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Chest Pain in Repeated Emergency Department Visitors

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Abstract

Introduction: Chest pain is responsible for up to 8% of all emergency department (ED) visits. It is a symptom of potentially harmful diseases including acute myocardial infarction (AMI). The aim of this study was to evaluate the prevalence of AMI and other causes of chest pain in repeated ED visitors with chest pain.

Method: We included patients presenting with chest pain to the ED of a tertiary referral hospital in 2015. Patients with ≥ 4 visits/year for chest pain were considered repeated chest pain visitors. Patients with chest pain visiting the ED two or three times/year were defined as the control group.

Results: 128 consecutive patients with at least two ED visits due to chest pain were included. Of these, 12 patients qualified as repeated ED visitors and generated 59 visits in total. Median age was 50.3 years and 33.3% were female. None of the repeated visitors had an AMI. In 18.6% of these visits (11 of 59), chest pain was due to cardiac causes such as hypertensive crisis or cardiac arrhythmia.

Twenty-three patients of the control group (n=116) experienced an AMI (19.8%). Nineteen of these infarctions occurred during the index ED visit and only four during a secondary visit. Two of these four patients had a known history of cardiovascular disease and all four of them had received a negative ischemic work-up during their index visit.

Other frequent reasons for chest pain in ED visitors were psychosomatic (33.9%), musculoskeletal/rheumatological (28.8%) or gastrointestinal disorders (10.2%).

Conclusion: Even though in every fifth ED visit of repeated chest pain visitors a cardiac etiology was the cause of the chest pain, there was no AMI in this group. These findings might be helpful for diagnostic measures and treatment options in repeated chest pain visits in the ED.

Keywords: Repeated emergency department users; Chest pain, Acute myocardial infarction

Introduction

Chest pain is the leading symptom in 5 to 8% of all emergency department (ED) visits [1-3] and is also one of the major reasons of repeated ED visits, causing around 6% of these cases [1]. Generally, in 15 to 25% of patients with chest pain, acute myocardial infarction (AMI) is the underlying cause [4-6]. International literature describes an all-population based, one-month mortality rate of AMI between 8 to 24% [7,8] and an all-population based, one-year mortality rate of 19% [9]. Therefore, AMI has to be diagnosed or ruled out quickly. For this purpose, a fast clinical assessment including cardiac biomarker testing and the rapid execution of an electrocardiogram (ECG) are necessary. Based on the leading symptoms and clinical presentation, ECG-findings and in combination

with elevated troponin levels, AMI can be defined as either a ST-segment elevation myocardial infarction (STEMI) or a non-ST-segment myocardial infarction (NSTEMI) [10]. In contrast, there are many other possible reasons for patients to present with chest pain, such as gastro-oesophageal, other cardiac or cardiovascular, neurological, psychological, or musculoskeletal causes [11].

Looking at the topics "repeated ED visits" and "chest pain" separately, there is a lot of literature covering various aspects [12-19].

There is no standardized definition of a "repeated ED visitor" in the literature. There is quite a wide range in the number of annual ED visits used for this definition [1,12,20-31], of which the definition of ≥ 4 visits/year is the most common one [21,31-33]. In our study, we defined a patient with four or more visits to the ED due to chest pain to be a "repeated" visitor. With regards to chest pain, studies have shown in general that chest pain patients tend to be in their mid-fifties [34,35], whereas patients with low risk for AMI are on average much younger [36] compared to high-risk patients [37]. In regard to the distribution of gender, study results vary [36-38]. Hospital admission rate for chest pain patients is between 19% and 27% [3,12]. Furthermore, anxiety has been shown to be associated with an increased risk of (repeated) ED visits in patients with low risk chest pain [39,40].

However, none of the reviewed literature investigated the rate of AMI in the subgroup of repeated ED visitors. Many studies have focused on the number of ED visits due to chest pain as an outcome [25,34,41-50] in the general ED population and have not focused on the subgroup of repeated patients. Furthermore, almost all of the reviewed studies had important exclusion criteria, e.g. specific age limits [51], AMI on index ED visit [43], too many return ED visits [38], language barriers [50] or a known history of coronary artery disease (CAD) [52]. Even though many of these studies investigated the prevalence of AMI [53-57], only a few did so after a one-year follow-up [58,59].

