Registers in cardiovascular epidemiology

Reitsma, J.B.

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Patterns of cardiovascular readmissions and death after acute myocardial infarction

JB Reitsma, GJ Bonsel, RMC Herings,
SH Heisterkamp, RW Koster, JGP Tijssen

ABSTRACT

Objective - To analyse the pattern of cardiovascular readmissions and death in hospital survivors of acute myocardial infarction, focusing on differences between men and women and on the importance of diabetes mellitus.
Design - Population-based cohort study using linked hospital discharge data.
Subjects - All hospital survivors of acute myocardial infarction from six medium-sized cities in The Netherlands discharged between January 1, 1981, and December 31, 1987.
Main outcome measures - Cardiovascular readmission rates per three month interval after the initial discharge for acute myocardial infarction. Time to readmission for different cardiovascular conditions or death for men *vs.* women and diabetic *vs.* nondiabetic patients. Models without and with adjustment for age and other base-line characteristics. Multiple failure model analysing up to three readmissions.
Results - The initial cohort of hospital survivors of acute myocardial infarction comprised 1,101 men and 418 women. Women were on average 6.4 years older (P=0.0001) than men and had a higher prevalence of diabetes (18 *vs.* 7%; P=0.001). The median duration of follow-up was 2.5 years. The highest rate of cardiovascular readmissions was observed during the first three months after the initial discharge, mainly (68%) due to coronary heart disease. The unadjusted relative risk of death for women as compared with men was 1.32 (95% confidence interval (CI) 0.90 to 1.93). After adjustment for age, this relative risk was reduced to 0.88 (95% CI 0.59 to 1.31), and to 0.73 (95% CI 0.49-1.11) after adjustment for other base-line characteristics. No excess risk was seen for women, both unadjusted and adjusted, when modelling the time to the combined endpoint of first cardiovascular readmission or death. Diabetic patients were at a higher risk of dying (unadjusted relative risk 3.12; 95% CI 2.06 to 4.71) and of being readmitted for all types of cardiovascular readmissions, but in particular for heart failure (unadjusted relative risk 3.72; 95% CI 2.68 to 5.15) and for stroke (unadjusted relative risk 3.48; 95% CI 2.40 to 5.03). These risks were only slightly reduced after adjustment for base-line characteristics.
Conclusions - The highest rate of cardiovascular readmissions was seen during the first three months following discharge. The excess risk of mortality for women disappeared, and was even reversed after adjustment. The risk of being readmitted was similar for men and women. Diabetic patients had a substantial higher risk of dying and of being readmitted for all cardiovascular conditions, but in particular for heart failure and stroke.

INTRODUCTION

The prognosis of patients with acute myocardial infarction has improved considerably over the past two decades.[1-3] Improvements in the acute care and in the secondary prevention of patients with myocardial infarction have contributed to this longer survival.[3,4]

Despite the available treatment options, survivors of acute myocardial infarction still have an increased risk of recurrent coronary syndromes, of other manifestations of atherosclerosis, of arrhythmias, of developing heart failure, and of death.[4-6] The majority of the large studies investigating the clinical consequences after myocardial infarction have focused on mortality alone, or on mortality combined with recurrent myocardial infarction.[4,7-9] The pattern of cardiovascular readmissions after acute myocardial infarction has been analysed in only a few studies with limited numbers of patients.[10-16] The development of other manifestations of atherosclerosis and of chronic conditions has become a major issue due to the growing number of patients in which premature death has been prevented due to advances in the treatment of myocardial infarction. Longitudinal data, in which a large and unselected group of patients with myocardial infarction is followed for a sufficient period of time, are needed to appropriately describe this complex process and to evaluate the price of initial success in these patients.[8]

We used linked hospital discharge data to describe the pattern of cardiovascular readmissions in a cohort of hospital survivors of myocardial infarction from several hospitals in the Netherlands. Record linkage techniques were used to recognise readmissions in the absence of a unique personal identifier. We determined the frequency, timing and causes of readmissions in this cohort, and to study clinical factors associated with an increased risk of readmission or death. Our main focus was on differences between men and women and on the importance of diabetes mellitus.

METHODS

Sources of data

This study is based on data from the PHARMO record linkage system, a database integrating drug dispensing records from community pharmacies and hospital discharge records of 6 medium-sized cities in The Netherlands, with an estimated population size of 300,000.[17] The hospital records were obtained from SIG Health Care Information. All hospital admissions in The Netherlands are recorded in a central database held by SIG Health Care Information. The records of this database contain both administrative and

clinical data, including age and sex of the patient, up to ten discharge diagnoses, up to six operation codes, and status at discharge (dead or alive). All diagnoses at discharge were coded according to the 9th version of the *Clinical Modification of the International Classification of Diseases* (ICD-9-CM).

