Feasibility of Insulin-Glucose Infusion in Diabetic Patients With Acute Myocardial Infarction

A report from the multicenter trial: DIGAMI

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OBJECTIVE — To investigate the effect of insulin-glucose infusion on metabolic control and hypoglycemic episodes and its feasibility and safety in patients with diabetes and myocardial infarction (MI) compared with conventional treatment.

RESEARCH DESIGN AND METHODS — Of 327 patients with suspected acute MI, 158 were randomized to insulin-glucose infusion for at least 24 h and 169 received conventional therapy. We determined the 24-h blood glucose profile in the infusion group, the degree of metabolic control, hypoglycemic events, and in-hospital complications within the two study groups.

RESULTS — Blood glucose fell from 14.6 ± 2.9 to 9.2 ± 2.9 mM during the first 24 h in patients receiving insulin-glucose and from 15.8 ± 4.3 to 12.0 ± 4.4 mM in control patients ($P < 0.01$). Serum potassium decreased 0.21 ± 0.56 mM in the infusion group ($P < 0.001$) and 0.11 ± 0.59 mM in the control group ($P < 0.05$). The difference between the groups was not significant. Twenty-eight of the 158 patients developed an episode of hypoglycemia (blood glucose < 3.0 mM) during the insulin-glucose infusion. There were no significant differences in the number of episodes of ventricular tachyarrhythmias or in ischemic events between patients with and without hypoglycemia.

CONCLUSIONS — The protocol outlined in this study gives more rapid and better metabolic control than does conventional treatment. This treatment seems to be a feasible alternative for clinical attempts. Before it can be recommended for general use, the impact on mortality needs to be evaluated.

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Received for publication 22 December 1993 and accepted in revised form 14 April 1994.

MI, myocardial infarction; DIGAMI, diabetes mellitus insulin-glucose infusion in acute myocardial infarction; NIDDM, non-insulin-dependent diabetes mellitus; IDDM, insulin-dependent diabetes mellitus; ECG, electrocardiogram; CCU, coronary care unit; ACE, angiotensin-converting enzyme.

Diabetic patients with acute myocardial infarction (MI) are at a high risk. Their hospital mortality is between 25 and 40% (1–5). They are also prone to develop serious complications, such as ventricular tachyarrhythmias and high-degree atrioventricular block (1,2,4). The difference in mortality between diabetic and nondiabetic individuals is further increased after discharge from the hospital, because of a high incidence of fatal reinfarctions (1,6–8).

The high post-MI mortality among diabetic patients has been attributed to a pronounced, widespread, and distal coronary atherosclerosis, claimed often to be combined with coexisting diabetic cardiomyopathy (9–11). Autonomic imbalance may also contribute (12). Furthermore, diabetic patients also have impaired platelet and fibrinolytic function, and these disturbances may also contribute to the mortality and the high rate of early recurrences (13–15). Metabolic disturbances, in particular those related to a high turnover of free fatty acids, that result in a diminished supply of glucose to the carbohydrate-dependent ischemic myocardium may contribute to the high initial mortality (16–18). The clinical condition, including factors such as severity of pain, level of anxiety, or degree of heart failure, will obviously influence the amount of insulin needed to normalize blood glucose. Improved metabolic control by means of intravenous insulin has been suggested to reduce the high initial complication rate and mortality among diabetic patients with acute MI (19). It has been claimed that infusion of insulin is a simple and safe way to improve glycemic control (19–21). However, there are no randomized controlled studies documenting that continuous intravenous infusion gives better metabolic control than does conventional treatment. Furthermore, the rate of hypoglycemic episodes and their possible impact on the occurrence of arrhythmias and ischemic events has not been evaluated in a large diabetic MI population with con-

comitant modern anti-ischemic treatment. The purpose of this interim report from a multicenter study, DIGAMI (diabetes mellitus insulin-glucose infusion in acute MI), is to answer these questions and to outline the feasibility and safety of an insulin-glucose infusion protocol for multicenter purpose.

RESEARCH DESIGN AND METHODS

Definitions

Patients were considered to have diabetes if they had been informed that they had this diagnosis and were on treatment (diet, tablets, or insulin). Patients with no previous diabetes diagnosis but with a blood glucose >11 mM on admission were classified as newly detected diabetes and were also included.

