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Incidence and prognosis of late readmission after percutaneous coronary intervention

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Abstract

Background: *Early readmission (< 30 days) after percutaneous coronary intervention (PCI) is associated with a worse prognosis, but little is known regarding the causes and consequences of late readmission. The aim of the present study was to determine the incidence, causes, and prognosis of patients readmitted > 1 < 12-months after PCI (late readmission).*

Methods: *Single-center retrospective cohort study of 743 consecutive post-PCI patients. Patient characteristics and follow-up data were collected by reviewing their electronic medical records and from standardized telephone interviews performed at 1 year and at the end of follow-up.*

Results: *Of the 743 patients, 224 (30.14%) were readmitted 1–12 months after PCI, 109 due to chest pain (48.66%), and 115 for other reasons (51.34%). Hospital readmission was associated with lower survival rates of 77.6% vs. 98.3% at 24 months and 73.5% vs. 97.6% at 36 months ($p < 0.001$). Univariate predictors for late readmission were hypertension, older age, chronic kidney disease, lower left ventricular ejection fraction, and lower baseline hemoglobin concentration. Only baseline hemoglobin concentration was an independent predictor of late readmission (odds ratio: 0.867, 95% confidence interval: 0.778–0.966, $p = 0.01$). Readmission for chest pain portrayed a lower mortality rate compared to other causes, with survival rates of 90.2% vs. 50% at 36 months ($p < 0.001$).*

Conclusions: *Late hospital readmission after PCI is associated with a worse prognosis and is related to patient comorbidities. Readmission for chest pain is common and portrayed a more favorable prognosis, similar to patients not readmitted. A readily available parameter, baseline anemia, was the main predictor of late readmission.* (Cardiol J 2023; 30, 5: 696–704)

Key words: patient readmission, percutaneous coronary intervention, chest pain, prognosis

Introduction

Readmission within 30 days of hospitalization for heart failure, acute myocardial infarction, or percutaneous coronary intervention (PCI) is associated with a worse prognosis and is frequently used as a quality-of-care index [1–9]. However, there is very little data on the prognostic impact of readmission beyond 30 days.

Percutaneous coronary intervention is one of the most common medical procedures in both the United States and Europe. A study published by Curtis et al. [10] in 2005 of Medicare patients who underwent PCI showed that 30-day readmission

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and mortality rates were 14.6% and 1.0%, respectively, with readmitted patients at increased risk of mortality at 30 days. Several other studies have confirmed the high incidence of early readmission, highlighting that 1 in 7–10 patients undergoing PCI are readmitted within 30 days [11–15]. These patients also have a higher 1-year mortality risk compared to patients who are not readmitted [14–17]. However, there are several clinical factors which may identify patients at higher risk of readmission, so identifying these factors and ensuring the correct hospital treatment and post discharge care could help prevent readmission and improve outcomes [18].

The vast majority of the information on readmission after PCI in the literature refers to early readmission, and there is very little data on the causes and prognosis of late readmission. This study aimed to determine the incidence, causes, and prognosis of patients readmitted > 30 days after PCI.

Methods

A single-center, retrospective cohort study was performed. All patients who underwent PCI from 2007–2011 at the Hospital Universitario Fundación Alcorcón in Madrid, Spain were included. Patients who died before discharge, patients referred from other hospitals solely for the procedure, and patients lost to follow-up within the first 12 months were excluded from the analysis.

The patients were selected from the catheterization laboratory database where all procedures and other clinical variables such as age, gender, cardiovascular risk factors, other comorbidities, and previous treatment were entered prospectively. The study was approved by the center's Research Ethics Committee.

Catheterization and treatment

The PCI was performed according to standard techniques. The number of diseased vessels, access route, contrast dose, fluoroscopy time, and number and type of stents used were recorded. Also recorded were the antithrombotic treatment, bleeding complications, angiographic success, and any other type of complication during the procedure.