All general and university hospitals participate in the national register (complete coverage), and a single institution is responsible for the training in coding of hospital staff. The register, however, does not contain a unique personal identifier to recognise readmissions. We combined several personal variables to obtain a sufficiently discriminating system to recognise records (admissions) belonging to the same patient. Key variables in our linkage algorithm were gender, date of birth, family practitioner code and postal code. The linkage algorithm acknowledges the fact that errors are present in variables derived from routine data sources (probabilistic linkage).[18,19] Information about when people moved out of the region, died, or switched to another family practitioner was recorded in the drug-dispensing data of the community pharmacies. In a previous validation study, examining a sample of 9,822 pairs of records and using the same linkage algorithm as in this study, both specificity and sensitivity were above 95%.[17] This accuracy is comparable to a linkage system based on a unique personal identifier.[19]

Study population and readmissions

The people studied were citizens of six cities who were discharged alive between January 1, 1981, and December 31, 1987 after hospitalisation for acute myocardial infarction. This cohort included both patients with a first myocardial infarction and patients with a reinfarction. The follow-up of the hospital survivors started at the date of discharge of the initial admission for acute myocardial infarction (index event). The end of follow-up was the date of death, out-migration, or January 1, 1988, whichever occurred first. We used the linked discharge and drug-dispensing database to identify readmissions and death from patients of the cohort. If present, multiple readmissions from the same patient were recorded.

We used ICD-9-CM code 410 to identify the index admission for acute myocardial infarction. Readmissions were included if their primary discharge diagnoses fell into the group of diseases of the circulatory system (group VII of the ICD classification rubrics 390 to 459). Within this group the following causes were analysed separately: coronary heart disease (ICD-9-CM 410-414), heart failure (428), stroke (430-438), and peripheral vascular disease (440-448). All readmissions were classified based on the primary discharge diagnosis.

Patients were considered diabetic if they had discharge diagnosis of diabetes mellitus (ICD-CM 250.x) in any position before, during or shortly after the initial hospitalisation for acute myocardial infarction. Patients were classified as having had a previous myocardial infarction if they had an additional discharge diagnosis of old myocardial infarction (ICD code 412), or a non-primary discharge diagnosis of myocardial infarction before the index admission. The detection of prior hospitalisations was restricted to hospital admissions from January 1, 1981 onwards. Patients were classified as having heart failure during the initial admission for acute myocardial infarction, if there was an additional discharge diagnosis of heart failure.

We could analyse only all cause mortality, as both the discharge data and the drug dispensing data do no contain information about the cause of death.

Statistical analyses

Base-line characteristics of the initial cohort of hospital survivors were compared using Student's t tests and χ^2 tests. The crude readmission rates were calculated by summing up all cardiovascular readmissions per three month interval and dividing it by the total follow-up time in that particular interval.

The readmission status of patients at different time points during follow-up were based on Kaplan-Meier estimates. We used the Cox proportional-hazards model to examine the association between the time to first readmission or death and the presence of base-line characteristics. We analysed the importance of sex and diabetes separately. We first did an unadjusted analysis (only sex or diabetes), then a model adjusting for age (linear), and finally a model including sex, age, presence of diabetes, presence of heart failure, and an indicator for previous myocardial infarction. Ties in all models were handled according to Efron's method.[20]

In addition, we did a multiple failure (readmission) time analysis. Patients with chronic diseases may experience repeated occurrences of the same event or several events of an entirely different nature. We analysed up to three cardiovascular readmissions per patient. The dataset was set up as described in scenario I of the article of Li and Lagakos.[21] In this scenario, there is a time to first, second, third readmission and a time to death. Patients who die before a first, second or third readmission are regarded as censored observations for these readmissions. Event four (death) is uncensored unless the subject experiences end-of-study censoring. Data was analysed using the approach of Wei, Lin, and Weissfeld.[22,23] This is a marginal approach, initially ignoring the correlation between failures to estimate the coefficients for each readmission

(failure type). A consistent estimate of the variance of the coefficients is calculated afterwards, by using a so-called sandwich estimator.

In all analyses, a P value of 0.05 or less was considered to indicate statistical significance. All statistical analyses were done in SAS for Windows version 6.12, except for the multiple failure Cox model for which we used S-Plus for Windows version 4.5.

