Type 2 Diabetes and Acute Myocardial Infarction

Angiographic findings and results of an invasive therapeutic approach in type 2 diabetic versus nondiabetic patients

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OBJECTIVE — Mortality in diabetic patients with acute myocardial infarction (MI) is high. The significance of the pretreatment coronary status in type 2 diabetic patients with acute MI, as well as the effect of mechanical revascularization using percutaneous transluminal coronary angioplasty (PTCA), has not been established.

RESEARCH DESIGN AND METHODS — All patients with type 2 diabetes and acute MI (n = 54) were prospectively enrolled into a study of immediate coronary angiography to guide PTCA of the occluded infarct vessel. Hospital and long-term course were assessed and compared with an unselected control group of nondiabetic patients (n = 358) who were enrolled in the same study.

RESULTS — Angiography showed that sites of occlusion and acute coronary flow were similar in both groups. Multivessel disease and shock were more common in type 2 diabetic versus nondiabetic patients: 69 vs. 51% and 21 vs. 10% ($P < 0.02$), respectively. Direct PTCA was successful in >90% in both groups. Mortality after 30 days was 13% in type 2 diabetic patients versus 5% in patients without diabetes ($P < 0.04$). Left ventricular (LV) ejection fraction before discharge was lower in diabetic patients (48 ± 17 vs. 55 ± 15%, $P < 0.05$). Mortality 1 year after discharge was 11 vs. 4% in diabetic versus nondiabetic patients ($P < 0.02$). Multivariate analysis identified type 2 diabetes as an independent risk factor for acute, but not for late, mortality.

CONCLUSIONS — Direct PTCA is safe and effective in type 2 diabetic patients with acute MI. Mortality after 30 days in unselected diabetic patients is <15% with this approach. Advanced disease and shock contribute to an increased mortality in type 2 diabetic patients with acute MI versus nondiabetic patients.

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Mortality of diabetic patients who develop acute myocardial infarction (MI) is high and exceeds that of nondiabetic patients (1–14). The causes for this are probably multifactorial. The role of the actual coronary status in the diabetic patient with acute MI in causing a high mortality is not exactly known. The pretreatment coronary status in diabetic patients with acute MI has rarely been visualized or specifically analyzed.

MI is caused, in most cases, by acute thrombotic occlusion of a coronary artery (15,16). Immediate recanalization of the occluded artery improves survival. Recanalization of acute coronary occlusion can be obtained by fibrinolytic agents or direct catheter-based percutaneous transluminal coronary angioplasty (PTCA). Prospective randomized comparisons between both approaches showed that direct PTCA yields high patency rates, resulting in at least similar or even more favorable clinical results (17–20). Direct PTCA is applicable in almost all patients with acute MI, including many patients with bleeding risks, which are particularly feared in diabetic patients (10,21). However, direct PTCA and its effects on acute and long-term mortality in diabetic patients, and particularly in type 2 diabetic patients, have not been specifically studied.

To elucidate the acute coronary status in type 2 diabetic patients with acute MI and to explore feasibility and results of immediate mechanical recanalization in this high-risk subgroup, we prospectively obtained acute coronary angiograms with the intention to perform direct PTCA in consecutive and unselected type 2 diabetic patients. The comparison with acute coronary angiograms and PTCA results from nondiabetic patients enrolled in the same study should help to understand prognostic differences between both groups. Long-term follow-up after acute PTCA was focused on whether late mortality and/or coronary events are excessive in type 2 diabetic patients.

RESEARCH DESIGN AND METHODS

— Acute angiograms as well as clinical short- and long-term results of direct and immediate catheter-based recanalization of infarct vessels in consecutive patients with acute MI and type 2 diabetes form the basis of this study. Results were compared with those from a control group of patients with acute MI but no diabetes.

Acute MI was diagnosed in 54 consecutive patients with type 2 diabetes (study group, Table 1), and, during the same period (January 1990 to April 1996), in 358 consecutive nondiabetic patients (Table 1). Assignment of patients into diabetic versus nondiabetic groups is in accordance with recent recommendations (22).

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Abbreviations: LV, left ventricular; MI, myocardial infarction; PTCA, percutaneous transluminal coronary angioplasty.
A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—*Patient characteristics in type 2 diabetic versus nondiabetic patients (univariate analysis)*

Parameter	Diabetic patients	Nondiabetic patients	*P*
n	54	358	—
Sex (F/M)	29/25	78/280	<0.0001*
Age (years)	66 ± 10	61 ± 12	0.003†
No previous MI (years)	67 ± 9	60 ± 12	0.001*
Age >75 years	10 (17)	43 (12)	NS
Cardiogenic shock	11 (20)	36 (10)	0.05*
Anterior MI	26 (48)	147 (41)	NS
Previous MI	13 (24)	64 (18)	NS
Creatinine (mg/dl)	1.21	1.13	0.05†
Hypertension	28 (52)	51 (14)	0.0001*
Hypercholesterolemia	21 (39)	56 (15)	0.0001*

Data are *n*, means ± SEM, or *n* (%). *χ^2 test; †*t* test.