Patients were classified as having non-insulin-dependent diabetes mellitus (NIDDM) or insulin-dependent diabetes mellitus (IDDM) by clinical history and according to the definitions of the National Diabetes Data Group (22). Thus, NIDDM patients were usually >40 years of age at diagnosis, non-insulin-requiring for 2 years after the diagnosis, and not prone to ketosis.

The diagnosis of *definite MI* was made if at least two of the following criteria were fulfilled: *1*) chest pain of at least 15-min duration; 2) at least two values of serum creatine kinase and serum creatine kinase-B above the normal range (normal value ± 2 SD) 10–16 h after onset of symptoms or at least two S-LD values above the normal range 48–72 h after onset of symptoms, including an isoenzyme pattern typical of MI; 3) development of new Q waves in at least 2 of the 12 standard electrocardiogram (ECG) leads.

The diagnosis of *possible MI* was made if chest pain was combined with only one serum creatine kinase or serum lactate dehydrogenase above the normal range and/or Q waves appeared in only 1 of the 12 standard ECG leads.

Myocardial ischemia was defined as chest pain of at least 30-min duration without any enzyme elevation, but with one of the following ECG changes: ST-depression (≥1 mm), ST-elevation (≥2 mm in chest leads, ≥1 mm in extremity leads), or T-wave inversion in at least 2 of the 12 standard ECG-leads.

Ventricular tachyarrhythmia was defined as the presence of either ventricular premature beats or ventricular tachycardia that required antiarrhythmic treatment or as documented ventricular fibrillation. Ventricular fibrillation was defined as early if it occurred within 48 h of the onset of symptoms and late if it occurred thereafter.

Only high-grade atrioventricular blocks (II-III) were considered. Standard ECG criteria were applied. To be noted in the case record form, the conduction defect had to be treated in some way.

Congestive heart failure was defined as clinical and/or radiological signs of pulmonary congestion resulting in the institution of treatment.

A measured blood glucose level <3 mM, usually associated with clinical symptoms, was considered hypoglycemia. Blood glucose was always checked at any suspicion of hypoglycemia.

Study protocol

In the DIGAMI study, a multicenter investigation, all patients admitted to the coronary care units (CCUs) of 16 Swedish hospitals (see APPENDIX) were considered for inclusion. Inclusion criteria were suspected acute MI within the preceding 24 h combined with previously known diabetes and blood glucose >11 mM or a blood glucose >11 mM without known diabetes. The following exclusion criteria were applied: inability to participate for reasons of health (e.g., patients too sick to give informed consent or patients unable to manage multi-dose insulin treatment), refusal after given information, residence outside the hospital catchment area, enrollment in other studies, or previous participation in DIGAMI.

Subjects without any exclusion criteria were blindly randomized to either an insulin-glucose or a control group. Patients in the insulin-glucose group received, besides standard CCU therapy, a 24-h insulin-glucose infusion followed by subcutaneous insulin four times daily for 3 months. Control patients were treated according to standard CCU practice. Thus, these patients did not receive any insulin unless deemed clinically necessary by the physician in charge.

The insulin-glucose infusions were started by the nurse in charge as soon as possible after the patient's arrival in the CCU. Samples for determination of blood glucose were drawn from an indwelling venous catheter at time intervals outlined in the protocol (see below). All analyses were performed by the CCU nurse with the use of a reflectance meter (Reflolux II®, Boehringer Mannheim, Scandinavia AB). The accuracy of this bedside reflectance meter had previously been checked by analyzing duplicate samples of blood by a glucose oxidase method (23). Before starting DIGAMI, the accuracy of this nurse-conducted bedside analysis of blood glucose was tested in a pilot center CCU subsequently enrolled in DIGAMI (Kärnsjukhuset, Skövde). The blood glucose levels obtained were compared with those obtained by a conventional glucose oxidase method used by the Department of Clinical Chemistry in this hospital. Duplicate blood samples were taken from an indwelling arm-vein catheter not used for the insulin-glucose infusion. There was a good correlation between the bedside monitoring in the CCU and the glucose oxidase method (Fig. 1). This correlation was obtained even though sampling and testing were performed during routine care by the various nurses in charge, who used the reflectance meter after a brief period of instruction and practice. Thus, blood glucose could be accurately determined within a few minutes and as a routine in the CCU. Serum potassium (normal range 3.5–5.0 mM) was measured immediately before starting the insulin-glucose infusion and then 6, 12, and 24 h after the