RESULTS

Cohort enrolment and base-line characteristics

Between January 1, 1981, and December 31, 1987, a total of 1,652 patients (72% male) were hospitalised for acute myocardial infarction. During the initial stay, 85 men (7.2%) and 48 women (10.3%) died (P=0.04). The remaining 1,519 hospital survivors were studied for subsequent readmissions, with a median duration of follow-up of 30 months. Women were on average 6.4 years older than men and had a higher prevalence of diabetes and congestive heart failure (table 1). Diabetic patients were on average 5.2 years older than nondiabetic patients (P=0.0001), and had more often symptoms of congestive heart failure during the initial admission (21.7% *vs.* 6.8%; P=0.001).

Table 1. Characteristics of the cohort of hospital survivors (N=1,519) following initial hospitalisation for acute myocardial infarction between January 1, 1981 and December 31, 1987 in one of six participating hospitals.

Characteristic	Men (N=1,101)	Women (N=418)	P-value
Age in years			
Mean±SD	56.4±11.7	62.7±12.3	0.0001
Median (P_{50})	57	64	
P_{25}-P_{75}	49-65	56-72	
Length of initial stay in days[†]			
Mean±SD	14.3±6.8	17.2±11.6	0.0001
Median (P_{50})	13	14	
P_{25}-P_{75}	11-16	11-19	
% of patients with history of acute myocardial infarction (no.)	4.5% (50)	3.3% (14)	0.3
% of patients with diabetes (no.)	7.1% (78)	17.7% (74)	0.001
% of patients with heart failure (no.)	6.9% (76)	12.0% (50)	0.001

[†] *t* test based on log transformed values (^{10}base) because of skewness of the data.

Readmission rate and causes of readmissions

During the entire follow-up period there were 800 cardiovascular readmissions caused by 524 patients. The highest readmission rate, around 160 readmissions per 1,000 patients, was observed in the first three months following discharge (figure 1). The majority of these readmissions (68%) was related to coronary heart disease. From nine months onwards, the rate of readmission was more or less stable with an average rate of about 35 readmissions per 1,000 patients per three month interval. Differences in crude readmission rates between men and women were small (upper panel figure 1). The highest readmission rate for diabetic patients was also found during the first three months after discharge, although the rate was nearly two-fold higher compared with nondiabetic patients (lower panel figure 1). The relative differences in readmission rates between diabetic and nondiabetic patients became slightly larger after the first three months.

The majority of all cardiovascular readmissions was caused by coronary heart disease (61%), followed by readmissions for heart failure (17%), for peripheral vascular disease (7%) and for stroke (5%). Acute myocardial infarction was the primary discharge diagnosis of 24% of all coronary readmissions. Coronary readmissions were more prominent among men (65%) than women (52%), while the proportion of readmissions related to congestive heart failure was higher in women (24%) than in men (14%). Heart failure readmissions were a prominent feature among diabetic patients, causing 37% of all readmissions compared with 13% in nondiabetic patients. Over time, the relative importance of coronary readmissions decreased, while the significance of more chronic conditions, such as heart failure and peripheral vascular disease increased. Among all first readmissions 67% was related to coronary diseases compared with 45% among third or higher readmissions. For heart failure and peripheral vascular disease, these percentages were 15% and 27%, and 4% and 16%, respectively.

Table 2 shows the distribution of patients according to their vital status and number of readmissions. Two years after the initial myocardial infarction, around 7% of all patients had died, 64% was alive and without any readmission, 21% was alive with one readmission, 6% alive with two readmissions, and 2% was alive and readmitted at least three times. These percentages were more or less similar among men and women. Diabetic patients fared much worse than nondiabetics (table 2).