In patients with a previously unknown metabolic status (n = 5) classification was postponed until ≥5 days post-MI and/or diabetogenic drugs or conditions, e.g., severe heart failure, catecholamine therapy, etc., were absent. At the time of the index MI, previous diabetes therapy was diet only in 8 patients, sulfonylureas alone in 24, metformin in 1, and insulin in 21 patients (combined with sulfonylureas in 6 of 21). Diabetes was diagnosed 11 ± 10 years (0–40) before the index MI.

Diagnosis of acute MI required the presence of typical chest pain (onset <6 h) and ST-segment elevation of >2 mm in the precordial leads or >1 mm in leads 1, 2, 3, avR, avL, or avF in patients with supraventricular rhythms and no left bundle branch block. The clinical presentation was decisive in patients with other rhythms or left-bundle branch block.

Hospital care

The diagnosis "acute MI" prompts treatment with intravenous heparin, acetylsalicylic acid (500 mg), and β-blockers if not contraindicated. Thereafter, all patients presenting within 6 h after onset of pain and an acute phase electrocardiogram undergo immediate standard diagnostic coronary angiography, 24 h/day. After identification of the infarct-related vessel, direct recanalization of that vessel using PTCA was attempted if the coronary flow was impaired to TIMI grades 0, 1, or 2 (23). Direct catheter intervention was termed "successful" if the residual stenosis was reduced to ≤50%. A total of 13 patients received intracoronary stenting, 2 diabetic and 11 nondiabetic patients (NS). It is of note that no patient, irrespective of age or clinical or other conditions, was excluded from this approach to her/his acute MI. Patients with contraindications to intravenous thrombolysis were also included. All patients or their closest relatives gave informed consent to the invasive approach. The time frame from onset of pain to hospital admission was 130 ± 180 min, to the start of the catheter intervention, 220 ± 200 min, and to successful PTCA, 250 ± 205 min, for both groups.

Thereafter, patients were transferred to the intensive care unit. Hospital care followed conventional guidelines until discharge (24). A total of 255 of 412 (62%) (25 of 54 diabetic and 240 of 358 nondiabetic patients) received early β-blockade, and this treatment was continued after discharge in 220 of 342 (64%) nondiabetic and in 22 of 46 (48%) diabetic hospital survivors. LV function was assessed >1 week after the index MI but before discharge. During postdischarge follow-up (>3 years), most of the patients were regularly seen in the outpatient department of this institution. Otherwise, the patients or the general physicians were contacted by phone. Stress testing and recatheterization during follow-up were guided by symptoms. Five patients (foreign residents) were lost to follow-up after discharge within the first year. Causes of death during follow-up were classified as cardiac, noncardiac, or unclear according to the judgment of the physician who documented the patient's death. Diagnosis of reinfarction required typical chest pain and enzyme rise (creatinine kinase) more than three times normal in the chronic phase and recurrence of severe chest pain and ST-elevation in the acute phase.

Statistic calculations were performed using a commercially distributed software package (PCS V2, TopSoft, Hannover, 1992) that provides univariate as well as multivariate analysis of data (descriptive statistics, testing for normal distribution, unpaired *t* test, χ^2 test including Yates correction for small sample sizes <5, logistic regression) (25). Kaplan-Meier (26) time-event analyses including the Mantel-Haenszel test and the proportional hazards model are provided (27) by this software package. Multivariate analysis of risk factors for early mortality included commonly used clinical parameters together with the presence/absence of type 2 diabetes. LV ejection fraction was assessed before discharge (when some patients had already died) and was, therefore, only added to the list of parameters for multivariate analysis for late, postdischarge mortality. For the multivariate analysis, the contiguous variables of age and LV ejection fraction were transformed into dichotomous variables with commonly used cutoff points of 75 years and 35%, respectively.

RESULTS — The proportion of patients with type 2 diabetes (n = 54) among all patients with acute MI (n = 412) was 13% (Table 1). Patients with acute MI and type 2 diabetes were older and often female, and 20% presented in cardiogenic shock (Table 1). Renal dysfunction, arterial hypertension, and/or hypercholesterolemia were present more often in the group of type 2 diabetic patients (Table 1).