To our knowledge, no data about chest pain in repeated ED visitors are available for Switzerland. Therefore, the aim of this current study was to determine the prevalence of AMI in patients who visited the ED due to chest pain more than once and to evaluate the aetiology of chest pain in those ED patients.

Materials and Methods

The University Hospital Zurich (UHZ)) is a tertiary referral hospital and is one of the biggest hospitals in Switzerland. The UHZ is affiliated to the University of Zurich. The ED of the UHZ offers the whole range of emergency medicine service and treated currently 45,000 adult patients in 2018.

We performed a retrospective study enrolling patients who presented with chest pain as a leading symptom and visited the ED of the UHZ at least twice between January 1st and December 31st, 2015.

We excluded all patients who visited the ED only once due to chest pain in 2015. Additionally, all patients younger than 18 years old were excluded.

The study was approved by the ethic committee of canton Zurich, Switzerland (BASEC N° Req-2016-00195).

Definitions

We grouped the study population with recurrent chest pain into a group of patients who visited the ED two or three times (control group) and into one group of patients visiting the ED four times or more, which we defined as "repeated" ED visitors.

Endpoints

The first endpoint was to investigate the prevalence of AMI in ED patients who visited the ED due to the leading symptom "chest pain" at least four times during a one-year period (repeated visitors). Secondarily, we investigated whether an AMI had been correctly diagnosed in these repeated ED visits. Furthermore, we evaluated reasons of chest pain other than AMI.

Baseline parameters

In addition to the defined endpoints, we extracted the following parameters from the clinical information system: age, gender, medical history and cardiovascular risk-profile (e.g. smoking, diabetes, dyslipidaemia, obesity, history of cerebrovascular insult (CVI) or CAD, positive family history for CAD/AMI).

All patients presenting to the ED of the USZ are triaged with the Emergency Severity Index (ESI) [60-63] which is defining the urgency of symptoms, acuity and resource needs from a grade 1 (life-threatening) to 5 (least urgent, needing no resource). The ESI triage levels are described in the baseline parameters.

Baseline parameters also include rates of transport by paramedics, time presenting in the ED (day-, mid-, or nightshift), as well as all methods of diagnostics used in the ED (troponin levels, ECG, focused echocardiogram) and during hospital admission (tests for cardiac ischemia e.g. stress-testing, coronary-CT and cardiovascular interventions, e.g. stenting or bypass surgery). Furthermore, we investigated what kind of diagnostics such as stress testing or imaging and interventions they had received in previous visits. In addition, outcome parameters such as the need for a hospital admission or

treatment in special care units, the need for intubation or cardiopulmonary resuscitation were recorded.

Statistics

First, a descriptive analysis of the entire patient population was performed. We expressed the distribution of variables using means and standard deviation (SD) for normally distributed data, and medians and interquartile ranges (IQR) for non-normally distributed data. We tested the data for normality with the Kolmogorov-Smirnov test and performed quantile-quantile plots.

The first endpoint (AMI) was reported as a frequency in percentage. Further secondary endpoints such as other reasons for chest pain were also reported as frequencies (%).

All statistical analyses were performed using STATA software (version 15, Stata Corp., College Station, Texas).

Results

At the ED of the UHZ, 27,998 patients accounted for 33,335 ED visits in 2015 due to a medical problem. Of these, 128 consecutive patients with at least two ED visits due to chest pain were included. These 128 patients (0.5% of the total ED patient population in 2015) accounted for 311 ED visits (0.9% of all ED visits).

Out of the 128 enrolled patients, 116 (90.6%) visited the ED two or three times due to chest pain (control group) and accounted for 252 (81%) of the total 311 ED visits. The remaining 12 patients (9.4%) had four or more ED visits due to chest pain (repeated group) and were responsible for 59 (19%) of the 311 ED visits.

Table 1 shows the patients' characteristics of the entire chest pain patient population as well as grouped by the control and the repeated group. Compared to the control group, repeated chest pain ED visitors (≥ 4 annual ED visits) tended to be younger (50.3 vs. 59.4 years), of male gender (67.7% vs. 57.8%) and suffered less often from coronary heart diseases (16.7% vs. 44%) or diabetes (8.3% vs. 28.4%). A positive family history for heart disease was present in every fourth of the repeated chest pain group compared to 44.8% in the control group. The repeated chest pain ED visitors in turn had higher rates of arterial hypertensions (66.7% vs. 59.5%) and psychosomatic disorders (75% vs. 26.7%).

