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Original article

Long-Term Mortality and Hospital Readmission After Acute Myocardial Infarction: an Eight-Year Follow-Up Study

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A B S T R A C T

Introduction and objectives: Acute myocardial infarction is responsible for most of the deaths in developed countries and for a very large number of hospital admissions. Specifically in Spain, each year about 140 000 deaths and 5 million hospital stays are due to acute myocardial infarction, corresponding to health care costs reaching 15% of total expenditure. Therefore, this paper presents an exhaustive analysis of acute myocardial infarction and the related prognosis, such as recurrence and mortality.
Methods: This observational study was carried out in Spain. Data were obtained using the Hospital Discharge Administrative Database from 2000 through 2007, inclusive. Specifically, 12 096 cases of acute myocardial infarction (8606 women and 3490 men) were reported during this period, with 2395 readmissions for this diagnosis. Readmissions were analyzed for frequency and duration using logistic regression and the Wang survival model. Mortality was analyzed using logistic regression.
Results: Readmission rates were 50% for patients younger than 45 years and 38% for those older than 75 years (P<.001). Men were readmitted more frequently than women throughout the follow-up period. Variables related to hospital mortality from acute myocardial infarction were the presence of diabetes, previous ischemic heart disease, and cerebrovascular disease.
Conclusions: Mid-term hospital readmissions are highly frequent in acute myocardial infarction survivors. Male sex, previous coronary heart disease, and the number of classical cardiovascular risk factors are the major risk predictors of this readmission. Our results highlight the need for improved medical care during acute myocardial infarction admission, integrated into secondary prevention programs.

Mortalidad a largo plazo y reingreso hospitalario tras infarto agudo de miocardio: un estudio de seguimiento de ocho años

Palabras clave:
Infarto de miocardio
Reingreso
Pronóstico
Supervivencia

R E S U M E N

Introducción y objetivos: El infarto agudo de miocardio es en los países desarrollados la causa más importante de mortalidad, así como de un gran número de ingresos hospitalarios. Concretamente, en España cada año se producen alrededor de 140.000 muertes y 5 millones de hospitalizaciones a causa de infarto agudo de miocardio, lo cual corresponde a unos costes de asistencia sanitaria que suponen un 15% de los gastos totales. En este artículo se presenta, pues, un análisis exhaustivo del infarto agudo de miocardio y el pronóstico que comporta en cuanto a recurrencia y mortalidad.
Métodos: Este estudio observacional se llevó a cabo en España. Los datos se obtuvieron de la Base de Datos Administrativa de Altas Hospitalarias para el periodo comprendido entre 2000 y 2007, ambos inclusive. Concretamente, se registraron 12.096 casos de infarto agudo de miocardio (8.606 mujeres y 3.490 varones) durante ese periodo, con un total de 2.395 reingresos por ese diagnóstico. Se analizó la frecuencia y la duración de los reingresos mediante regresión logística y con el modelo de supervivencia de Wang. La mortalidad se analizó mediante una regresión logística.
Resultados: Las tasas de reingreso fueron del 50% en los pacientes de menos de 45 años y del 38% en los de más de 75 años (p < 0,001). Los varones reingresaron con mayor frecuencia que las mujeres durante todo el periodo de seguimiento. Las variables relacionadas con la mortalidad hospitalaria por infarto agudo de miocardio fueron diabetes mellitus, antecedentes de cardiopatía isquémica y enfermedad cerebrovascular.

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Conclusiones: Los reingresos hospitalarios a medio plazo son muy frecuentes en los pacientes que sobreviven a un infarto agudo de miocardio. El sexo masculino, los antecedentes de enfermedad coronaria y el número de factores de riesgo cardiovascular clásicos son factores predictivos importantes del riesgo de reingreso. Nuestros resultados resaltan la necesidad de una mejora de la asistencia médica durante el ingreso por infarto agudo de miocardio, de manera integrada en los programas de prevención secundaria.