Angiographic findings

Coronary angiography before therapy showed that more than two of three of diabetic patients had multivessel disease (Table 2), compared with a 50% incidence in patients without type 2 diabetes (Table 2). Occlusion of the left anterior descending artery proximal to the first septal branch (including one patient with acute left main stem closure), the circumflex artery proximal to the marginal branch, and the right coronary proximal to the first right ventricular branch was found in 11 (19%), 4 (7%), and 9 (16%) diabetic patients, respectively, compared with 77 (22%), 41 (11%), and 51 (14%) nondiabetic patients (NS) (Table 2). TIMI flow grades (23) in the infarct vessel and collateral flow (28) were not different in type 2 versus nondiabetic patients (Table 2).

Direct PTCA

Recanalization of the infarct vessel using PTCA was attempted in 51 of 54 (94%)

Table 2—*Angiographic findings before therapy in type 2 diabetic versus nondiabetic patients (χ^2 test)*

Parameter	Diabetic patients	Nondiabetic patients	*P*
n	54	358	—
Multivessel disease	37 (69)	183 (51)	0.03
Proximal occlusion	24 (44)	169 (47)	NS
TIMI flow			NS
0	43 (80)	284 (79)	
1	4 (7)	29 (8)	
2	6 (11)	32 (9)	
3	1 (2)	13 (4)	
Collateral flow			NS
Grade 0	18 (33)	116 (32)	
Grade 1	18 (33)	121 (34)	
Grade 2 and 3	18 (33)	121 (34)	

Data are *n* (%). Contralateral flow data are based on Rentrop classification (28).

type 2 diabetic patients and in 336 (94%) nondiabetic patients. PTCA was deferred in 25 patients (6%) because of spontaneous TIMI grade 3 flow (23) (*n* = 14), emergency bypass grafting (*n* = 3), peripheral occlusion of a small vessel (*n* = 5), or intracoronary fibrinolysis (*n* = 3), irrespective of comorbidity with type 2 diabetes. PTCA was angiographically successful in 49 of 51 (96%) vs. 321 of 336 (96%) patients, respectively. Altogether, 94% of patients in both groups, 51 of 54 type 2 diabetic versus 336 of 358 nondiabetic patients, left the catheterization laboratory with an open infarct artery due to successful interventions or spontaneous reperfusion.

In-hospital course

Total mortality after 30 days was 6.1% (*n* = 25); in-hospital mortality was 5.8% for the entire population (Table 3) and 1.4% for patients without cardiogenic shock (5 of 365). Acute mortality was higher in diabetic patients (Table 3). Six of eight diabetic patients who died in-hospital had cardiogenic shock upon admission. Excluding patients with cardiogenic shock upon admission, acute mortality in diabetic patients was 4% (two patients) vs. 1% in nondiabetic patients (three patients) (NS).

Infarct size (estimated from peak creatinine kinase) and the incidence of nonsustained ventricular tachycardia on Holter before discharge were similar in both groups (Table 3). Mean LV ejection fraction before discharge, however, was 48 ± 17 (15–70) vs. 55 ± 15% (15–75) in diabetic versus nondiabetic patients ($P < 0.05$, Table 3).

In-hospital reinfarction occurred in a total of 15 patients (3.6%), in 4 (7%) patients of the type 2 diabetic group, and in 11 patients (3%) of the nondiabetic group (NS). Repeat PTCA during the initial hospital phase was required in 8 of 54 (15%) diabetic patients and in 60 of 358 (17%) nondiabetic patients (NS). Altogether, 42 patients were scheduled for bypass surgery, 8 in the diabetic group (15%) and 33 in the nondiabetic group (9%) (NS). Repeat revascularization of the infarct-related vessel (PTCA and/or bypass surgery) was performed in 11 (21%) patients with type 2 diabetes and in 63 (18%) nondiabetic patients (NS). Renal function in patients with diabetic nephropathy is vulnerable to intravenous contrast agents. Creatinine measured just before angiography and on days 1 and 2 after PTCA was significantly higher in patients with type 2 diabetes (1.2 vs. 1.1, 1.3 vs. 1.2, and 1.4 vs. 1.2 mg/dl, $P < 0.05$ for all measurements). Of 54 type 2 diabetic patients, 6 had preexisting nephropathy with creatinine >1.4 mg/dl. A transient creatinine rise to >2 mg/dl was observed in 2 of these 6 patients and in 4 of 48 diabetic patients without known nephropathy.

Type 2 diabetic nonsurvivors tended to be older, female, and generally had multivessel disease when compared with survivors (Table 4). Infarct location, comorbidity with hypertension, previous MIs, and insulin-dependency were evenly distributed between diabetic survivors and nonsurvivors (Table 4). Insulin was (temporarily) added to previous noninsulin therapy in 14 of 33 patients. Hospital death occurred in 2 of 14 patients in whom insulin was added to therapy and in 2 of 19 in whom diabetes therapy remained unchanged (NS). All smokers survived (9 of 54).