Follow-up and endpoints

All patients undergoing PCI in this hospital have a systematic clinical follow-up for at least 12 months. Follow-up clinical data was obtained by reviewing the hospital's electronic medical records and from standardized telephone interviews performed at 1 year and at the time of data collection for the study at the end of the follow-up. Detailed clinical information was collected including current medication, clinical status, and the need for any additional intervention, hospitalization, or Emergency Department visit after hospital discharge. The endpoints analyzed were the need and reason for readmission and mortality in the late follow-up period.

Definitions

Late readmission was defined as from 30 days to 12 months after PCI. Both hospitalization and admission to emergency departments were considered as readmissions. Readmission for chest pain was defined as those whose main reason for consultation was thoracic pain. Follow-up time was defined as the time from the PCI to the date the data was collected and analyzed.

Acute myocardial infarction was defined as the recurrence of symptoms suggestive of ischemia accompanied by an increase in markers of myocardial damage [19]. The left ventricular ejection fraction (LVEF) was estimated by echocardiography.

Statistical analysis

For the data analysis, we used the statistical packages SPSS version 20 and STATA 13. Quantitative variables are described as mean ± standard deviation. Categorical variables are described as absolute values and percentage. Univariate analysis was performed to compare patient characteristics based on the cause of readmission. The Student's t-test was used to compare the differences in the distribution of a quantitative variable and Pearson's χ^2 test or the Fisher exact test to compare the differences between categorical variables. A univariate and multivariate logistic regression analysis was performed to determine independent predictive factors for readmission. The variables included in the multivariate analysis were those significantly related to readmission in the univariate model and those considered of clinical relevance. The results are expressed as odds ratio (OR) and its 95% confidence interval (95% CI). To study overall survival, the time from the date of catheterization until death or until the last visit was calculated. Survival functions were estimated considering readmission as a time-dependent covariate; that is, if the patient is readmitted, the pre-readmission time and the post-readmission time are taken into account in the analysis. Similarly, overall survival

Table 1. Clinical and laboratory data.

	Readmission > 1 < 12 months (n = 224)	No readmission > 1 < 12 months (n = 519)	P-value
Gender (female)	41 (18.3%)	89 (17.1%)	0.704
Hypertension	165 (73.7%)	334 (64.4%)	0.013
Diabetes	77 (34.4%)	191 (36.8%)	0.527
Smoking	54 (24.1%)	157 (30.3%)	0.088
CKD	30 (13.4%)	43 (8.3%)	0.033
Previous PCI	56 (25%)	109 (21%)	0.229
Previous AMI	51 (22.8%)	91 (17.5%)	0.046
Catheterization indication:	25 (11.2%)	66 (12.7%)	0.003
Stable angina	55 (24.6%)	128 (24.7%)	
Unstable angina	37 (16.5%)	133 (25.6%)	
STEMI	58 (25.9%)	109 (21%)	
NSTEMI	26 (11.6%)	62 (11.9%)	
Silent ischemia	23 (10.3%)	21 (4%)	
Age [years]	68.76 ± 11.69	65.11 ± 11.25	< 0.001
LVEF [%]	52.4 ± 10.96	54.37 ± 9.55	0.021
Previous hemoglobin [g/dL]	13.15 ± 1.79	13.75 ± 1.63	< 0.001
Previous creatinine [mg/dL]	1.27 ± 0.89	1.09 ± 0.49	0.005
Oral anticoagulation treatment	70 (31.25%)	32 (6.17%)	0.003

Data are expressed as mean ± standard deviation or number (%); CKD — chronic kidney disease; PCI — percutaneous coronary intervention; AMI — acute myocardial infarction; STEMI — ST-segment elevation myocardial infarction; NSTEMI — non-ST-segment elevation myocardial infarction; LVEF — left ventricular ejection fraction

was analyzed based on readmission for chest pain or other reasons. Survival functions were compared using the log-rank test. All tests were considered bilateral and a p-value < 0.05 was considered statistically significant.