Causes and severity of chest pain

Out of all the 311 ED visits caused by these 128 patients, 111 visits (35.7%) were due to cardiac disorders, 104 visits (33.4%) were due to musculoskeletal and/or rheumatological disorders and 45 visits (14.5%) were due to psychosomatic disorders (Table 2).

	All patients with chest pain N = 128	**Patients with < 4 ED visits/year (control group) N = 116 (90.6%)**	**Patients with ≥ 4 ED visits/ year (repeated group) N = 12 (9.4%)**
Age (yrs.)	58.5 (16.1)	59.4 (16)	50.3 (15.7)
Female gender, n (%)	53 (41.4%)	49 (42.2%)	4 (33.3%)
Number of ED visits, n	2 (2 – 2.5)	2 (2 – 2)	4 (4 – 5)
Coronary heart disease, n (%)	53 (41.4%)	51 (44.0%)	2 (16.7%)
Cerebrovascular disease, n (%)	8 (6.3%)	8 (6.9%)	0%
Diabetes mellitus, n (%)	34 (26.6%)	33 (28.4%)	1 (8.3%)
Arterial hypertension, n (%)	77 (60.2%)	69 (59.5%)	8 (66.7%)
Chronic obstructive pulmonary disease, n (%)	13 (10.2%)	12 (10.3%)	1 (8.3%)

Chronic kidney failure, n (%)	31 (24.2%)	29 (25%)	2 (16.7%)
Chronic liver insufficiency, n (%)	64 (50%)	59 (50.9%)	5 (41.7%)
Obesity (BMI > 30 kg/m^2), n (%)	39 (30.5%)	35 (30.2%)	4 (33.3%)
Rheumatological disease, n (%)	50 (39.1%)	45 (38.8%)	5 (41.7%)
Psychosomatic disorders, n (%)	40 (31.3%)	31 (26.7%)	9 (75%)
Regular nicotine use, n (%) past nicotine use pack years	39 (30.5%) 44 10 (0 – 30)	36 (31.0%) 39 (33.6%) 10 (0 – 35)	3 (25%) 5 (41.7%) 5.5 (0 – 21.5)
Positive family history for heart disease, n (%)	55 (43.0%)	52 (44.8%)	3 (25%)

All results were reported as mean (standard deviation) or median (25th – 75th percentile) ED: Emergency Department; BMI: Body Mass index

Table 1: Patients' characteristics.

As shown in Table 2, ED visits made by repeated chest pain ED visitors were less likely to have an underlying cardiac (18.6% vs. 39.7%) or musculoskeletal/ rheumatologic disorder (28.8% vs. 34.5%) but were more likely to have a psychosomatic disorder (33.9% vs. 9.9%) as a cause.

Cardiac causes for chest pain varied between the two groups: in the repeated group, these ED visits were either caused by a hypertensive crisis (6 visits; 54.5%) or cardiac arrhythmias (5 visits; 45.5%); none was due to a myocardial infarction. In the control group, most frequent cardiac causes for ED visits due to chest pain were myocardial infarction (23%), hypertensive crisis (22%), arrhythmia (19%) and cardiac decompensation (17%).

Sixty-eight (21.9%) of the 311 ED visitors arrived by emergency medical services. All chest pain ED patients were assessed upon arrival using the ESI. In both study groups, patients were mostly triaged as ESI 3 (Table 2).

Incidence of acute myocardial infarction

AMI was diagnosed in 23 of the 311 individual ED visits due to chest pain (7.4%).