Half of 24 hospital deaths in both groups occurred within 24 h. Heart failure caused 17 of 24 hospital deaths: 2 patients had LV rupture, 1 patient experienced fatal reinfarction, and 4 fatalities were noncardiac. No differences in causes of death were seen between groups. Causes of in-hospital death in diabetic patients were LV failure (five patients), early LV rupture, pneumonia, and stroke due to cerebral metastasis of a previously unknown gallbladder carcinoma. LV rupture and cerebral metastasis were confirmed at autopsy.

Since acute mortality was significantly higher in diabetic versus nondiabetic patients, multivariate analysis was used to test whether type 2 diabetes was an independent risk indicator (Table 5). The commonly used clinical parameters sex, infarct location, advanced age, triple vessel disease, and the presence/absence of type 2 diabetes were entered into a logistic regression model. Univariate analysis of these parameters with respect to 30-day mortality had shown that sex and infarct location were not predictive, but that 30-day mortality was higher in patients ≥75 years of age (9 of 63 vs. 15 of 349, $P < 0.01$,

Table 3—*Hospital course in type 2 diabetic versus nondiabetic patients (univariate analysis)*

Parameter	Diabetic patients	Nondiabetic patients	*P*
n	54	358	—
In-hospital mortality	8 (15)	11 (4)	0.005*
30-Day mortality	7 (13)	18 (5)	0.04†
Ck_{max} (U/l)	1,100 ± 1,100	970 ± 870	NS‡
LV ejection fraction (%)	48 ± 17	55 ± 15	0.02‡
Nonsustained ventricular tachycardia	7 (13)	43 (12)	NS*
In-hospital reinfarction	4 (7)	11 (3)	NS*

Data are *n* (%) or means ± SEM. *χ^2 test; †Kaplan-Meier analysis; ‡*t* test.

Table 4—*Characteristics of hospital survivors versus nonsurvivors in the group of type 2 diabetic patients (univariate analysis)*

Parameter	In-hospital death	Hospital survivor	*P*
n	8	46	—
Sex (F/M)	5/3	20/26	NS*
Age (years)	72 ± 7	66 ± 10	NS†
Cardiogenic shock	6	5	0.002*
Anterior MI	4	22	NS*
Previous MI	2	11	NS*
Coronary status			
One-vessel disease	—	17	—
Two- or three-vessel disease	8	29	NS*
Previous noninsulin therapy	4	29	NS*
Previous insulin therapy	4	17	NS*
Diabetes duration (years)	14 ± 3	11 ± 10	NS†
Hypercholesterolemia	3	18	NS*
Hypertension	3	25	NS*

Data are *n* or means ± SEM. *χ^2 test; †*t* test.

χ^2 test), in patients with three-vessel disease (12 of 105 vs. 12 of 307, $P < 0.01$, χ^2 test), and in type 2 diabetic patients (Table 3). Logistic regression (Table 5) identified type 2 diabetes together with advanced age as independent risk factors for 30-day mortality. If, however, the clinical condition of shock was added to these parameters in Table 5, shock (odds ratio of 46) and age ≥75 years (odds ratio of 5) were the only significant indicators for early mortality. The odds ratio for type 2 diabetes predicting 30-day mortality would decrease to 1.9 (95% CI 0.5–7.1) ($P = 0.3$).

Follow-up

A total of 388 patients, 46 type 2 diabetic patients, and 342 nondiabetic patients were discharged alive. Type 2 diabetic and nondiabetic patients were followed for 3.1 ± 1.7 years and 3.1 ± 1.5 years, respectively (NS).

Recurrent MI was noted in 3 of 46 type 2 diabetic patients after discharge and in 18 of 342 patients without diabetes (NS); 16 of 21 MIs were true reinfarcts. In total, target vessel revascularization at any time was required in 118 patients (in 13 type 2 diabetic vs. 105 nondiabetic patients, NS). The relative incidence (Kaplan-Meier analysis, Mantel-Haenszel test) of target vessel revascularization was 27% in type 2 diabetic patients versus 28% in nondiabetic patients (NS) in the first year after discharge. Target vessel revascularization was bypass surgery in 47 patients, 7 of whom were diabetic (NS), and repeat PTCA in the remaining patients. A total of 52 patients had elective bypass surgery after the acute MI phase, including 47 target vessel revascularizations and 5 cases of surgery for progression of coronary artery disease in vessels other than the index vessel. Of these 52 patients, 9 were diabetic and 43 were not (NS).