Results

Baseline characteristics and incidence of late readmission after PCI

From 2007 to 2011, excluding patients referred from other hospitals solely for the procedure, 769 patients from our healthcare area underwent PCI. Of these, 20 patients died before discharge and 6 (0.8%) were lost to follow-up before completing 12 months. Therefore, the initial study sample consisted of 743 patients (mean age 66 ± 11.5 years; 89 [17.3%] females). The mean follow-up was 27 ± 0.5 months. Of the 743 patients studied, 26 (3.5%) were readmitted within the first month and 224 (30.14%) were readmitted from 1 to 12 months after PCI. Table 1 shows the baseline characteristics (clinical and laboratory data) of the patients who were readmitted and those who were not. Patients were routinely discharged on dual antiplatelet therapy with acetylsalicylic acid and clopidogrel. Only 6 patients were discharged on prasugrel and none on ticagrelor. One hundred and two patients were on oral anticoagulants at hospital discharge.

Table 2 shows the angiographic data from the interventional procedure in both groups of patients. Significant baseline differences can be seen overall between the two groups. Patients who were readmitted late after PCI were older, had a higher prevalence of hypertension and coronary heart disease, higher creatinine levels, and lower LVEF and hemoglobin. The number of drug-eluting stents implanted in this group was lower, as was the number of complete revascularizations.

Causes of late readmission

There was a total of 224 readmissions from 1 to 12 months after PCI of which 217 were unplanned. Cardiac causes accounted for 46% (n = 103) of the total number of readmissions. Chest pain recurrence was the most frequent cause of readmission (48.66%). Of the 109 patients rehospitalized for chest pain, a cardiac origin was ruled out in 38 (34.86%). Among the other reasons for readmis-

Table 2. Angiographic and interventional procedure data.

	Readmission > 1 < 12 months (n = 224)	No readmission > 1 < 12 months (n = 519)	P-value
Radial access	187 (83.5%)	445 (85.7%)	0.428
Complete revascularization	124 (55.4%)	339 (65.3%)	**0.018**
Procedural success	224 (100%)	517 (99.6%)	1
Drug-eluting stent	136 (60.7%)	270 (52%)	**0.028**
Stents implanted:			0.191
1	128 (57.1%)	328 (63.2%)	
2–3	90 (40.2%)	173 (33.3%)	
≥ 4	6 (2.7%)	18 (3.5%)	
Diseased vessels:			0.134
1	96 (42.9%)	261 (50.3%)	
2	80 (35.7%)	171 (32.9%)	
3	46 (20.5%)	83 (16%)	

Data are expressed as mean ± standard deviation or number (%).

sion, the most common was infectious diseases, followed by heart failure and arrhythmia. Table 3 shows the specific reasons for late readmission in the present cohort.

Predictive factors and prognosis of late readmission after PCI

In the univariate logistic regression analysis, the predictive factors for late readmission after PCI were hypertension, older age, chronic kidney disease, lower LVEF, and lower hemoglobin concentration at initial admission. In the multivariate analysis, only the baseline hemoglobin level turned out to be an independent predictor of late rehospitalization (OR: 0.867, 95% CI 0.778–0.966, $p = 0.01$).

Overall survival at 12, 24, and 36 months was 96.1%, 94.4%, and 92%, respectively. The mortality rate was higher if the patient was readmitted, with survival rates at 24 and 36 months of 76.7% and 73.2%, respectively, as opposed to 98.3% and 97.6% in patients not readmitted ($p < 0.001$; Fig. 1).

Baseline characteristics and prognosis of patients readmitted for chest pain versus readmission for other reasons

Tables 4 and 5 show the baseline characteristics (clinical and laboratory data) and angiographic data from the interventional procedure for patients readmitted late for chest pain and those readmitted for other reasons. Patients readmitted for chest pain after PCI were younger, had a higher LVEF and

Table 3. Reasons for late readmission (> 30 days) after percutaneous coronary intervention.