The incidence for having an AMI during an ED visit after

	All ED visits due to chest pain N = 311	**ED visits of patients with < 4 ED visits/ year N = 252 (81%)**	**ED visits of patients with ≥ 4 ED visits/year N = 59 (19%)**
Cardiac disorders, n (%)	111 (35.7%)	100 (39.7%)	11 (18.6%)
Musculoskeletal and/or rheumatologic disorders, n (%)	104 (33.4%)	87 (34.5%)	17 (28.8%)
Psychosomatic disorders, n (%)	45 (14.5%)	25 (9.9%)	20 (33.9%)
Gastrointestinal disorders, n (%)	25 (8.0%)	19 (7.5%)	6 (10.2%)
Pulmonary disorders, n (%)	20 (6.4%)	15 (5.9%)	5 (8.5%)
Drug intoxications, n (%)	3 (1%)	3 (1.2%)	0%
Unknown, no diagnosis, n (%)	3 (1%)	3 (1.2%)	0%

Cardiac causes for chest pain, n (%)	111 (100%)	100 (100%)	11 (100%)
- Hypertensive emergency/ urgency	28 (25.2%)	22 (22%)	6 (54.5%)
- Arrhythmia*	24 (21.6%)	19 (19%)	5 (45.5%)
- Acute myocardial infarction	23 (20.7%)	23 (23%)	0%
- Cardiac decompensation	17 (15.3%)	17 (17%)	0%
- Angina pectoris without infarction	7 (6.3%)	7 (7%)	0%
- Myo- and/or Pericarditis	7 (6.3%)	7 (7%)	0%
- Different heart valve problems	4 (3.6%)	4 (4%)	0%
- Aortic dissection	1 (0.9%)	1 (1%)	0%
Emergency Severity Index (ESI), n (%)			
- ESI 1	1 (0.3%)	1 (0.4%)	0%
- ESI 2	80 (25.7%)	65 (25.8%)	15 (25.4%)
- ESI 3	220 (70.7%)	181 (71.8%)	39 (66.1%)
- ESI 4	10 (3.2%)	5 (2%)	5 (8.5%)
- ESI 5	0%	0%	0%
Transport by paramedics to the ED, n (%)	68 (21.9%)	60 (23.8%)	8 (13.6%)
Presentation of patients during following shifts, n (%)			
- Dayshift			
- Midshift	114 (36.7%)	96 (38.1%)	18 (30.5%)
- Nightshift	116 (37.3%)	91 (36.1%)	25 (42.4%)
	81 (26.0%)	65 (25.8%)	16 (27.1%)

ED: Emergency Department; ESI: Emergency Severity Index * defined as Atrial Fibrillation (AF), Atrial Flutter (AFL) and tachycardia

Table 2: Causes & severity of chest pain in recurrent ED visits.

the index ED visit is shown in Table 3a, with the risk for the whole chest pain study population being 2.2%, 2.9% for the control group and 0% for the repeated visitors.

All 23 myocardial infarctions occurred within the control group (Table 3b) indicating a prevalence of 19.8% (23 out of 116 patients). These patients were between 51 and 86 years old and six were female. Nineteen of the 23 AMIs occurred during the first ED visit, four occurred during the second ED visit. Of these four patients, three were male and one was female. The woman and one of the men had a known history of coronary heart disease. All four of these patients had received ischemia diagnostics during their index ED visit, all of which had been negative. The diagnoses of these four patients on their first visit were pulmonary infection, cardiac decompensation (each occurring once) and musculoskeletal disorder (occurring twice).

Outcome

Table 4 presents outcome parameters of the individual ED visits. On average, repeated chest pain ED visitors spent 60 minutes less in the ED (219 vs. 279.5 minutes), but waited similarly until they were seen by an emergency physician (12.5 vs. 7 minutes). Repeated chest pain ED visitors were less likely to be admitted to the hospital (15.3% vs. 41.7%). All 39 in-house admissions to special care units occurred in the control group. One repeated chest pain ED visitor had to be intubated for cardioversion; no cardiopulmonary resuscitation was necessary in either group.

Conducted diagnostics in the ED

Table 5a shows diagnostic tests done during the ED stay.

	All patients with chest pain N = 128	**Patients with < 4 ED visits/year (control group) N = 116 (90.6%)**	**Patients with ≥ 4 ED visits/ year (repeated group) N = 12 (9.4%)**
Number of ED visits			
- total, n	311	252	59
- index ED visits, n	128	116	12
- subsequent visits, n	183	136	47
Incidence of AMI			
- total, n	23	23	0
- on index ED visit, n	19	19	0
- after the index ED visit, n	4	4	0
Risk for having an AMI after the index ED visit, (%)	2.2%	2.9%	0%
ED: Emergency Department; AMI: Acute Myocardial Infarction			

Table 3a: Risk for AMI during an ED visit after the index ED visit.