Some 42 patients died during follow-up: 10 of 46 type 2 diabetic patients and 32 of 342 patients without diabetes. Kaplan-Meier analysis of cumulative mortality and mortality occurring after discharge (Table 6) showed a higher total cumulative as well as postdischarge mortality in type 2 diabetic patients at any point during follow-up. Causes of death were cardiac in 14 of 32 nondiabetic patients and in 7 of 10 type 2 diabetic patients (NS), including 4 patients with end-stage heart failure. Sudden death occurred in one diabetic patient and in seven patients without diabetes (NS). Multivariate analysis (proportional hazards model) of indicators for postdischarge mortality (Table 7) used the same parameters as in Table 5 (30-day mortality) and added LV ejection fraction that was assessed shortly before discharge. Age >75 years, three-vessel coronary artery disease, and LV ejection fraction <35% were independent risk factors for postdischarge mortality. Type 2 diabetic patients carried an odds ratio for postdischarge mortality of 1.5 (NS) compared with nondiabetic patients.

CONCLUSIONS — Immediate coronary angiography in 54 type 2 diabetic patients with acute MI shows that most of these patients (two of three) have multivessel disease. No significant differences in occlusion sites, collateral circulation, and spontaneous coronary flow rates were found between diabetic and nondiabetic patients. This finding is consistent with necropsy studies noting that diabetic patients more often had multivessel disease, but the disease was not necessarily more diffuse than in patients without diabetes (29).

Angiographic results of direct PTCA in type 2 diabetic patients are comparable to nondiabetic patients (Table 2) with angiographic patency rates of >90%. The mechanism and site of acute coronary occlusion with respect to the visible epicardial coronary arteries are not fundamentally different in type 2 diabetic versus nondiabetic patients. Significant contrast-related permanent impairment of renal function or periprocedural cranial or ocular hemorrhages did not occur. We therefore propose that the technique of direct angiography and PTCA is safe and effective in type 2 diabetic patients with acute MI.

Acute mortality in our group of diabetic patients with acute MI was 13% within 30 days. Acute mortality of <20% in an unselected and consecutive group of type 2 diabetic patients has not been reported previously. In the U.K. Prospective Diabetes Study of type 2 diabetic patients, about half of all MIs were fatal in either treatment arm (30). The DIGAMI study (31) found 1,240 patients eligible, but included only 620 patients; about half of them received thrombolysis. The 30-day mortality in this selected group of patients ranged from 10 to 15%. The TAMI study (32) in 1,071 selected

Table 5— *Independent indicators of 30-day mortality in patients with acute MI (logistic regression model)*

Variable	Odds ratio (95% CI)	*P* value
Female sex	1 (0.3–2.8)	NS
Anterior MI	1.2 (0.5–3.3)	NS
Age >75 years	3.3 (1.2–9.5)	0.03
Three-vessel disease	2 (0.7–5.5)	NS
Type 2 diabetes	3.4 (1.1–10)	0.03

Table 6—*Total cumulative mortality and mortality after discharge in type 2 diabetic and nondiabetic patients (Kaplan-Meier analysis, Mantel-Haenszel χ^2 test)*

	Type 2 diabetic patients	Nondiabetic patients	*P* value
Cumulative mortality			
6 months	19	6	0.004
1 year	24	8	<0.001
2 years	27	9	<0.001
3 years	31	12	0.001
Postdischarge mortality			
6 months	4	2	NS
1 year	11	4	0.02
2 years	14	5	0.02
3 years	19	8	NS

Data are %.

patients found an in-hospital mortality of 11% in diabetic patients that was nearly twice as high as that in nondiabetic patients. Although results from different studies can only be compared with extreme caution, we suspect that the moderate 30-day mortality of 13% in our unselected type 2 diabetic patients is clinically meaningful and related to early and complete revascularization of the infarct artery in our patients.

Yet, mortality after 30 days in type 2 diabetic patients with acute MI remains significantly higher than in patients without diabetes (13 vs. 5%). We found, as others have (7,9–11,32,33), several factors in patients with diabetes that are likely to act in unfavorable concert: *1*) advanced coronary artery disease, *2*) a high incidence (20%) of cardiogenic shock, *3*) a high comorbidity with arterial hypertension (52%), *4*) advanced age (66 ± 9 years) at the time of the index MI, and 5) a high percentage of women, who are suspected to have a worse acute prognosis after MI than men (3,32,34). Blunted anginal pain perception in diabetic patients may account for our observation that type 2 diabetic patients present later in the disease process and, therefore, have more advanced coronary artery disease and shock at the time of the index MI (32). However, after correction for these variables in diabetic patients, logistic regression still identified type 2 diabetes as a risk factor for acute mortality (Table 5).