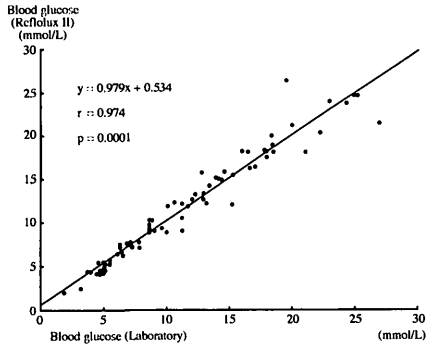

Figure 1—*Comparison of blood glucose measured by Reflolux II in the CCU with blood glucose measured in the laboratory by the standard glucose oxidase method.*

infusion started. Serum potassium was checked immediately in patients who developed any kind of clinically significant arrhythmia.

Insulin-glucose administration

The insulin-glucose infusions were instituted and handled according to a predefined protocol (Table 1). Insulin-glucose was continued until stable normoglycemia was attained and always for at least 24 h. Subcutaneous insulin treatment was instituted immediately after the cessation of the infusion in a multi-dose regimen to maintain stable normoglycemia.

Our initial goal was to develop a protocol for insulin-glucose infusion that rapidly normalized blood glucose. This was tested in the pilot center before the initiation of the main study. The first protocol was designed to achieve a blood glucose level between 5 and 8 mM as fast as possible (group I, n = 13 patients). The blood glucose levels decreased rapidly, but at the price of an unacceptably high incidence of symptomatic hypoglycemia. These attacks appeared usually when the clinical condition of the patient had been stabilized for ~4–5 h after starting therapy. By raising the targeted blood glucose level somewhat (7–10.9 mM), concomitant with a slight decrease in the initial insulin bolus, the number of hypoglycemic events was considerably reduced (group II, n = 14 patients). There was still a substantial decrease in blood glucose within 3 h, and a reasonable level was maintained over the 24 h of monitoring.

Before starting DIGAMI, additional adjustments were made in the protocol to further prevent hypoglycemic complications. These adjustments were based on the fact that some individuals reacted with a rather pronounced initial decrease in blood glucose. Thus, if this decrease exceeded 30%, infusion rate was not changed even if blood glucose remained >11 mM. Furthermore, if the value decreased to <11 mM, the infusion rate was decreased in spite of a blood glucose value within the desired range. To prevent excess blood sampling and to meet the diminished insulin requirements during the night, the infusion rate was reduced by 50% at 10:00 P.M. if the blood glucose value had been stabilized to <11 mM.

The study was approved by the ethical committees at Karolinska Institute Stockholm, University of Gothenburg, University of Lund, and Uppsala University Sweden.

Statistical analysis

Standard statistical methods were used. The significance of the differences between the two groups has been tested by Student's t test and Fisher's exact test. Differences within groups were tested by a paired test. A two-tailed $P < 0.05$ was considered statistically significant.

RESULTS— We present data from 327 randomized patients during the period January 1990 to April 1992, of whom 158 were allocated to the insulin-glucose infusion group and 169 to the control group. Pre-hospital characteristics are presented in Table 2. There were no significant differences between the two groups. A large proportion of the patients had known ischemic heart disease, hypertension, and congestive heart failure. Almost 80% of the patients had NIDDM. Fifteen percent of the patients were not previously known to have diabetes. Approximately one-third of the patients were on treatment with β-blockers, aspirin, or long-acting nitrates, and ~25% were smokers.