Admissions for chest pain (n = 109, 48.7%)	
STE-ACS	4 (3.67%)
NSTE-ACS	43 (39.45%)
Stable angina	24 (22.01%)
Non-cardiac chest pain	38 (34.86%)
Admissions for other causes (n = 115, 51.3%)	
Infections	27 (23.47%)
Heart failure	16 (13.91%)
Arrhythmias	14 (12.17%)
Cancer	11 (9.56%)
Gastrointestinal bleeding	10 (8.69%)
Stroke/TIA	10 (8.69%)
Elective surgeries/diagnostic procedures	7 (6.08%)
ENT bleeding	2 (1.73%)
Bone fractures	3 (2.60%)
Liver disease	3 (2.60%)
PE/DVT	1 (0.86%)
Peripheral vascular disease	3 (2.60%)
Hypertensive crisis	2 (1.73%)
Psychiatric disorders	2 (1.73%)
Abdominal pain	2 (1.73%)
Acute kidney injury	2 (1.73%)

Data are expressed as number (%); STE-ACS — ST-segment elevation acute coronary syndrome; NSTE-ACS — non-ST-segment elevation acute coronary syndrome; TIA — transient ischemic attack; ENT — ear, nose and throat; PE — pulmonary embolism; DVT — deep vein thrombosis

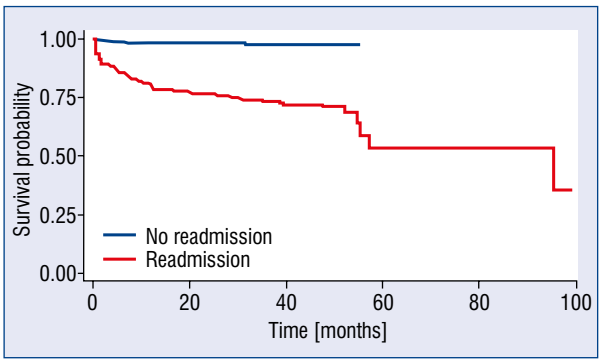

Figure 1. Survival curves stratified according to whether or not patients were readmitted after percutaneous coronary intervention (log rank test, p < 0.001).

hemoglobin concentration, and a higher prevalence of unstable angina.

Figure 2 shows the survival curves according to the reason for readmission after PCI, whether chest pain, or other reasons. The mortality rate was higher after readmission for other reasons than for chest pain, with survival rates at 24 and 36 months of 93.4% and 90.2%, respectively, if readmitted for chest pain, and 53.5% and 50% if readmitted for other reasons (p < 0.001).

Discussion

The main findings of this study were that late readmission after PCI is common, that late readmission is associated with poorer survival in long-term follow-up, and, lastly, and contrary to what might have been expected, that readmission for chest pain is not a negative prognostic factor.

Late readmission

Most of the evidence on the risk of repeated hospitalizations and the subsequent effect on prognosis is limited to 30 days post-intervention. Two reviews by Khawaja et al. [20] and Kwok et al. [21] reported that hospital readmission after PCI is a common occurrence, with 30-day rates ranging from 4.7% to 15.6%. In contrast, in the present study, only 26 (3.5%) patients were readmitted within the first month. The Khawaja et al. [20] and Kwok et al. [21] studies also highlighted a higher 1-year mortality risk among patients readmitted within 30 days of discharge.

Table 4. Clinical and laboratory data for patients according to whether they were readmitted because of chest pain or for other reasons after percutaneous coronary intervention (PCI).

	Readmission > 1 < 12 months for chest pain (n = 109)	Readmission > 1 < 12 months for other reasons (n = 115)	P-value
Gender (female)	20 (18.3%)	21 (18.3%)	0.986
Hypertension	77 (70.6%)	88 (76.5%)	0.318
Diabetes	32 (29.4%)	45 (39.1%)	0.124
Smoking	26 (23.9%)	28 (24.3%)	0.931
CKD	10 (9.2%)	20 (17.4%)	0.071
Previous PCI	22 (20.2%)	34 (29.6%)	0.706
Previous AMI	26 (23.9%)	25 (21.7%)	0.231
Catheterization indication:			**0.022**
Stable angina	14 (12.8%)	11 (9.6%)	
Unstable angina	37 (33.9%)	18 (15.7%)	
STEMI	14 (12.8%)	23 (20%)	
NSTEMI	26 (23.9%)	32 (27.8%)	
Silent ischemia	10 (9.2%)	16 (13.9%)	
Other	8 (7.3%)	15 (13%)	
Age [years]	66.52 ± 12.49	70.89 ± 10.5	**0.001**
LVEF [%]	54.76 ± 8.11	50.16 ± 12.74	**0.001**
Previous hemoglobin [mg/dL]	13.44 ± 1.69	12.86 ± 1.84	**0.014**
Previous creatinine [g/dL]	1.18 ± 0.83	1.36 ± 0.94	0.136