It has been reported that long-term results of elective PTCA for chronic coronary artery disease are less favorable in diabetic patients because of frequent restenosis or rapid progression of atherosclerosis (35–39). Event-free survival after PTCA for non–Q-wave infarction was also found to be worse in diabetic patients (40). Therefore, we followed the survivors of the acute phase in both patient groups for >3 years. Reinfarction and target vessel revascularization tended to occur more frequently in patients with type 2 diabetes, but this trend did not reach statistical significance. We propose that the favorable effects of direct PTCA in the acute infarct phase were not rapidly reversed by extensive restenosis rates or progression of the coronary artery disease in type 2 diabetic patients because it was observed after elective PTCA in stable diabetic patients.

Late total mortality after discharge was higher in type 2 diabetic patients than in nondiabetic patients after 1 and 2 years (Table 6). Cumulative 1-year mortality was 24% in our group of patients, compared with 22% in the DIGAMI study (31). The proportional hazards model, however, failed to identify type 2 diabetes as an independent risk factor for mortality after discharge (Table 7). The incidence of sudden, presumably arrhythmogenic, death was not increased in our group of type 2 diabetic patients (1 of 10 deaths) despite recent concerns (41,42).

Limitations of the study

The total number of type 2 diabetic patients in this study is small (n = 54). However, patients were unselected, and probably representative: the incidence of type 2 diabetes among the entire cohort (13%), the distribution of sex, and the advanced age of patients with diabetes is in accordance with demographic information derived from recent megatrials (10,11). Because the percentage of diabetic patients with acute MI is generally around 10–15%, single-center experiences in diabetic patients with acute MI will always be limited. In addition, this study does not permit any conclusion as to which recanalization regime, i.e., intravenous lysis or direct PTCA, is preferable in diabetic patients amenable to both strategies. But such information would be clinically relevant. Again, because of the small percentage of type 2 diabetic patients among all patients with acute MI, single-center prospective comparisons between both strategies including much larger numbers of patients will be difficult to obtain. Multicenter comparisons could include many more diabetic patients but are limited by other factors, such as variable PTCA expertise.

Clinical implications and conclusion

Direct PTCA in type 2 diabetic patients with acute MI is feasible and safe. Angiographic results are as favorable as those in patients without diabetes. Acute mortality can be reduced to <20%. Therefore, direct PTCA performed by experienced operators can be used in type 2 diabetic patients with acute MI as a general strategy as well as an alternative approach if intravenous fibrinolysis is contraindicated. Yet, hospital mortality in unselected type 2 diabetic patients is threefold higher than that in nondiabetic control patients. Increased age, more advanced coronary disease, comorbidity with arterial hypertension, and, most importantly, a high incidence of cardiogenic shock explain only in part the poorer survival of diabetic patients with acute MI. Favorable acute results of direct PTCA are maintained during follow-up. However,

Table 7—*Independent indicators of postdischarge mortality (proportional hazards model)*

Variable	Odds ratio (95% CI)	*P* value
Female sex	1.8 (0.8–4.2)	NS
Anterior MI	1.5 (0.7–3.4)	NS
Age >75 years	2.5 (1.0–5.9)	0.05
Three-vessel disease	2.6 (1.2–5.5)	0.015
Type 2 diabetes	1.5 (0.6–3.7)	NS
LV ejection fraction <35%	3.6 (1.5–8.7)	0.004

since their clinical course is unstable, diabetic patients should be followed carefully after the MI.