Abbreviations

AMI: acute myocardial infarction
CVD: cardiovascular disease
CVRF: cardiovascular risk factors
MBDS: Minimum Basic Data Set
PCI: percutaneous coronary intervention

INTRODUCTION

Cardiovascular disease (CVD), especially acute myocardial infarction (AMI), is the leading cause of death in developed countries and the second leading cause of hospital mortality.[1,2] Readmission after AMI is common, ranging from 8% to 20% in the first year.[3,4] Therefore, readmission rates should be a relevant outcome in clinical trials. Cardiovascular risk factors (CVRF) can currently explain most of the cases of AMI.[1,5,6] However, little is known about the association between these CVRF and readmission or hospital mortality after an AMI. Diabetes and hypertension are the most frequently studied CVRF in relation to AMI readmissions, but few studies on predictors of readmission for AMI have included both.[7]

In order to reduce readmission rates after AMI, accurate risk estimates are needed. This information would allow clinicians caring for patients to implement secondary prevention, and will also serve as performance measure, which would enable the policy makers to allocate limited healthcare resources.

The aim of this study was to analyze the contribution of CVRF to readmission rates and mortality after an AMI in a general population cohort.

METHODS

Subjects

This observational study includes all patients aged 15 years or older, admitted in all emergency services in Aragon (a northern Spanish region, with a population of 1 269 027, representing 2.88% of the Spanish population) between 2000 and 2007 with the principal diagnosis of AMI. Excluded were patients not residing in the region. AMI diagnosis, coded as 410.xx, was based on International Classification of Disease, 9th Clinical Modification (ICD 9-CM). Also included were variables such as sex, age, duration of hospitalization, and hospital mortality. Other diagnostic codes included as CVRF in the database were smoking use (305.1, v1582), diabetes mellitus (250.*), lipid disorder (272.*), obesity (278.*), and hypertension (401.*, 405.*). We also considered other previous CVD: angina pectoris (413.*), previous coronary artery disease (425.4, 425.5, 425.9, 428.0, 428.9, 402.*), and cerebrovascular disease (435.*-438.*).

Information about hospitalization episodes was obtained from the Minimum Basic Data Set (MBDS) on Hospital Discharges. The MBDS is a registry of all admissions, which includes administrative data (age, sex, city, family doctor, type of admission, etc.) and clinical data (principal diagnosis and other secondary diagnoses, diagnostic and therapeutic procedures); all public and private hospitals are required to report these data to a central state database. Diagnoses and procedures in the MBDS are also coded in accordance with the ICD 9-CM.

Statistical Analysis

Patients with or without readmission for recurrent AMI were compared. Continuous variables are presented as average and standard deviation; for categorical variables the frequencies distribution was selected. The differences between groups were tested by the nonparametric Mann Whitney U test due to their non-normal distribution. For qualitative variables the differences were analyzed by the chi-square test.

The AMI mortality rates were analyzed using a logistic regression model (with entry of variables with univariate significance level of 0.2 and stepwise rejection of variables at the 0.05 level of significance). Regression model was validated using the Hosmer-Lemeshow test and receiver operating characteristic curves.

As patients can be readmitted more than once, which can cause correlations between the events tested, classical statistical estimators are biased and inefficient. Statistical methodology must take this problem into account. In the case of independent data, the interoccurrence survival function can be estimated by the generalization of the limit-product estimator (Kaplan-Meier).[8] However, if data are correlated, as is the case for readmission rates in a forward follow-up longitudinal data set, other models should be used such as the estimator proposed by Wang and Chang that considers whether interoccurrence times are correlated or not.[9]

For testing correlation we used a graphic method proposed by González et al., drawing the survival function using first a survival function estimator based on correlation between events and next a survival function estimator based on independence between events. In case of similarity, we assume independence. In our case, both graphs were very different.

A value of P<.05 was considered statistically significant for all analyses. Statistical analyses were conducted using STATA 10.0/SE (Stata Corp, College Station, Texas, United States) and the survival and "survrec" libraries implemented in the R 2.8.1 software package.