A majority of patients in each group (control = 83%; infusion = 90%) fulfilled the diagnostic criteria for MI, and only four patients lacked signs of severe coronary artery disease. About 50% of the patients received intravenous thrombolysis and nitrates. Most of the patients were treated with β-1-selective blockers (con-

Table 1—*Protocol used by the CCU nurses for the insulin-glucose infusions*

B-glucose (mM)	
>15	Give 8 IU of insulin as an intravenous bolus injection and increase infusion rate by 6 ml/h.
11–14.9	Increase infusion rate by 3 ml/h.
7–10.9	Leave infusion rate unchanged.
4–6.9	Decrease infusion rate by 6 ml/h.
<4	Stop infusion for 15 min. Then test B-glucose and continue testing every 15 min until B-glucose ≥7mM. In the presence of symptoms of hypoglycemia administer 20 ml 30% glucose intravenously. The infusion is restarted with a infusion rate decreased by 6 ml/h when B-glucose ≥7mM.

Infusion: 500 ml 5% glucose with 80 IU of soluble insulin ~1 IU/6 ml). Start with 30 ml/h. Check blood glucose after 1 h. Adjust infusion rate according to the protocol and aim for a blood glucose level of 7–10 mM. Blood glucose should be checked after 1 h if infusion rate has been changed, otherwise every 2 h. If the initial fall in blood glucose exceeds 30%, the infusion rate should be left unchanged if blood glucose is higher than 11 mM and reduced by 6 ml/h if blood glucose is within the targeted range of 7–10.9 mM. If blood glucose is stable at ≤10.9 mM after 10:00 P.M., reduce infusion rate by 50% during the night.

Table 2—*Pre-hospital characteristics*

Parameter	Control group	Infusion group	*P*
n	169	158	—
Age (years)	68 ± 9	66 ± 9	NS
Sex			
Male	110 (65)	103 (65)	NS
Female	59 (35)	55 (35)	
Previous			
MI	61 (36)	57 (36)	NS
Angina pectoris	93 (55)	91 (57)	NS
Hypertension	87 (51)	71 (45)	NS
Congestive heart failure	43 (25)	36 (23)	NS
Type of diabetes			
NIDDM	139 (82)	127 (80)	NS
IDDM	30 (18)	31 (20)	NS
Previously unknown diabetes	29 (17)	19 (12)	NS
Duration of diabetes (years)	10.8 ± 11.9	10.2 ± 10.4	NS
Antidiabetic treatment at entry			
None	29 (17)	19 (12)	NS
Diet	21 (13)	15 (10)	NS
Tablets	54 (32)	69 (44)	NS
Insulin	65 (38)	55 (34)	NS
Other treatment at entry			
β-blockers	56 (33)	54 (34)	NS
Aspirin	55 (32)	42 (27)	NS
Nitrates	52 (30)	39 (25)	NS
ACE inhibitors	31 (18)	21 (18)	NS
Digoxin	32 (19)	21 (18)	NS
Smokers	31 (18)	44 (28)	0.06

Data are *n* (%) or means ± SD.

trol = 66%; infusion = 69%) and aspirin (control = 78%; infusion = 82%). There were only a few arrhythmic complications.

Blood glucose at randomization was 15.8 ± 4.3 mM in the control group and 14.6 ± 2.9 mM in the infusion group ($P = 0.046$). The level decreased significantly during the first 24 h in both groups, but more so in the infusion group (5.3 ± 3.9 compared with 3.8 ± 4.6 mM; $P < 0.0001$). HbA_{1c} was 8.1 ± 2.0% in the control group compared with 8.6 ± 2.0% in the infusion group (NS). There was a slight but significant decrease in serum potassium in both groups, which was more pronounced among infusion patients, 0.21 ± 0.56 mM ($P < 0.001$) compared with 0.11 ± 0.59 mM ($P = 0.035$) in the control group. None of the infusion patients had a serum potassium <3.5 mM at the end of the infusion.

Blood glucose levels had a relatively rapid initial decrease, with a nadir of 6.6 ± 2.6 mM at 6 h after infusion start, where 75% of the patients had blood glucose ≤8.8 mM. The curve then leveled off but increased during the last hours of infusion, reading a mean blood glucose level of 9.2 ± 2.9 mM at 24 h compared with 12.0 ± 4.4 in the control group ($P < 0.0001$).

During the 24-h infusion, 28 patients (17%) had one episode of hypoglycemia (blood glucose level >3.0 mM); none of these were registered twice. None of the control patients had similar episodes ($P < 0.001$).