Data are expressed as mean ± standard deviation or number (%); CKD — chronic kidney disease; AMI — acute myocardial infarction; STEMI — ST-segment elevation myocardial infarction; NSTEMI — non-ST-segment elevation myocardial infarction; LVEF — left ventricular ejection fraction

Table 5. Angiographic and interventional procedure data according to whether or not patients were readmitted because of chest pain or for other reasons after percutaneous coronary intervention.

	Readmission > 1 < 12 months for chest pain (n = 109)	Readmission > 1 < 12 months other reasons (n = 115)	P-value
Radial access	94 (86.2%)	93 (80.9%)	0.279
Complete revascularization	60 (55%)	64 (55.6%)	0.996
Procedural success	109 (100%)	115 (100%)	0.996
Drug-eluting stent	61 (56%)	75 (65.2%)	0.18
Stents implanted:			0.531
1	64 (58.7%)	64 (55.7%)	
2–3	41 (37.6%)	49 (42.6%)	
≥ 4	4 (3.7%)	2 (1.7%)	
Diseased vessels:			**0.021**
1	45 (41.3%)	51 (44.3%)	
2	48 (44%)	32 (27.8%)	
3	16 (14.7%)	30 (26.1%)	

Data are expressed as mean ± standard deviation or number (%).

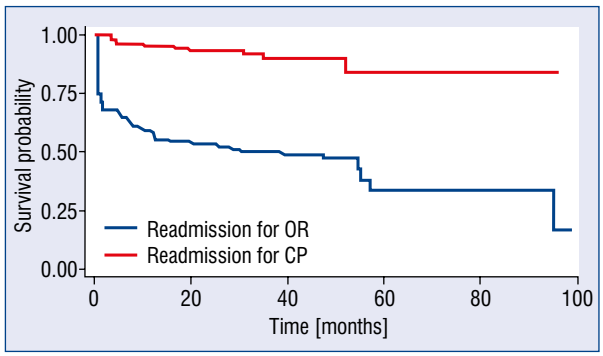

Figure 2. Survival curves stratified according to the reason for readmission after percutaneous coronary intervention (log rank test, p < 0.001); OR — other reasons; CP — chest pain.

There is little information in the literature on the incidence of readmission beyond the first 30 days post-PCI, never mind specifically on its prognostic implications. A recent article by Kwok et al. [21] which analyzed 2,412,000 patients from the US Nationwide Readmission Database, reported readmission incidences at 7, 30, 90, and 180 days of 2.5%, 9.9%, 18.0%, and 24.8% respectively, comparable to the 30.14% readmission rate from day 30 to day 365 in the current study. Over half of the readmissions were for noncardiac reasons and the majority of them were for nonspecific chest pain. Of the readmissions for cardiac causes, 27.6% were due to myocardial infarction, but there was no specific assessment of the prognostic impact of these late readmissions. In the Hansen et al. [22] series of 17,111 patients from two hospitals in Denmark, the incidence of readmission in the first year was 50.4%. The predictors of readmission were female gender, diabetes, age, and the Charlson comorbidity index, although once again they did not assess the prognostic impact of readmission during follow-up. Lastly, in the Moretti et al. [23] series of 1,193 patients, the incidence of readmission at 60 days was 6.3%, with the most common reasons being unstable angina and nonspecific chest pain. The need for readmission at 60 days was associated with a higher mortality rate (8.5 vs. 3.8%, p = 0.05) at 2 years follow-up. These reports are in line with the present findings, where patients readmitted late after PCI also had poorer mean survival compared to those not readmitted.