RESULTS

A total of 11 062 patients (7870 men [71.1%] and 3192 women [28.9%]) was discharged with a diagnosis of AMI between 2000 and 2007. Figure 1 summarizes the outcomes of patients throughout the observation period.

Table 1 describes baseline characteristics of patients with or without AMI recurrence according to sex.

Patients who died during follow-up were older and had more prevalence of diabetes and previous coronary and cerebrovascular disease, in both men and women (Table 2).

Table 3 shows the main clinical and demographic variables related with the acute phase mortality for AMI. Variables directly related to hospital mortality from myocardial infarction were the presence of diabetes and previous ischemic heart disease and cerebrovascular disease. An inverse correlation was fond between acute phase mortality and percutaneous coronary intervention (PCI) during index admission. Women and older patients showed a higher risk of mortality for AMI.

Estimated readmission rates (Table 4) were 50% for patients younger than 45 years and 38% for those older than 75 (P<.001). Men were readmitted more frequently than women throughout the follow-up period. Although CVRF did not influence the probability of being admitted for AMI, they clearly influenced median time to readmission (809 days for patients with no CVRF vs 35 days for those having all 5). Probability estimation of readmission in the first year for patients without previous CVD was 85.6% compared to 35.7% of patients with previous CVD.

DISCUSSION

Readmission Rates and Cardiovascular Risk Factors

The main result of our study is that long-term readmission for recurrent AMI is common in patients discharged for an AMI and is related to the presence of CVRF. General characteristics and hospital events of our population are similar to other national[2,3,10,11] and international[4,6,12,13] cohorts, which might make our results representative of current clinical practice in the real-world post-AMI clinical setting and could also help to identify patients at high risk for long-term complications.

One of the major strengths of our study is the large sample size, which allows us to identify risk factors associated with clinical