References

1. Czyzk A, Krolewski AS, Szablowska S, Alot A, Kopczynski J: Clinical course of myocardial infarction among diabetic patients. *Diabetes Care* 3:526–529, 1980
2. Smith JW, Marcus Fl, Serokman R, for the Multicenter Postinfarction Research Group: Prognosis of patients with diabetes mellitus after acute myocardial infarction. *Am J Cardiol* 54:718–721, 1984
3. Savage MP, Krolewski AS, Kenien GG, Lebeis MP, Christlieb AR, Lewis SM: Acute myocardial infarction in diabetes mellitus and significance of congestive heart failure as a prognostic factor. *Am J Cardiol* 62:665–669, 1988
4. Singer DE, Moulton AW, Nathan DM: Diabetic myocardial infarction: interaction of diabetes with other preinfarction risk factors. *Diabetes* 38:350–357, 1989
5. Stone PH, Muller JE, Hartwell T, York BJ, Rutherford JD, Parker CB, Turi ZG, Strauss W, Braunwald E, Jaffe AS, and the MILIS study group: The effect of diabetes mellitus on prognosis and serial left ventricular function after acute myocardial infarction: contribution of both coronary artery disease and diastolic left ventricular dysfunction to the adverse prognosis. *J Am Coll Cardiol* 14:49–57, 1989
6. Mueller HS, Cohen HS, Braunwald E, Forman S, Feit F, Ross A, Schweiger M, Cabin H, Davison R, Miller D, Solomon R, Knatterrud GL, for the TIMI Investigators: Predictors of early morbidity and mortality after thrombolytic therapy for acute myocardial infarction: analyses of patient subgroups in the TIMI trial, phase II. *Circulation* 85:1254–1264, 1992
7. Zuanetti G, Latini R, Maggioni AP, Santoro L, Franzosi MG, for the GISSI-2 Investigators: Influence of diabetes on mortality in acute myocardial infarction: data from the GISSI-2 study. *J Am Coll Cardiol* 22:1788–1794, 1993
8. Kodama K, Sakagashira S, Hori M: Prognostic significance of diabetes mellitus in patients with acute myocardial infarction after recanalization. *Diabetes Res Clin Pract* 30:71–75, 1996
9. Woodfield S, Lundergan CF, Reiner JS, Greeenhouse SW, Thompson MA, Rohrbeck SC, Deychak Y, Simoons ML, Califf RM, Topol EJ, Ross AM, for the GUSTO-I Angiographic Investigators: Angiographic findings and oucome in diabetic patients treated with thrombolytic therapy for acute myocardial infarction: the GUSTO-I experience. *J Am Coll Cardiol* 28:1661–1669, 1996
10. Mak KH, Moliterno DJ, Granger CB, Miller DP, White HD, Wilcox RG, Califf RM, Topol EJ: Influence of diabetes mellitus on clinical outcome in the thrombolytic era of acute myocardial infarction. *J Am Coll Cardiol* 30:171–179, 1997
11. Zuanetti G, Latini R, Maggioni AP, Franzosi MG, Santoro L, Tognoni L, for the GISSI-3 Investigators: Effect of the ACE inhibitor lisinopril on mortality in diabetic patients with acute myocardial infarction: data from the GISSI-3 study. *Circulation* 96:4239–4245, 1997
12. Chun BY, Dobson AJ, Heller RF: The impact of diabetes on survival among patients with first myocardial infarction. *Diabetes Care* 20:704–708, 1997
13. Jacoby RM, Nesto RW: Acute myocardial infarction in the diabetic patient: pathophysiology, clinical course and prognosis. *J Am Coll Cardiol* 20:736–744, 1992
14. Orlander P, Goff D, Morrissey M, Ramsey D, Wear M, Labarthe D, Nichaman M: The relation of diabetes to the severity of acute myocardial infarction and post-myocardial infarction survival in Mexcican-Americans and non-Hispanic whites. *Diabetes* 43:897–902, 1994
15. DeWood M, Spores J, Notske M, Mouser L, Burroughs R, Golden M, Lang H: Prevalence of total coronary occlusion during the early hours of transmural myocardial infarction. *N Engl J Med* 303:897–902, 1980
16. Davies M, Thomas A: Plaque fissuring: the cause of acute myocardial infarction, sudden ischemic death and crescendo angina. *Br Heart J* 53:363–373, 1985
17. Gibbons RJ, Holmes DR, Reeder GS, Bailey KR, Hopfenspirger MR, Gersh BJ, for the Mayo Coronary Care Unit and Catheterization Laboratory Groups: Immediate angioplasty compared with the administration of a thrombolytic agent followed by conservative treatment for myocardial infarction. *N Engl J Med* 328:685–691, 1993
18. Grines CL, Browne KF, Marco J, Rothbaum D, Stone GW, O'Keefe J, Overlie P, Donohue B, Chelliah N, Timmis GC, Vlietstra RE, Strzelecki M, Puchrowicz-Ochocki S, O'Neill WW, the Primary Angioplasty in Myocardial Infarction Study Group: A comparison of immediate angioplasty with thrombolytic therapy for myocardial infarction. *N Engl J Med* 328:673–679, 1993
19. Zijlstra F, de Boer MJ, Hoorntje JCA, Reiffers S, Reiber JHC, Suryapranata H: A comparison of immediate coronary angioplasty with intravenous streptokinase in acute myocardial infarction. *N Engl J Med* 328:680–684, 1993
20. GUSTO-IIb Angioplasty Substudy Investigators: A clinical trial comparing primary coronary angioplasty with tissue plasminogen activator for acute myocardial infarction. *N Engl J Med* 336:1621–1628, 1997
21. Lew AS, Hod H, Cercek B, Shah P, Ganz W: Mortality and morbidity rates of patients older and younger than 75 years with acute myocardial infarction treated with iv streptokinase. *Am J Cardiol* 59:1–5, 1987
22. Expert Committee on the Diagnosis and Classification of Diabetes Mellitus: Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. *Diabetes Care* 21 (Suppl. 1):S5–S19, 1998
23. Chesebro J, Knatterud G, Roberts R, Borer J, Cohen L, Dalen J, Francis C, Hillis D, Ludbrook P: Thrombolysis in myocardial infarction (TIMI) trial, phase I: a comparison between intravenous tissue plasminogen activator and streptokinase. *Circulation* 765:142–157, 1987
24. Committee on Management of Acute Myocardial Infarction: ACC/AHA guidelines for the management of patients with acute myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol* 28:1328–1419, 1996
25. Hanushek EA, Jackson JE: *Statistical Methods for Social Scientists.* New York, Academic, 1977
26. Kaplan EL, Meier P: Nonparametric estimation from incomplete observations. *J Am Statist Ass* 53:457–481, 1958
27. Lawless JF: Statistical models and methods for lifetime data. New York, Wiley, 1982
28. Rentrop K, Cohen M, Blanke H, Phillips R: Changes in collateral filling immediately following controlled coronary occlusion by an angioplasty balloon in man. *J Am Coll Cardiol* 5:587–592, 1985
29. Waller B, Palumbo P, Roberts W: Status of the coronary arteries at necropsy in diabetes mellitus with onset after age 30 years. *Am J Med* 69:498–506, 1980
30. UK Prospective Diabetes Study Group: Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). *Lancet* 352:837–853, 1998
31. Malmberg K, Ryden L, Efendic S, Herlitz J, Nicol P, Waldenstroem A, Wedel H, Welin L, on behalf of the DIGAMI study group: Randomized trial of insulin-glucose infusion followed by subcutaneous insulin treatment in diabetic patients with acute myocardial infarction (DIGAMI study): effects on mortality at 1 year. *J Am Coll Cardiol* 26:57–65, 1995
32. Granger C, Califf R, Young S, Candela R, Samaha J, Worley S, Kereiakes D, Topol E: Outcome of patients with diabetes mellitus and acute myocardial infarction treated with thrombolytic agents: the thrombolysis and angioplasty in myocardial infarction (TAMI) study group. *J Am Coll Cardiol* 21:920–925, 1993
33. Fava S, Azzopardi J, Muscat H, Fenech F: Factors that influence outcome in diabetic subjects with myocardial infarction. *Diabetes Care* 16:1615–1618, 1993