In Table 3, the in-hospital characteristics and complications of the 28 infusion patients with hypoglycemia are compared with those of the 130 infusion patients who did not have any hypoglycemic episodes. Patients with hypoglycemia were significantly older than those without hypoglycemia. Interestingly, almost all episodes of hypoglycemia occurred in patients with known tablet or insulin-treated diabetes (93%). There were only two patients with hypoglycemia among 34 patients who were newly diagnosed or on previous dietary treatment. β-blockers seemed not to increase the risk for hypoglycemia.

There were no differences in blood glucose levels at randomization or after 24 h between patients with (14.4 ± 3.0 vs. 9.7 ± 3.8 mM) and without (14.7 ± 2.9 vs. 9.1 ± 2.95 mM) hypoglycemia. HbA_{1c} was 8.4 ± 1.9% in the group without hypoglycemia compared with 9.1 ± 1.9% in the hypoglycemic group (NS).

Patients with hypoglycemia had significantly higher serum potassium levels both at randomization (4.48 ± 0.57 vs. 4.23 ± 0.53; $P < 0.05$) and after 24 h (4.30 ± 0.41 vs. 4.00 ± 0.40) than did those without hypoglycemia.

The two groups were not different with respect to diagnosis or in-hospital treatment. Notably, hypoglycemic episodes did not increase the number of in-hospital complications such as arrhythmias or recurrent infarction (Table 3).

Of 169 control patients, 139 were classified as having NIDDM, and 104 of those were not previously treated with insulin. During the hospital stay, 55 (53%) of those patients received an extra bolus of fast-acting insulin on at least one occasion. The average total dose was 54 ± 63 IU, median value 32 (4–271) IU. In total, 14% of the patients in the control subgroup without previous insulin treatment were discharged with insulin treatment.

CONCLUSIONS— In the acute phase of MI, there is a dramatic increase

Table 3—*Comparative characteristics between patients in the infusion group with and without hypoglycemia.*

	No hypoglycemia	Hypoglycemia	*P*
n	130	28	
Age (year)	65 ± 9.1	70 ± 5.2	<0.001
Sex			
Male	87 (67)	16 (57)	NS
Female	43 (33)	12 (43)	
Previous MI	46 (36)	10 (36)	NS
Type of diabetes			
NIDDM	106 (81)	21 (75)	NS
IDDM	24 (19)	7 (25)	NS
Previously unknown diabetes	18 (13)	1 (4)	NS
Antidiabetic treatment at entry			
None	18 (14)	1 (4)	NS
Diet	14 (11)	1 (4)	NS
Tablets	55 (42)	14 (50)	NS
Insulin	43 (33)	12 (42)	NS
Other treatment at entry			
β-blockers	43 (33)	10 (36)	NS
ACE inhibitors	17 (13)	4 (14)	NS
Nitrates	29 (23)	10 (36)	NS
In-hospital diagnosis			
Definite MI	116 (89)	26 (93)	NS
Possible MI	5 (4)	0 (0)	NS
Myocardial ischemia	7 (5)	2 (7)	NS
Other	2 (2)	0 (0)	NS
Localization			
Anterior	97 (74)	25 (89)	NS
Treatment during hospital stay			
Thrombolysis	68 (52)	14 (50)	NS
Intravenous nitroglycerin	71 (55)	10 (36)	0.062
Intravenous heparin	18 (14)	3 (11)	NS
β-blockers	83 (64)	15 (55)	NS
Aspirin	100 (78)	19 (69)	NS
In-hospital complications			
Early ventricular fibrillation	1	0	NS
Late ventricular fibrillation >48 h	3	2	NS
Ventricular tachycardia	6	2	NS
Atrioventricular block grade III	3	0	NS
Atrial fibrillation	17 (13)	6 (21)	NS
Reinfarction during hospital stay	7 (5)	1 (3)	NS

Data are *n* (%) or means ± SD.