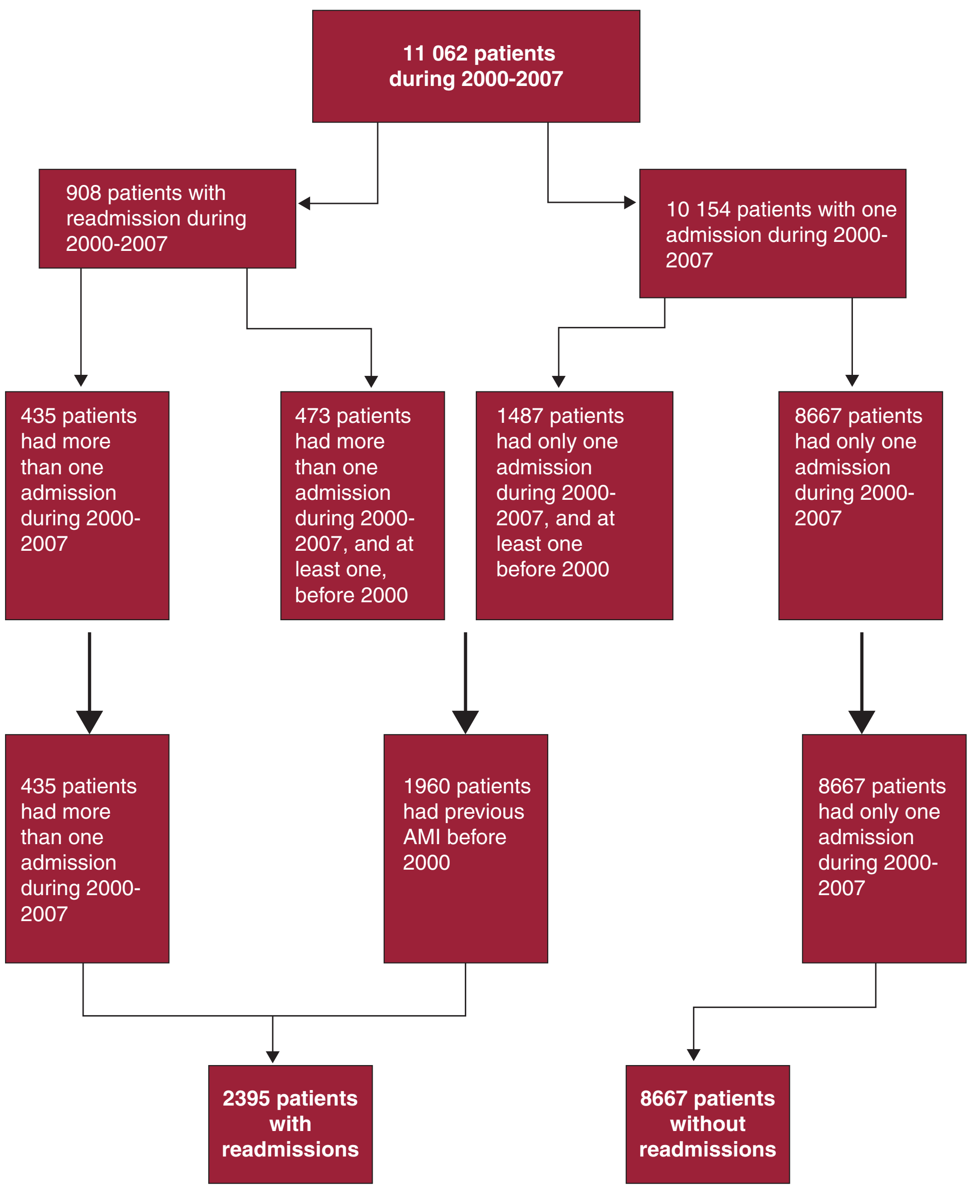

Figure 1. Sample Size Description: Flowchart. AMI, acute myocardial infarction.

Table 1
Demographics, Cardiovascular Risk Profile and Characteristics According to Sex in Patients With Acute Myocardial Infarction Diagnosis, Patients With More Than One Discharge and Patients Without Readmission

	All AMI patients			Patients without recurrent AMI			Patients with recurrent AMI		
	Men (n=7870)	Women (n=3192)	*P*-value	Men (n=6070)	Women (n=2597)	*P*-value	Men (n=1800)	Women (n=595)	*P*-value
Age, years	67±13.35	75.93±11.14	<.001	66.45±13.56	75.88±11.31	<.001	68.84±12.44	76.80±10.37	<.001
<45	543 (6.31)	66 (1.89)		2490 (41.02)	370 (14.25)		595 (33.06)	57 (9.58)	
45-65	3000 (34.86)	440 (12.61)		1616 (26.62)	604 (23.26)		516 (28.67)	145 (24.37)	
65-75	2419 (28.11)	916 (26.25)		192 (3.16)	88 (3.39)		55 (23.61)	21 (3.53)	
>75	2644 (30.72)	2068 (59.26)		1772 (29.19)	1535 (59.11)		634 (35.22)	372 (62.52)	
Acute phase mortality	898 (10.43)	679 (16.46)	<.001	611 (10.07)	533 (20.52)	<.001	286 (15.89)	156 (24.54)	<.001
Diabetes	1968 (22.87)	1285 (36.82)	<.001	1286 (21.19)	892 (34.35)	<.001	507 (28.17)	264 (44.37)	<.001
Dyslipemia	3317 (38.54)	1112 (31.86)	<.001	2217 (36.52)	806 (31.04)	<.001	837 (46.50)	231 (38.82)	.010
Hypertension	3601 (41.84)	1994 (57.13)	<.001	2519 (41.50)	1480 (56.99)	<.001	838 (46.56)	381 (64.03)	<.001
Obesity	866 (10.06)	492 (10.14)	<.001	614 (10.12)	355 (13.67)	<.001	202 (11.22)	105 (17.65)	.001
Current smoker	3100 (36.02)	217 (6.22)	<.001	2341 (38.57)	180 (6.93)	<.001	568 (31.56)	29 (4.87)	<.001
No. of CVRF			.012			.043			.176
0	1490 (18.93)	624 (19.55)		1176 (19.37)	538 (20.72)		314 (17.44)	86 (14.45)	
1	2607 (33.13)	1097 (34.37)		2084 (34.33)	916 (35.27)		523 (29.06)	181 (30.42)	
2	2379 (30.23)	906 (28.38)		1808 (29.79)	721 (27.76)		571 (31.72)	185 (31.09)	
3	1059 (13.46)	451 (14.13)		763 (12.57)	337 (12.98)		296 (16.44)	114 (19.16)	
4	288 (3.66)	109 (3.41)		207 (3.41)	81 (3.12)		81 (4.50)	28 (4.71)	
5	47 (0.60)	5 (0.16)		32 (0.53)	4 (0.15)		15 (0.83)	1 (0.17)	
Previous ischemic cardiopathy	866 (10.06)	602 (17.25)	<.001	557 (9.18)	413 (15.90)	<.001	272 (15.11)	160 (26.89)	<.001
Cerebral vascular disease	275 (3.20)	158 (4.53)	<.001	169 (2.78)	116 (4.47)	<.001	91 (5.06)	35 (5.88)	.434
Angina	131 (1.52)	53 (1.52)	.988	86 (1.42)	37 (1.42)	.977	41 (2.28)	16 (2.69)	.132