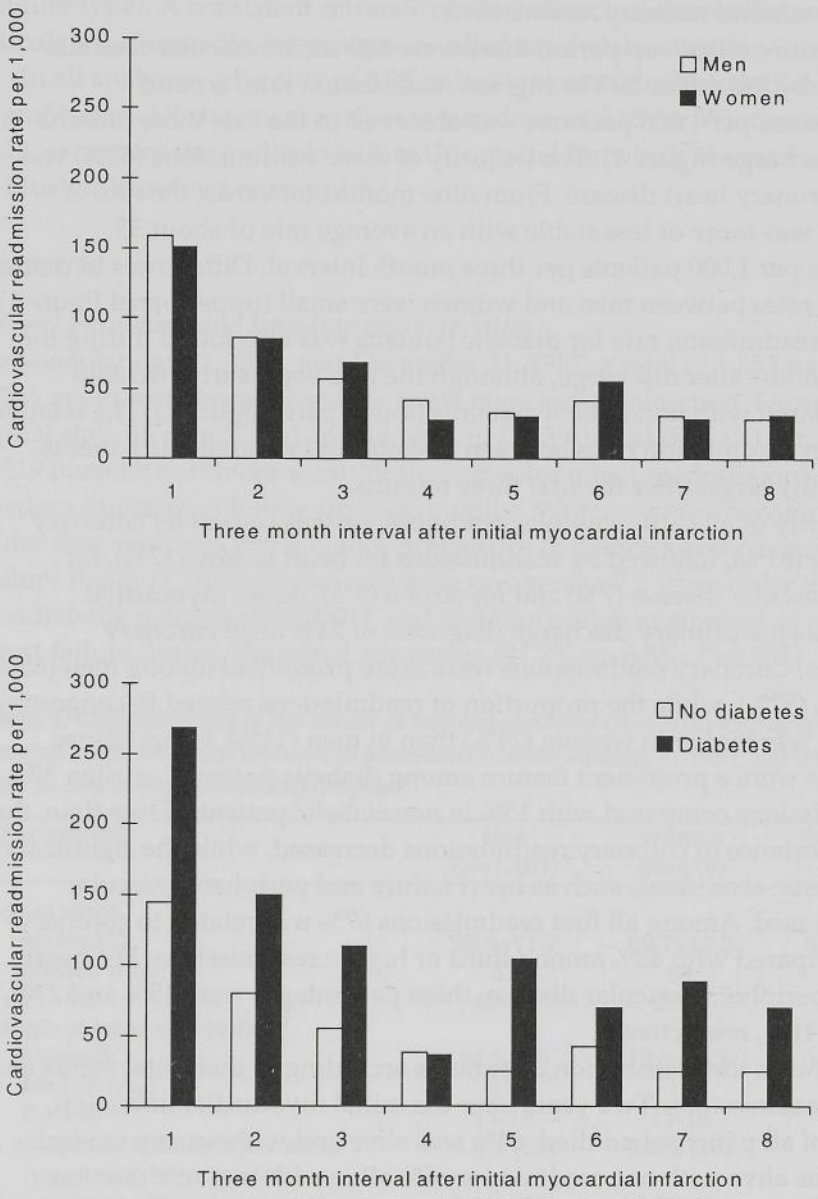

Figure 1. Cardiovascular readmission rate per 1,000 men and women (upper panel) and per 1,000 nondiabetic and diabetic patients (lower panel) for each three month interval after the initial discharge for acute myocardial infarction. The bars show crude readmission rates for each interval.

Table 2. Distribution of patients (in %) according to their number of readmissions at one, two and three years after discharge for the initial admission for acute myocardial infarction. Differences by sex and presence of diabetes mellitus.

Readmission status	One year after initial discharge				Two years after initial discharge				Three years after initial discharge			
	Men	Women	no DM	DM	Men	Women	no DM	DM	Men	Women	no DM	DM
Alive and without readmission	72.0	72.1	73.3	60.4	63.7	63.5	66.0	42.1	59.0	57.0	61.1	35.6
One readmission and alive	18.5	19.7	18.3	23.0	21.4	21.4	20.9	26.4	22.9	22.2	22.3	26.9
Two readmissions and alive	4.4	2.9	3.9	4.9	6.5	3.1	5.3	8.5	6.3	5.7	5.5	10.7
Three or more readmissions and alive	1.3	0.5	0.9	3.0	2.3	2.9	2.3	4.2	3.9	3.4	3.6	5.4
Dead	3.9	4.8	3.6	8.7	6.0	9.1	5.5	18.8	7.8	11.7	7.5	21.5

DM = diabetes mellitus.

Time to first cardiovascular readmission or death

In the unadjusted analysis, women had a higher risk of dying and of being readmitted for heart failure or for stroke (table 3). Only the risk of being readmitted for coronary heart disease was lower in women than in men in the unadjusted analysis. The excess risk for women disappeared or was even reversed after age was included in the model. A further reduction was observed when other base-line characteristics were introduced.

Diabetic patients had a 3.1 higher risk of dying than nondiabetic patients. This excess risk decreased slightly when other factors were introduced. The presence of diabetes was associated with higher rates of readmission for all causes (table 3). As a result, only 42% of the diabetic patients was alive and without a readmission after two years compared with 66% in patients without diabetes (table 2). In particular, diabetic patients were at a higher risk of being readmitted for heart failure (relative risk 3.72; 95% CI 2.68 to 5.15) and for stroke (relative risk 3.48; 95% CI 2.40 to 5.03). In the full model these relative risks were lower (table 3), mainly because diabetic patients were on average five years older than nondiabetic patients and had a higher prevalence of heart failure symptoms during the initial admission for acute myocardial infarction.

Multiple readmission model according to Wei-Lin-Weissfeld

In the multiple failure Cox model we analysed the time up to three readmissions. In general, men and women had a similar risk of being readmitted after adjustment for base-line characteristics, although the risk of being readmitted for the second and third time was non-significantly lower in women (table 4).