96.5% ECGs and in 90.7% troponin-T-testings were done. ECGs were similarly often performed in both groups (96.8% vs. 94.9%), but during ED visits caused by repeated visitors, troponin-T-testing was less likely performed (79.7% vs. 93.3%).

Table 5b shows subsequent diagnostic testing beyond the ED visit. It includes tests performed during the hospital stay, as well as any prior (done up to one year before each ED visit) and any subsequent testing (done up to one year after each ED visit).

35.6% of the repeated chest pain ED visitors had undergone ischemia diagnostics in the year prior to their ED visits compared to the 42.9% in the control group.

During hospital stay, 10.2% of repeated chest pain ED visitors received an echocardiography done by a cardiologist during the hospital stay compared to the 43.7% in the control group. The repeated ED visitors also received fewer ischemia diagnostics (3.4% vs. 21.8%) during hospitalization. In the year after the index ED visit (including the immediate hospitalization), 16.9% of repeated ED visitors underwent some kind of ischemia diagnostics, compared to 32.1 % of the control group.

Discussion

In this study, the overall prevalence of AMI was 7.4%, but no AMI occurred in repeated ED visitors with chest pain. The repeated chest pain ED visitor tended to be male, around 50 years old and suffered mostly from psychosomatic or musculoskeletal disorders, followed by hypertensive crisis or arrhythmia that were the only cardiovascular etiologies for chest pain. The overall risk of having an AMI after the index ED visit was 2.2% in the entire study population whereas it was 0% for the repeated ED visitors.

None of the reviewed articles has specifically analysed the AMI rate in repeated ED visitors with chest pain. Our results are novel, and we used the rate of AMI during a defined follow-up period after an index ED visit due to chest pain as a reference. The periods of follow-up have been individually set in each study, for example 30 days [43] or up to 180 days [64]. The risk of having an AMI in low-risk patients with chest pain during follow-up visits ranges from 0 to 0.4% while follow-up periods varied

	Age	Sex	Total number of ED visits	AMI in which ED visit	AMI	AMI after how many days after 1st ED visit	History of coronary syndrome	Previous ischemia diagnostics	Previous cardiac therapy	LOS	Reasons for chest pain in further ED visits
# 1	80	M	2	First	NSTEMI	-	Yes	1987, 2003, 2012	Bypass & Stents	8	Progress of aortic valve stenosis 11 months later
# 2	51	M	2	First	NSTEMI	-	No	No	-	5	Anxiety/panic
# 3	86	F	2	First	STEMI	-	Yes	2012	Stents	10	Cardiac decompensation
# 4	51	F	2	First	NSTEMI	-	Yes	2013	Stents	11	Upper pulmonary infection
# 5	52	M	2	First	NSTEMI	-	No	-	-	1	Anxiety/panic
# 6	54	M	2	First	STEMI	-	No	-	-	2	Musculoskeletal
# 7	77	M	2	First	NSTEMI	-	No	-	-	7	Cardiac decompensation
# 8	55	M	2	First	NSTEMI	-	Yes	2012	Stents	8	Musculoskeletal
# 9	55	F	2	First	NSTEMI	-	No	-	-	13	Musculoskeletal
# 10	61	M	2	First	STEMI	-	No	-	-	5	Musculoskeletal
# 11	58	M	3	First	STEMI	-	Yes	1998, 2004, 2008	Stents	4	Both ED visits due to musculoskeletal disorders
# 12	53	M	2	First	NSTEMI	-	Yes	2002	-	6	Arrhythmia
# 13	56	M	2	First	STEMI	-	No	-	-	4	Gastro-esophageal reflux

# 14	80	F	2	First	NSTEMI	-	No	-	-	7	Musculoskeletal
# 15	64	M	3	First	STEMI	-	Yes	2014	Stents	7	Both ED visits due to cardiac decompensation by drug malcompliance
# 16	65	M	2	Second	STEMI	8	Yes	1998, 2012, 2014	Stents	9	First ED visit: pulmonary infection (no in-stent stenosis in coronary angiography)
# 17	55	M	2	First	STEMI	-	No	-	-	6	Musculoskeletal
# 18	68	M	2	First	NSTEMI	-	Yes	2012	Stents	7	Anxiety/panic
# 19	75	F	2	Second	NSTEMI	222	Yes	2012, 2013	Stents	3	First ED visit: musculoskeletal (no in-stent stenosis in coronary angiography)
# 20	64	M	2	First	NSTEMI	-	No	-	-	9	Musculoskeletal
# 21	52	M	2	Second	NSTEMI	99	No	-	-	5	First ED visit: cardiac decompensation (no ischemia signs in the heart MRI)
# 22	67	F	3	First	NSTEMI	-	No	-	-	5	Hypertensive urgency, musculoskeletal
# 23	57	M	2	Second	NSTEMI	139	No	-	-	12	First ED visit: musculoskeletal (no ischemia signs in the single photon emission computer tomography)