AMI, acute myocardial infarction; CVRF, cardiovascular risk factors: obesity, dyslipemia, diabetes, hypertension, current smoker.
Comparison uses a chi-square test for categorical variables and Mann Whitney U test for continuous variables.
Data are expressed as mean±standard deviation or no. (%).

Table 2
Demographics Cardiovascular Risk Profile and Characteristics According to Sex in Patients With Acute Myocardial Infarction Diagnosis Who Died, Compared to Survivors With the Same Diagnosis

	No survivors			Survivors		
	Men (n=897)	Women (n=679)	*P*-value	Men (n=6973)	Women (n=2513)	*P*-value
Age, years	75.98±9.97	80.83±9.20	<.001	65.84±13.29	74.76±11.27	<.001
<45	97 (10.81)	34 (5.01)	<.001	2988 (42.85)	393 (15.64)	<.001
45-65	248 (27.65)	87 (12.81)		1884 (27.02)	662 (26.34)	
65-75	35 (3.90)	13 (1.91)		212 (3.04)	96 (3.82)	
>75	517 (57.64)	545 (80.27)		1889 (27.09)	1362 (54.20)	
Diabetes	262 (29.21)	274 (40.35)	<.001	1531 (21.96)	882 (35.10)	<.001
Disliypemia	190 (21.18)	148 (21.80)	.768	2864 (41.07)	889 (35.38)	<.001
Hypertension	367 (40.91)	369 (54.34)	<.001	2990 (42.88)	1492 (59.37)	<.001
Obesity	32 (3.57)	56 (8.25)	<.001	784 (11.24)	404 (16.08)	<.001
Current smoker	144 (16.05)	10 (1.47)	<.001	2765 (39.65)	199 (7.92)	<.001
No. of CVRF			.036			.023
0	291 (32.44)	171 (25.18)		1199 (17.19)	453 (18.03)	
1	316 (35.23)	249 (36.67)		2291 (32.86)	848 (33.74)	
2	203 (22.63)	179 (26.36)		2176 (31.21)	727 (28.93)	
3	76 (8.47)	70 (10.31)		983 (14.10)	381 (15.16)	
4	10 (1.11)	10 (1.47)		278 (3.99)	99 (3.94)	
5	1 (0.11)	0		46 (0.66)	5 (0.20)	
Previous coronary disease	262 (29.21)	122 (17.97)	<.001	1230 (17.64)	346 (13.77)	<.001
Cerebrovascular disease	75 (8.36)	40 (5.85)	.062	185 (2.65)	111 (4.42)	<.001
Angina	7 (0.78)	10 (1.47)	.188	120 (1.72)	43 (1.71)	.974

CVRF, cardiovascular risk factors: obesity, dyslipemia, diabetes, hypertension, current smoker.
Comparison uses a chi-square test for categorical variables and Mann Whitney U test for continuous variables.
Data are expressed as mean±standard deviation or no. (%).