The smallest relative risk for diabetes was observed for the time to first readmission (relative risk 1.73; 95% CI 1.35 to 2.22), the relative risk increased to 2.55 (95% CI 1.68 to 3.87) for the second readmission and remained more or less stable for the third readmission (relative risk 2.24; 95% CI 1.09 to 4.60).

As expected, age was strongly related to death, but was not associated with a higher rate of cardiovascular readmissions, whether first, second or third.

Patients presenting with heart failure symptoms during the initial admission had a higher risk of being readmitted than patients without signs of heart failure. The importance of initial heart failure symptoms increased with every readmission. The adjusted relative risk rose from 1.77 (95% CI 1.31 to 2.39) for the first readmission, to 2.65 (95% CI 1.69 to 4.16) for the second, to 4.83 (95% CI 2.65 to 8.82) for the third. Patients with previous myocardial infarction were at an increased risk of being readmitted, but had no excess risk of dying.

Table 3. The effect of sex and diabetes on the risk of several cardiovascular readmission or death in patients after their initial myocardial infarction. Unadjusted relative risks, relative risks after adjustment for age, and after adjustment for age and other base-line variables[†].

Time to different readmissions or death	Female sex			Presence of diabetes		
	Unadjusted RR (95% CI)	RR adjusted for age (95% CI)	RR adjusted for age and other covariates[†] (95% CI)	Unadjusted RR (95%CI)	RR adjusted for age (95% CI)	RR adjusted for age and other covariates[†] (95% CI)
Death	1.32 (0.90-1.93)	0.88 (0.59-1.31)	0.73 (0.49-1.11)	3.12 (2.06-4.71)	2.40 (1.58-3.64)	2.30 (1.48-3.58)
First CVD or death	1.04 (0.86-1.25)	0.99 (0.82-1.20)	0.92 (0.76-1.12)	1.94 (1.55-2.44)	1.90 (1.51-2.39)	1.73 (1.37-2.20)
First CHD or death	0.83 (0.67-1.04)	0.84 (0.67-1.06)	0.79 (0.63-0.99)	1.57 (1.20-2.05)	1.61 (1.23-2.10)	1.61 (1.22-2.12)
First HF or death	1.46 (1.08-1.98)	0.97 (0.71-1.34)	0.78 (0.56-1.10)	3.72 (2.68-5.15)	2.90 (2.08-4.04)	2.48 (1.75-3.53)
First stroke or death	1.39 (0.98-1.97)	0.94 (0.65-1.35)	0.78 (0.54-1.14)	3.48 (2.40-5.03)	2.70 (1.86-3.94)	2.63 (1.77-3.90)
First PVD or death	1.19 (0.84-1.69)	0.83 (0.58-1.20)	0.71 (0.49-1.04)	2.82 (1.93-4.13)	2.24 (1.52-3.30)	2.26 (1.51-3.39)

[†] full model includes sex, age, presence of diabetes or heart failure, and previous myocardial infarction.
RR = relative risk; CI = confidence interval; CVD = cardiovascular disease; CHD = coronary heart disease; HF = heart failure; PVD = peripheral vascular disease.

Table 4. Multiple failure Cox model (model according to Wei, Lin and Weissfeld) analysing time to first, second, third cardiovascular readmission and death.

Predictor	Time to first readmission RR (95% CI)	Time to second readmission RR (95% CI)	Time to third readmission RR (95% CI)	Time to death RR (95% CI)
Female sex	0.98 (0.80-1.20)	0.77 (0.52-1.14)	0.79 (0.39-1.60)	0.73 (0.47-1.14)
Diabetes	1.73 (1.35-2.22)	2.55 (1.68-3.87)	2.24 (1.09-4.60)	2.30 (1.45-3.67)
Age per 10-year increment	0.97 (0.90-1.04)	0.99 (0.87-1.13)	0.89 (0.72-1.09)	1.69 (1.39-2.06)
Heart failure	1.77 (1.31-2.39)	2.65 (1.69-4.16)	4.83 (2.65-8.82)	2.00 (1.22-3.27)
Previous AMI	1.82 (1.27-2.60)	1.61 (0.83-3.12)	2.06 (0.81-5.26)	0.90 (0.36-2.25)

RR = relative risk; CI = confidence interval; AMI = acute myocardial infarction.

Discussion

Cardiovascular readmissions were common in our cohort of hospital survivors of acute myocardial infarction from several hospitals in the Netherlands. The highest rate of readmission was observed within the first three months after the initial discharge. The majority of the cardiovascular readmissions was caused by (recurrent) coronary events, but over time there was a shift towards chronic conditions, like congestive heart failure and peripheral vascular disease. The proportion of patients alive and free of any cardiovascular readmission after one year was 72% in both men and women.