34. Tansey M, Opie L, Kennelly B: High mortality in obese women with acute myocardial infarction. *Br Med J* 1:1624–1626, 1977
35. Deligonul U, Vandormael M, Kern M, Galan K: Repeat coronary angioplasty for restenosis: results and predictors of follow-up clinical events. *Am Heart J* 117: 997–1002, 1989
36. Ellis S, Vandormael M, Cowley M: Coronary morphologic and clinical determinants of procedural outcome with angioplasty for multivessel coronary disease. *Circulation* 82:1193–1201, 1990
37. Kip KE, Faxon DP, Detre KM, Yeh W, Kelsey SF, Currier JW, for the Investigators of the NHLBI PTCA Registry: Coronary angioplasty in diabetic patients: the NHLBI PTCA Registry. *Circulation* 94:1818–1825, 1996
38. The BARI investigators: Influence of diabetes on 5-year mortality and morbidity in a randomized trial comparing CABG and PTCA in patients with multivessel disease: the Bypass Angioplasty Revascularization Investigation (BARI). *Circulation* 96:1761–1769, 1997
39. Barsness GW, Peterson ED, Ohman ME, Nelson CL, DeLong DR, Reves JG, Smith PK, Anderson D, Jones RH, Mark DB, Califf RM: Relationship between diabetes mellitus and long-term survival after coronary bypass and angioplasty. *Circulation* 96:2551–2556, 1997
40. Gowda M, Vacek J, Hallas D: One-year outcomes of diabetic vs nondiabetic patients with non-Q-wave acute myocardial infarction treated with percutaneous transluminal coronary angioplasty. *Am J Cardiol* 81:1067–1071, 1998
41. Rathman W, Ziegler D, Jahnke M, Haastert B, Gries F: Mortality in diabetic patients with cardiovascular autonomic neuropathy. *Diabet Med* 10:820–824, 1993
42. Stevens M, Raffel D, Allman K, Dayanikli F, Ficaro E, Sandford T, Wieland D, Pfeifer M, Schwaiger M: Cardiac sympathetic dysinnervation in diabetes: implications for enhanced cardiovascular risk. *Circulation* 98:961–968, 1998