M: Male; F: Female; AMI: Acute Myocardial Infarction; STEMI: ST-segment Elevation Myocardial Infarction; NSTEMI: Non-ST-segment Elevation Myocardial infarction; LOS: Length of hospital stay; ED: Emergency Department

Table 3b: Diagnosis of AMI in 23 patients of the control group.

	All ED visits due to chest pain **N = 311**	**ED visits of patients with < 4 ED visits per year** **N = 252 (81%)**	**ED visits of patients with ≥ 4 ED visits per year** **N = 59 (19%)**
ED stay (minutes)	269 (193 – 344)	279.5 (199.5 – 349.5)	219 (172 – 219)
Waiting time (minutes)	7.5 (0 – 17)	7 (0 – 15.5)	12.5 (3 – 21)
In-house admission, n (%)	114 (36.7%)	105 (41.7%)	9 (15.3%)
Length of hospital stay (of all) - only in those who were hospitalized (days)	0 (0 – 4) 6 (4 – 9)	0 (0 – 5) 6 (4 – 9)	0 (0 – 0) 4 (3 – 6)
Special care unit, n (%)	39 (12.5%)	38 (15.1%)	0%
Length of special care unit stay - only in those patients who were admitted to the special care unit (days)	0 (0 – 0) 2 (2 – 4)	0 (0 – 0) 2 (2 – 4)	- -
Need for intubation during the ED stay, n (%)	1 (0.3%)	0%	1% for cardioversion
Need for intubation during the hospital stay, n (%)	-	-	-
Need for CPR during the ED stay, n (%)	-	-	-
Need for CPR during the hospital stay, n (%)	-	-	-
Need for cardiac surgery during the hospital stay, n (%)	4 (1.3%)	4 (1.6%)	0%
All results were reported median (25^{th} – 75^{th} percentile); ED: Emergency Department; CPR: Cardio-Pulmonary Resuscitation			

Table 4: Outcome of the individual ED visits.

widely from one to fourteen months [38,45,65]. Our findings in ED patients with low-risk for AMI were similar to the literature. In the group of repeated ED visitors, who were shown to be of low-risk for AMI, no AMIs occurred. In contrast, patients of the control group, in which all 23 cases of AMI occurred, were on average older and had more cardiovascular risk factors than the repeated ED patients. Thus, patients of the control group were generally at higher risk of experiencing an AMI, which is represented by an AMI prevalence of 19.8%. These results corroborate with the literature of chest pain patients with an intermediate- and high-risk for AMI after 180 days of follow-up of 5.5% and 34.7% respectively [66].

	All ED visits due to chest pain **N = 311**	**ED visits of patients with < 4 ED visits per year** **N = 252 (81%)**	**D visits of patients with ≥ 4 ED visits per year** **N = 59 (19%)**
ECG, n (%)	300 (96.5%)	244 (96.8%)	56 (94.9%)
Laboratory tests: troponin-T, n (%)	282 (90.7%)	235 (93.3%)	47 (79.7%)
Focused cardiac ultrasound, n (%)	13 (4.2%)	13 (5.2%)	0%

ED: Emergency Department; ECG: Electrocardiography

Table 5a: Diagnostic tests during the ED stay.