Surprisingly few studies have analysed the pattern of readmissions after acute myocardial infarction, especially given the fact that cardiovascular diseases are among the diagnostic groups most often associated with multiple hospitalisations.[24] The reasons to readmit patients with initial myocardial infarction to the hospital are diverse and include the progression of coronary atherosclerosis requiring diagnostic work-up and/or revascularisation, the occurrence of significant cardiac events such as unstable angina pectoris, reinfarction, cardiac arrhythmias, congestive heart failure, as well as poor general health and emotional well-being.[15] In other studies describing readmission patterns, the proportion of patients readmitted after acute myocardial infarction was 10 to 22% after six months,[13,15] 32 to 54% after one year,[10,12,14] and 54 and 60% after five year.[11,12] Our results are somewhat lower with 28% readmitted after one year and 41% after three years. The comparison is hampered by differences in age and other base-line characteristics of the populations, by the type of readmissions that have been studied (all conditions

as opposed to cardiovascular and coronary readmissions only) and by differences in the way mortality was handled. In particular, the all cause readmission rate among Medicare beneficiaries (United States) was extremely high, with an average rate of about 700 readmissions per 1,000 patients in the first three months compared with 157 cardiovascular readmissions in our study.[16] One additional explanation that could explain this large difference in readmission rate is the more aggressive approach to diagnose and treat remaining coronary ischemia in the United States.[25]

Differences between men and women

The risk of dying for women as compared with men was lower after adjustment for age and diabetes mellitus. Many articles have focused on the differences in mortality between men and women following myocardial infarction.[9] Apparently, the higher initial mortality in women is mainly explained by older age and unfavourable risk characteristics of women. The majority of the studies comparing mortality between men and women among hospital survivors reported similar mortality rates or lower rates among women, in particular studies with a follow-up of longer than one year.[9] Our findings (adjusted relative risk of dying for women of 0.73) are in line with these studies.

The overall risk of being readmitted (any cardiovascular disease) was similar for men and women after adjustment. Coronary readmissions shortly after discharge were more common among men, which might suggest that men had more recurrent events or that men were more intensively monitored. Other studies have reported differences in the use of coronary procedures between men and women with coronary heart disease.[26-29]

The importance of diabetes mellitus

Diabetes was strongly associated with death (unadjusted relative risk 2.15) and with being readmitted (unadjusted relative risk 1.76). Furthermore, the causes of cardiovascular readmissions were different in diabetic and nondiabetic patients. In diabetic patients, more readmissions were caused by congestive heart failure (unadjusted relative risk of 3.72). Other studies focusing on the relation between diabetes and heart disease found similar results.[30-31] Congestive heart failure and cardiogenic shock are more common and severe in patients with diabetes than would be predicted from infarction size alone.[31-33] Many additional compromising factors have been proposed, including increased platelet aggregation, decreased fibrinolytic activity and diastolic dysfunction.[31] The combination of subclinical diabetic cardiomyopathy amplified by the higher prevalence of coexistent hypertension seems to

reduce the compensatory ability of the noninfarcted myocardium. This combination of factors could be responsible for the higher incidence of heart failure in diabetic patients.[31]

Methodological considerations

The following issues need attention: the accuracy of the linkage algorithm, the characteristics of the PHARMO record database and the use of hospital discharge data.

Two types of errors can be made during record linkage: incorrectly counting a record as a readmission when in reality the records belong to different individuals, and not identifying a readmission. In a previous validation study, using the same linkage algorithm as in our study, both sensitivity and specificity exceeded 95%.[17] Additional information was gathered and examined in this validation study to reveal the true status (same or different individuals) of linked and non-linked admissions.

For several reasons we underestimated the number of readmissions during the follow-up period. First, readmissions of cohort member in hospitals outside the primary associated hospitals could not be identified. Although the cities and hospitals were chosen in such a way to minimise this problem, these hospitalisations will have occurred. Second, information about the death of cohort members was not fully complete in the drug dispensing database, in particular for patients dying outside the hospital. As a result, the total percentage of patients still alive would be overestimated, leading to an underestimation of the readmission rate.