Table 3
Logistic Regression Model. Acute Phase Mortality as Dependent Variable. Variables Related to Demographic Characteristic, Cardiovascular Risk Factor and Intervention Considered as Independent

Variable	Mortality, OR (95%CI)	*P*-value
Age	1.05 (1.04-1.06)	<.001
Sex (female)	1.29 (1.14-1.46)	<.001
Diabetes	1.32 (1.16-1.49)	<.001
Atherosclerosis	0.61 (0.54-0.70)	<.001
Hypertension	0.83 (0.74-0.93)	.002
Obesity	0.56 (0.44-0.71)	<.001
Current smoker	0.61 (0.50-0.74)	<.001
Ischemic heart disease	1.69 (1.47-1.93)	<.001
Cerebrovascular disease	1.60 (1.26-2.02)	<.001
PCI	0.50 (0.38-0.66)	<.001
Coronary angiography	0.60 (0.48-0.75)	<.001

95%CI, 95% confidence interval; PCI, percutaneous coronary intervention; OR, odds ratio.
R2 Negelkerke=0.186. c statistic=0.765, *P*-value (Hosmer Lemerhow test), *P*=.812.

endpoints. Although some of these associations were quite weak, our results are in concordance with previous data that clearly identified age, diabetes, and previous CVD as major determinants of hospital mortality in AMI patients. We have also found that existing hypertension or current smoking is associated with lower mortality rates. These apparently paradoxical associations have been largely described previously.[14–17] The "protective" effect of hypertension on cardiovascular outcomes has been attributed to the especially bad prognosis associated with hypotension in the acute phase of AMI; in the case of current smokers, the reason could be that these patients are usually much younger and apparently healthier than nonsmokers (ie, the "sick quitters" bias). Moreover, patients with hypertension and current smokers usually receive more medical treatment and coronary revascularization.[14–17]

Previous Cardiovascular Disease and Mortality

Another relevant result of our study is that previous CVD is the main predictor of mortality. The reduction in hospital mortality of patients with acute coronary syndromes has lead to an increase in the number of patients with chronic coronary heart disease that are prone to suffer new cardiovascular events.[4,11,18] In fact, patients with established CVD are considered as high-risk in the risk stratification of patients with hypertension,[19] chest pain, or acute coronary syndromes.[20] Moreover, the presence of atherosclerotic lesions in different vascular territories has an additive effect on cardiovascular events and mortality. The 3-year follow-up of the REACH (REduction of Atherothrombosis for Continued Health) registry showed that all cardiovascular events increase from 25.5% to 40.5% and cardiovascular mortality from 4.7% to 8.8% if more than one vascular territory was affected.[21] Similar results have also been reported in Spain in the setting of post-AMI patients.[11] Our results emphasize the critical role of previous CVD on long-term prognosis of post-AMI patients.

Readmissions and Quality of Care

Hospital readmission is considered for many health providers as a measure of health care quality. As CVD is the leading cause of mortality, especially due to AMI[1], all clinical events related to its morbidity and mortality should be carefully described. Moreover,

Table 4
Percentage for Acute Myocardial Infarction Readmission Obtained by Wang Model

	Readmission for AMI, %		Median time to readmission, days
	1 year	3 year	
Age			
<45	49.97	75.56	378
45-65	44.19	73.90	467
65-75	38.60	71.70	632
>75	38	72.34	583
Sex			
Male	9.60	21.50	2010
Female	7.30	12.90	2436
Diabetes			
No	41.08	74.36	511
Yes	41.30	73.46	546
Hypertension			
No	41.78	74.77	502
Yes	40.63	73.70	556
Dyslipemia			
No	39.92	73.24	543
Yes	41.88	76.17	524
Obesity			
No	41.58	75.86	511
Yes	41.92	75.94	506
Current smoker			
No	42.31	72.33	477
Yes	41.52	74.53	516
Number of CVRF present			
0	34.43	67.09	809
1	40.17	74.18	1437
2	41.37	73	1552
3	37.96	68.55	845
4	43	78.15	237
5	35.10	66.40	35
Previous CVD			
No	85.56	94.53	34
Yes	35.71	74.07	606