Identifying patients at a higher risk of readmission after PCI is important from a clinical viewpoint. In the Khawaja et al. study [20], the factors associated with a higher early readmission rate were female gender, diabetes, kidney disease, peripheral vascular disease, and non-elective PCI. Several algorithms have been validated to establish the risks of mortality and developing complications during and after PCI [24–39], and to predict the risk of readmission in the first 30 days postintervention. The factors associated with early readmission have been age, female gender, obesity, history of

heart failure, peripheral vascular disease, chronic obstructive pulmonary disease, diabetes, chronic kidney disease, and decreased LVEF and glomerular filtration rate [40].

In the present study, the only factor associated with a higher readmission rate in the first year in the multivariate analysis was a lower baseline hemoglobin concentration. This finding underlines that if we are to prevent repeated hospitalizations, certain comorbidities, such as anemia, need to be borne in mind when planning follow-up for these patients. Cardiac rehabilitation as a prevention strategy has been shown in numerous studies to not only reduce mortality rates after acute myocardial infarction and after PCI [41–43], but also to reduce readmissions [44]. Cardiac rehabilitation was not available at the institution of this study at the time of patient recruitment but since its implementation a significant reduction has been observed of early readmissions and we believe it is an important strategy that can be used to improve this metric. Widespread implementation of such a strategy could also be a well-advised and efficient measure to prevent late hospital readmissions. Additionally, to further help reduce avoidable hospital admissions telemedicine or new digital technology that enhances education of patient and care-givers can also prove to be useful.

Readmission for chest pain

In patients discharged after PCI, chest pain recurrence is a common cause of readmission and a common concern for their physicians. As in other studies that analyzed early readmissions [10–12, 14], the most common cause of late readmission in the current cohort was also chest pain (49%). Some of these readmissions are due to the progression of atherosclerotic disease or complications after a successful PCI (restenosis and stent thrombosis). Others, however, are avoidable. A systematic review of 34 studies, most of them retrospective, found that an average of 27% of readmissions could have been avoided [45]. Hansen et al. [46] suggested a series of actions aimed at reducing avoidable readmissions, including patient education, reconciliation of medication, planning of follow-up appointments after discharge, follow-up calls, communication with the family doctor responsible for follow-up, home visits, transition coaches, patient-centered discharge instructions and continuity of care by the same physician after admission. Although these measures are recommended to avoid early readmissions, they might also prevent readmissions over the long-term. In the present cohort of patients readmitted for chest pain, the cause was non-cardiac in 34.8%, and a significant number of these readmissions could probably have been avoided. In this context, readmission could be considered as a quality index for the care received.

One surprising finding of this study was that readmission for chest pain was not associated with decreased follow-up survival. One plausible explanation is that patients readmitted for chest pain had a better clinical profile (younger and higher LVEF and hemoglobin concentration). Moreover, as previously stated, chest pain was considered noncardiac in a significant number of these patients and the readmission could be related to inadequate education and follow-up after diagnosis of a serious illness. Such circumstances could be related to avoidable causes of readmission, but would not negatively affect the patient's prognosis.

Limitations of the study

The main limitation of this study is the observational and retrospective design, with all the restrictions and selection and information bias inherent to this type of study. However, it should be noted that these were consecutive patients, and only 6 were lost to follow-up. Other important limitations could be the sample size and the fact that the results come from a single-center experience, emphasizing the need for further multicenter studies with larger sample sizes. The use of drug eluting stents (DES) in this cohort was low (54.6%) compared to nowadays standards. During the time of the study, the center was following a pre-specified strategy of using bare metal stents in low restenosis risk patients in order to be more cost-effective. The clinical restenosis rate was low (8.6%) and although it could have been even lower with a higher DES utilization, it was believed that the results would not have been different. In a previous study we have reported that the clinical restenosis rate using this strategy is very low in the specific setting of ST-segment elevation myocardial infarction [47]. Additionally, the number of female patients in the study was small (17%) a limitation that should be born in mind when trying to generalize the results to female patients.

Conclusions

Late readmission (> 1 month < 12 months) after PCI is associated with a worse prognosis. Most hospital readmissions are related to patient comorbidities and not to the PCI procedure. Chest

pain is a common cause of readmission, but it has a more favorable prognosis than readmission for other causes. Simple and readily available parameters, such as baseline hemoglobin concentration, are good predictors of the need for late readmission.

Conflict of interest: None declared

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