in the release of catecholamines (24–26). This leads to a decrease in insulin production and in tissue sensitivity to insulin (27,28). Insulin antagonists like cortisol and glucagon are also released (26, 29, 30). Moreover, catecholamines increase lipolysis, resulting in an increase in fatty-acid mobilization (27). Accordingly, several factors contribute to a diminished glucose utilization and increased free fatty acid mobilization in the body, resulting in an increase in β-oxidation in the carbohydrate-dependent ischemic myocardium. The accumulation of free fatty acids is harmful to the myocardium (18). Consequently, acute intervention with insulin-glucose infusion is a logical approach to improve myocardial glucose utilization and metabolism, with the ultimate goal of preserving jeopardized myocardial tissue. A prerequisite to test this hypothesis in a trial is a practicable protocol for the infusion of insulin-glucose. This should be safe and easy to handle in the CCU and, preferably, possible to be initiated by the nurse in charge of the patient without unnecessary delay in obtaining blood glucose levels or completing special order forms. It should also be compatible with other treatment in the CCU, including thrombolysis, intravenous infusion of nitroglycerin, and β-blockade.

Gwilt et al. (20) described an insulin infusion protocol that reduced blood glucose to 7.6 ± 4.0 mM after 12 h, but for patients with blood glucose >15 mM, the decrease was slow, with a 12-h value of 9.4 ± 4.4 mM. Symptomatic hypoglycemia occurred in 15% of the 29 patients. This regimen was then implemented in a small mortality study, which failed to show any beneficial effect on morbidity or mortality compared with historical controls (21). Husband et al. (31) suggested that the metabolic goal in diabetic patients with acute MI should be to keep the blood glucose at 5.6–11.2 mM. By reviewing historical controls, they found that only 60% of diabetic patients with MI had a mean blood glucose value <13 mM. They suggested a more strict glycemic control by using either subcutaneous insulin three times daily or a glucose-insulin-potassium infusion. The latter was reserved for more seriously ill patients with slightly higher initial blood glucose values than the subcutaneous group, but in spite of that, the glucose-insulin-potassium infusion group had better glycemic control 24 h after admission (8.1 ± 2.6 vs. 10.2 ± 2.7 mM; $P < 0.001$) (31). Contradictory to Gwilt, Clark et al. (19), in a nonrandomized study, found a reduction both in morbidity and mortality using a similar insulin infusion protocol. In that study, the authors did not describe the degree of metabolic control or hypoglycemic complica-

tions obtained by their insulin regimen. Recently, Hendra and Yudkin (32) suggested an algorithm for insulin infusion for diabetics with MI, which they postulated to be rapid and safe. In that report, blood glucose level 6 h after the start of infusion was 8.8 ± 2.5 mM. Six of 29 patients (21%) did, however, develop hypoglycemia during the 48-h period of infusion.

When working out the protocol used in this study, one of the major goals was to obtain a rapid decrease in blood glucose values, because the hormonal and metabolic disturbances develop rapidly (25,26) and irreversible ischemic damage may be produced within hours (33). Our protocol resulted in a more rapid glycemic control than those described previously, with a mean blood glucose level of 7.3 ± 3.4 mM 4 h and 6.6 ± 2.9 mM 6 h after the start of infusion. Sixty-three percent of the patients had a blood glucose level ≤8 mM after 4 h and as many as 70% reached that level after 6 h. The somewhat increased blood glucose level at 24 h was still significantly lower than that of the control group. It may have been better with a lower level at this time, but that level could probably only be acheived at the cost of more hypoglycemic episodes.

In this study, 28 patients (18%) developed hypoglycemia during the infusion period, compared with none in the control group. It is therefore clear that the infusion of insulin-glucose contains a risk for this category of patients. The patients with hypoglycemia were somewhat older but otherwise not different from the patients without hypoglycemia. The incidence of arrhythmias such as ventricular fibrillation, ventricular tachycardia, and atrial fibrillation was low; it did not exceed what could be expected in the patient population studied. There was no evidence of an increased degree of ischemia or an increased incidence of ischemic episodes in the hypoglycemic group. Treatment with β-blockade did not affect the number or intensity of hypoglycemic events. Glycogenolysis and gluconeogenesis in the liver are stimulated through β_2-receptors (34). During unselective β-blockade, prolongation of hypoglycemia has been described (35,36). This has not been reproduced when using β-1-selective blockade (35,37–39).