This study uses information from administrative data sources with all its associated problems.[38,39] We used ICD-CM codes 410 to identify patients with acute myocardial infarction. Studies that have validated the use of code 410 in the hospital, revealed that the percentage of false-positive codings varied between 10 to 20%.[34-37] The two most common reasons for such false-positive codings were admissions of patients with recent myocardial infarction instead of 'fresh' myocardial infarction (often related to cardiac procedures) and admissions for possible acute myocardial infarction subsequently ruled out, but still appearing as the primary discharge diagnosis. The rate of false-negative codings for acute myocardial infarction is generally judged as low. Another drawback of hospital discharge data is the limited amount of detailed clinical information. However, using a small set of base-line variables we found estimates very similar to the Framingham study in respect to the effect of age and diabetes.[40] One of the strengths of this study is the fact that this large population of patients with acute myocardial infarction was derived

from several hospitals in the Netherlands rather than from a single institution. Furthermore, we looked beyond first readmissions using multiple failure Cox models. These models provided additional insight into the unfavourable combination of diabetes and heart failure (table 4).

In summary, cardiovascular readmissions are common among survivors of acute myocardial infarction, with the highest readmission rate during the first three months after discharge. The majority of all readmissions was related to coronary heart disease. Over time, however, readmissions for congestive heart failure, peripheral vascular disease and stroke became more prominent. The rate for all cardiovascular readmissions combined was similar among men and women, but men were more likely to be rehospitalised for coronary causes, while women were at a higher risk of readmissions for congestive heart failure and stroke. Diabetic patients had a higher risk of dying and of being readmitted. The presence of heart failure symptoms during the initial admission and the development of these symptoms during follow-up were associated with higher readmission rates. Diabetes was associated with both factors, which explains the unfavourable pattern of readmissions in these patients. More longitudinal data on morbidity and mortality is needed to fully describe the health consequences of patients with acute myocardial infarction, especially in an era in which more and more patients survive their initial attack.

References

1. Gheorghiade M, Ruzumna P, Borzak S, Havstad S, Ali A, Goldstein S. Decline in the rate of hospital mortality from acute myocardial infarction: impact of changing management strategies. Am Heart J 1996;131:250-256.
2. Rosamond WD, Chambless LE, Folsom AR, Cooper LS, Conwill DE, Clegg L, Wang CH, Heiss G. Trends in the incidence of myocardial infarction and in mortality due to coronary heart disease, 1987 to 1994. N Engl J Med 1998;339:861-867.
3. Braunwald E. Cardiovascular medicine at the turn of the millennium: triumphs, concerns, and opportunities. N Engl J Med 1997;337:1360-1369.
4. Moss AJ, Benhorin J. Prognosis and management after a first myocardial infarction. N Engl J Med 1990;322:743-753.
5. Peterson ED, Shaw LJ, Califf RM. Risk stratification after myocardial infarction. Ann Intern Med 1997;126:561-582.
6. Kannel WB, Sorlie P, McNamara PM. Prognosis after initial myocardial infarction: the Framingham Study. Am J Cardiol 1979;44:53-59.
7. van Domburg RT. Introduction and review of long-term outcome in coronary heart disease. In: Long-term survival and predictors of mortality in coronary heart disease. Thesis, Rotterdam, The Netherlands, 1998:7-26.
8. Peterson ED, Shaw LJ, Califf RM. Guidelines for risk stratification after myocardial infarction. Ann Intern Med 1997;126:556-560.
9. Vaccarino V, Krumholz HM, Berkman LF, Horwitz RI. Sex differences in mortality after myocardial infarction: is there evidence for an increased risk for women? Circulation 1995;91:1861-1871.
10. Herlitz J, Karlson BW, Sjölin M, Ekvall HE, Hjalmarson Å. Prognosis during one year of follow-up after acute myocardial infarction with emphasis on morbidity. Clin Cardiol 1994;17:15-20.
11. Herlitz J, Bengtson A, Wiklund I, Hjalmarson Å. Morbidity and quality of life 5 years after early intervention with metoprolol in suspected acute myocardial infarction. Cardiology 1988;75:357-364.
12. Maynard C, Every NR, Weaver WD. Factors associated with rehospitalization in patients with acute myocardial infarction. Am J Cardiol 1997;80:777-779.
13. Marrugat J, Sanz G, Masiá R, Valle V, Molina L, Cardona M, Sala J, Serés L, Szescielinski L, Albert X, Lupón J, Alonso J. Six-month outcome in patients with myocardial infarction initially admitted to tertiary and nontertiary hospitals. J Am Coll Cardiol 1997;30:1187-1192.
14. Dwyer EM Jr, McMaster P, Greenberg H, and the Multicenter Postinfarction Research Group. Nonfatal cardiac events and recurrent infarction in the year after acute myocardial infarction. J Am Coll Cardiol 1984;4:695-702.
15. Mæland JG, Havik OE. Use of health services after a myocardial infarction. Scand J Soc Med 1989;17:93-102.