AMI, acute myocardial infarction; CVD, cardiovascular disease (angina, previous infarction, cerebrovascular disease, ischaemic heart disease); CVRF, cardiovascular risk factors (obesity, dyslipemia, diabetes, hypertension, current smoker).

efforts for their reduction are likely to be endorsed by clinicians and administrators.

Several studies have analyzed 6-month or 1-year readmission for AMI in hospital survivors after the index AMI. Our study is the first in which the relationship between all main CVRF and mid-term hospital readmission has been correlated. Previous reports have attempted to relate the majority of readmissions to the quality of the care provided during the index admission, the patient education protocol, or the outpatient care after discharge, but findings have been varied greatly. In all clinical conditions studied by Thomas,[22] readmission rates of patients who received poor-quality care and patients whose care was acceptable were very similar. Roe et al. assessed risk-adjusted outcomes after different diagnoses, such as stroke, AMI, and heart failure, and concluded that the length of hospitalization, the mortality rate, and unplanned readmissions were predicted mainly by factors such as age, severity of the disease, and comorbidity.[23] Finally, CVD is known to significantly alter quality of life, mainly when patients develop symptoms of angina or heart failure[1]; the long-term follow-up of our study also highlights the high rate of hospital readmissions and recurrent AMI in these patients that may, eventually, contribute to worsen both the quality of life and the prognosis.

Comprehensive discharge planning plus outpatient support may reduce readmission rates and improve health outcomes for patients with AMI. Current management of postdischarge AMI patients that include ambulatory care and multidisciplinary teams are highly recommended due to the beneficial effects; the efficacy of programs incorporating discharge planning, transitional care, and postdischarge management for these patients has been clearly established.[3,24,25]

It is important to emphasize the effect of PCI in reducing recurrent readmissions and mortality rates. Thrombolysis has revolutionized emergency treatment of AMI,[20,26,27] but primary PCI is currently considered the best reperfusion treatment and is successful in over 90% of cases.[20,26–32] Nevertheless, thrombolysis is still performed in many countries because PCI requires a complex organization of health resources which many countries cannot afford.[27] The GRACE registry has confirmed that trial results obtained in carefully selected patients treated by experienced cardiologists in well-equipped centers may not be so easily obtained in the average patient in day-to-day practice of busy hospitals.[21] More recently, a randomized trial demonstrated that complete revascularization of AMI patients before hospital discharge reduces mortality and readmissions during the following 3 years.[30] Nevertheless, PCI-treated patients still have a high risk of future cardiovascular events if new coronary lesions develop or previous nonsignificant plaques become unstable.[32] In the study by Lemesle et al., the need for a new PCI on a nonculprit coronary lesion was as high as 50% in the first year after an acute coronary syndrome; diabetes, previous coronary bypass, and peripheral artery disease were identified as major risk factors for this event.[12] Our results agree with those of Lemesle et al. and provide longer follow-up with similar trends in the need for future revascularization.

Limitations

The use of an administrative database for data collection has both advantages and disadvantages. First, all patients diagnosed with AMI in the emergency room in public hospitals were recruited in this study. Nevertheless, the quality of diagnostic characterization can be biased due to the suspicion of a certain pathology that can or cannot be confirmed afterwards. This possibility is low due to the specificity of the clinical data in AMI, but should not be overlooked.

CONCLUSIONS

Mid-term hospital readmissions are highly frequent in AMI survivors. Male sex, previous coronary heart disease, and number of classic CVRF are the major risk predictors of this event. In our wide sample of current clinical practice, hospital readmission is effectively reduced by PCI. Our results highlight the need for improved medical care during AMI admission, integrated into secondary prevention programs.

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CONFLICTS OF INTEREST

None declared.

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