Lindström et al. (40) claimed that patients with NIDDM and insulin-induced hypoglycemia are more prone to ventricular arrhythmias, probably because of increased levels of epinephrine and concomitant hypokalemia. This has also been noticed in healthy subjects and in patients with IDDM (41). β-blockers prevent catecholamine-induced hypokalemia (42). We have previously reported that early institution of β-1-selective blockade in diabetic individuals with acute MI is well tolerated and reduces mortality and further ischemic events (43). In DIGAMI, 54 patients (34%) were on β-blockers at admission to the hospital. A total of 99 (70%) of the 158 patients in the infusion group received β-blockers during the acute phase of the disease; the percentages were similar in patients with and without hypoglycemia. This high usage of β-blockers may have protected against harmful effects of hypoglycemia.

The decrease in serum potassium was an expected effect of the insulin-glucose infusion. Hypokalemia is related to ventricular tachyarrhythmias (44). The shift in serum potassium was, however, small and did not differ between patients with and without hypoglycemia. In all, only two patients in the hypoglycemic group had ventricular tachycardia followed by ventricular fibrillation. This occurred at 28 and 83 h, respectively, after the cessation of insulin infusion. None of these patients had any signs of arrhythmias during the infusion period. Atrioventricular block grade III occurred among three patients in the infusion group, all of whom belonged to the group without hypoglycemia.

The reflectance meter used in this study gives reproducible and accurate blood glucose values (45). The rapid information on blood glucose was the key to the infusion protocol. The number of blood glucose determinations needed during the 24-h infusion was reasonable and within the limits of routine care. We are convinced that the safety and efficacy of an insulin-glucose protocol depends on easy and rapid access to blood glucose data. One problem is to avoid excess finger pricks, because it hurts and might cause prolonged bleeding when concomitant thrombolytic treatment is given. We obtained blood glucose samples through an indwelling venous catheter, which produced reliable results with a minimum of patient discomfort.

In conclusion, the protocol outlined in this study gives more rapid and better metabolic control than conventional treatment. This treatment seems to be a feasible alternative for routine use. Treated patients do, however, exhibit an increased risk of hypoglycemic episodes, but still, the incidence of in-hospital complications such as arrhythmias and recurrent ischemia is not affected in the hypoglycemic group. This protocol is intended to be a practical approach for insulin-glucose administration to diabetic patients with acute MI. Whether this approach will result in an improved prognosis remains to be established. Such studies are needed before the protocol can be recommended for general use.

Acknowledgments— This study is supported by grants from the Swedish Heart and Lung Foundation, Hoechst AG, Novo-Nordisk Insulinfond, Svenska Diabetesförbundet, and Jönköpings läns landstings vetenskapliga råd.

APPENDIX— The following people and institutions participate in the DIGAMI investigation: Central Hospital Eskilstuna, Eskilstuna: Cristina Jarnert, MD, Katarina Ahlin, RN; Falun Hospital, Falun: Lars Hagström, MD, Ulla-Britt Engström, RN; Sahlgren's Hospital, Göteborg: Johan Herlitz, MD, Margareta Sjölin, RN; Ostra Hospital, Göteborg: Lennart Welin, MD, Gunnel von Hofsten;

Ryhov Hospital, Jönköping: Olof Svensson, MD, Lollo Ekfeldt, RN; Köping Hospital, Köping: Peter Nicol, MD, Rosamund Eriksson, RN; Karlshamn Hospital, Karlshamn: Karim Mokktar, MD, Katarina Ahlin, RN; Malmö General Hospital, Malmö: Bo Israelsson, MD, Anneli Ivarsson, RN; Mölndal Hospital, Mölndal: Rune Henning, MD, Anna-Stina Jonsson, RN; Nyköping Hospital, Nyköping: Vibecke Bergman, MD, Sofia Johansson, RN; Karolinska Hospital, Stockholm: åke Olsson, MD, Eva Olason, RN; Central Hospital, Skövde: Peter Smedgård, MD, Lis Ståhl, RN; Södertälje Hospital, Södertälje: Kjell Haglund, MD, Louise Andersson, RN; Akademiska Hospital, Uppsala: Gerhard Wikström, MD, Marita Adling, RN; Västerås Hospital, Västerås: Stellan Band, MD, Marie Steneus, RN; Central Hospital, Orebro: Erik Schwartz, MD, Helmy Eklund.

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