16. Fisher ES, Wennberg JE, Stukel TA, Sharp SM. Hospital readmission rates for cohorts of Medicare beneficiaries in Boston and New Haven. N Engl J Med 1994;331:989-995.
17. Herings RMC. PHARMO: A record linkage system for postmarketing surveillance of prescription drugs in The Netherlands. Thesis, Utrecht, The Netherlands, 1993.
18. Howe GR, Lindsay J. A generalized iterative record linkage computer system for use in medical follow-up studies. Comput Biomed Res 1981;14:327-340.
19. Gill LE, Baldwin JA. Methods and technology of record linkage: some practical considerations. In: Textbook of medical record linkage. Oxford University Press, New York, 1987:39-55.
20. Efron B. The efficiency of Cox's likelihood function for censored data. J Am Stat Assoc 1977;72:557-565.
21. Li QH, Lagakos SW. Use of the Wei-Lin-Weissfeld method for the analysis of a recurring and a terminating event. Stat Med 1997;16:925-940.
22. Wei LJ, Lin DY, Weissfeld L. Regression analysis of multivariate incomplete failure time data by modeling marginal distributions. J Am Stat Assoc 1989;84:1065-1073.
23. Lin DY. Cox regression analysis of multivariate failure time data: the marginal approach. Stat Med 1994;13:2233-2247.
24. Wenger NK, Marcus FI, O'Rourke RA. Cardiovascular disease in the elderly. J Am Coll Cardiol 1987;10(suppl A):80A-87A.
25. Yusuf S, Flather M, Pogue J, Hunt D, Varigos J, Piegas L, Avezum A, Anderson J, Keltai M, Budaj A, Fox K, Ceremuzynski L. Variations between countries in invasive cardiac procedures and outcomes in patients with suspected unstable angina or myocardial infarction without initial ST elevation. Lancet 1998;352;507-514.
26. Ayanian JZ, Epstein AM. Differences in the use of procedures between women and men hospitalized for coronary heart disease. N Engl J Med 1991;325:221-225.
27. Shaw LJ, Miller DD, Romeis JC, Kargl D, Younis LT, Chaitman BR. Gender differences in the noninvasive evaluation and management of patients with suspected coronary artery disease. Ann Intern Med 1994;120:559-566.
28. Jaglal SB, Goel V, Naylor CD. Sex differences in the use of invasive coronary procedures in Ontario. Can J Cardiol 1994;10:239-244.
29. Clarke KW, Gray D, Keating NA, Hampton JR. Do women with acute myocardial infarction receive the same treatment as men? BMJ 1994;309:563-566.
30. Sniderman A, Michel C, Racine N. Heart disease in patients with diabetes mellitus. J Clin Epidemiol 1992;45:1357-1370.

31. Aronson D, Rayfield EJ, Chesebro JH. Mechanisms determining course and outcome of diabetic patients who have had acute myocardial infarction. Ann Intern Med 1997;126:296-306.
32. Stone PH, Muller JE, Hartwell T, York BJ, Rutherford JD, Parker CB, Turi ZG, Strauss HW, Willerson JT, Robertson T, 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 disease and diastolic left ventricular dysfunction to the adverse prognosis. J Am Coll Cardiol 1989;14:49-57.
33. Jaffe AS, Spadaro JJ, Schechtman K, Roberts R, Geltman EM, Sobel BE. Increased congestive heart failure after myocardial infarction of modest extent in patients with diabetes mellitus. Am Heart J 1984;108:31-37.
34. van Walraven C, Wang B, Ugnat AM, Naylor CD. False-positive coding for acute myocardial infarction on hospital discharge records: chart audit results from a tertiary centre. Can J Cardiol 1990;6:383-386.
35. Beaglehole R, Stewart AW, Walker P. Validation of coronary heart disease hospital discharge data. Aust NZ J Med 1987;17:43-46.
36. Kennedy GT, Stern MP, Crawford MH. Miscoding of hospital discharges as acute myocardial infarction: implications for surveillance programs aimed at elucidating trends in coronary artery disease. Am J Cardiol 1984;53:1000-1002.
37. Iezzoni LI, Burnside S, Sickles L, Moskowitz MA, Sawitz E, Levine PA. Coding of acute myocardial infarction: clinical and policy implications. Ann Intern Med 1988;109:745-751.
38. Lauderdale DS, Furner SE, Miles TP, Goldberg J. Epidemiologic uses of Medicare data. Am J Epidemiol 1993;15:319-327.
39. Roos LL, Sharp SM, Cohen MM. Comparing clinical information with claims data: some similarities and differences. J Clin Epidemiol 1991;44:881-888.
40. Wong ND, Cupples A, Ostfeld AM, Levy D, Kannel WB. Risk factors for long-term coronary prognosis after initial myocardial infarction: the Framingham Study. Am J Epidemiol 1989;130:469-480.