metab* 50:475–79, 1980
3. Davidson JK, DeBra DW: Immunologic insulin resistance. *Diabetes* 27:307–18, 1978
4. Levin P, Falleo JM, O'Dorisio TM, Catland S: Limitations in usefulness of single dose intermediate acting insulin: a rapid response pattern in some type I diabetics. *Am J Med Sci* 286:11–16, 1983

Capillary Glucose Monitoring in Community Hospitals

Capillary glucose monitoring is widely used by patients at home and has been shown to be more accurate than semiquantitative urine glucose testing (1–3). Morris et al. (3) found glycosuria in 9% of patients with plasma glucose <150 mg/dl and a normal urine test in 16.5% with plasma glucose >200 mg/dl. The American Diabetes Association's advisory board has recommended that semiquantitative urine glucose no longer be used to adjust insulin doses in hospitalized patients (4). Frequent plasma glucose determinations by venipuncture are costly, somewhat painful, and the results are not immediately available to the physician. We therefore developed a program of capillary glucose monitoring in our community's hospitals.

Nursing personnel in two rural hospitals (average census 115 and 250 patients) were taught to measure capillary blood glucose with a Glucoscan reflectant meter. As a part of quality control, a simultaneous capillary blood glucose was obtained whenever a laboratory plasma glucose was ordered (572 data-pair comparisons). The 494 data pairs falling within the manufacturer's stated range of accuracy (25–450 mg/dl) were analyzed statistically. Data were analyzed separately from the general medical and surgical units of hospitals A and hospital B, the intensive care units, the emergency rooms, and a specialized diabetic unit in hospital B.

Regression statistics revealed that the Glucoscan device was linear and accurate throughout its range of 25–450 mg/dl of blood glucose (Table 1). Overall pool coefficient of determination (R^2) was .975 and ranged between .956 and .989 at the different hospital units. Regression slopes and intercepts from all hospital units were close to their ideal values of unity and zero, but the correlation was significantly better on the diabetes unit ($P < .01$). Seventy-eight (13.6%) of the data pairs fell outside the range of 25–450 mg/dl and were not included in the statistical analysis. Most of these (76) were Glucoscan readings >450 mg/dl or "high" and corresponded to laboratory glucose values of 339–1290 mg/dl. Although there were larger discrepancies between the Glucoscan and laboratory results at these high levels, a Glucoscan reading of >450 mg/dl always indicated a need for additional treatment. Thus, there was no problem with overtreatment based on Glucoscan determinations in our patients. We routinely confirm Glucoscan readings of >450 mg/dl with a laboratory glucose to determine how high the blood sugar actually is.

Our results indicate that accurate capillary blood glucose testing is feasible on the general medical and surgical units of community hospitals. We were able to utilize Glucoscan readings in individual patients to make adjustments in insulin doses according to modifications of recently published algorithms (1). We did not experience a problem with falsely elevated Glucoscan readings leading to inappropriate insulin therapy. Although Glucoscan measurements were most accurate on a designated diabetes unit, the regression statistics from all units were quite good (Table 1). Therefore, there is no need to restrict Glucoscan measurements to specialized nursing units. We believe that programs for bedside capillary glucose testing under proper supervision of a diabetic specialist and/or the clinical laboratory director should replace urine glucose testing in hospitalized patients.

GEORGE C. BORST, MD
SHEILA RICE, RN
WILMA L. ROBINSON, RN

TABLE 1
Regression statistics

Parameter	Hospital A	Hospital B	Diabetic unit in hospital B	Emergency room	Intensive care unit	Pooled
N	117	75	185	68	49	494
Slope	1.003	0.933	1.001	0.975	0.993	0.996
Intercept	0.732	1.990	0.496	1.421	−.331	0.523
R^2	.975*	.957*	.989	.976*	.956*	.975
C.V. (%)	16.7	22.0	11.0	16.1	21.0	16.4
Mean absolute error (%)	11.98*	17.14*	8.34	11.11*	15.54*	11.68

*Statistically significant ($P < .05$) difference from DU.