	All ED visits due to chest pain **N = 311**	**ED visits of patients with < 4 ED visits/ year** **N = 252 (81%)**	**ED visits of patients with ≥ 4 ED visits/ year** **N = 59 (19%)**
Diagnostics done <u>before</u> the index ED visit			
Any previously performed ischemia diagnostic test, no longer than one year ago, n (%)	129 (41.5%)	108 (42.9%)	21 (35.6%)
Diagnostics done <u>during</u> the hospital stay			
Echocardiography by cardiologists during hospital stay, n (%)	116 (37.3%)	100 (43.7%)	6 (10.2%)
Coronary angiography for therapy of coronary ischemia, n (%)	23 (8%)	23 (9.1%)	0%
Any ischemia diagnostic test in the same hospital stay, n (%)	57 (18.3%)	55 (21.8%)	2 (3.4%)
Diagnostics done <u>after</u> the index ED visit			
Any ischemia diagnostic test after the index ED visit, not later than one year after index ED visit, n (%)	91 (29.3%)	81 (32.1%)	10 (16.9%)

ED: Emergency Department

Table 5b: Diagnostic tests / therapy before and after ED visits as well as during hospitalization.

In the current study, the overall prevalence of AMI (7.4%) in chest pain patients was lower compared to the range (15-25%) described in the literature [4-6]. This can be mostly explained by the restrictive inclusion criteria and focus on the subgroup of recurrent ED patients for this current study. Additionally, it is partly explained by the Swiss Health Care System. In case of an acute event, e.g. a STEMI, timely diagnostics and therapy are standardized in Switzerland according to the European Society of Cardiology guidelines [67]. The difference to other countries is that Swiss patients, when suffering from stable chest pain, have a wider and faster access to elective cardiac diagnostic tests and may receive earlier interventions (e.g. stenting) if needed. Thus, underlying coronary artery diseases are excluded by advanced and early accessible diagnostic tests. Almost 20% of the control group experienced an AMI. Most of the AMIs (19 of 23) occurred during the first ED visit and patients immediately received a coronary angiography for therapy of coronary ischemia. This rate is clearly lower compared to the literature about AMI due to cardiac causes of chest pain (40-60%) and reflects the wide and fast availability of elective cardiac diagnostic tests in Switzerland in stable patients [68].

While only four of all 23 cases of AMI occurred during a secondary ED visit, one may argue clear warning signs could have been missed during the index ED visit. Schull et al. reported a similar rate of missed AMI (2%) in chest pain patients discharged from the ED [69]. They defined an AMI as "missed", if a patient with AMI had had a previous ED visit up to 7 days before the incident or if an alternative ED discharge diagnosis had been determined masking the AMI due to typical or atypical presentations (e.g. "angina", "abdominal pain", "gastritis", "syncope", "shortness of breath") or the patient was not admitted to the hospital [69]. In our study, all four patients with an AMI during the second ED visit had had a complete and negative diagnostic ischemia testing done on the index visit. Furthermore, these AMIs occurred within 8 to 222 days after the index ED visit. Therefore, one can argue that no case of AMI was missed during the index ED visit in this current study population.

Interestingly, only few of the reviewed articles have analysed non-ischemic causes of chest pain in repeated ED visitors [39,66,68-70]. Generally, 20-60% of chest pain is of non-cardiac origins [70]. 50-90% of patients with non-cardiac chest pain show mainly symptoms of gastro-oesophageal reflux and 5-30% of musculoskeletal problems [71]. In our study, non-cardiac disorders were the cause for chest pain in more than 60% of all ED visits. Our analysis showed that chest pain was caused in a third of all repeated ED visits by a psychosomatic origin. Identically to our study, anxiety was shown to be one of the main reasons for repeated ED visits in patients with low-risk chest pain [39]. Furthermore, the current study showed a cardiac cause for chest pain in about 20% of repeated ED visits. However, none of these visits were due to cardiac ischemia, but due to hypertensive crisis or cardiac arrhythmias. These results are similar to the literature which shows that all non-ischemic cardiac causes are responsible for 10 to 20% of chest pain cases [68,72]. Common causes of non-ischemic cardiac chest pain in the literature were aortic dissection, acute pericarditis, heart failure, mitral valve prolapse and post-stent insertion chest pain [72]. However, chest pain was not a common symptom of hypertensive crisis [73]. No studies were found that primarily investigated cardiac arrhythmias as the specific cause of chest pain.

In our study, patients of the repeated group had a lower number of troponin-T testing performed at ED admission when compared to the control group. No data in the literature are available on investigating the rates of troponin-T-testing in chest pain patients. Therefore, a comparison of our results with the literature was not possible. In twelve of the 59 repeated ED visits (20.3%) no testing of troponin-T levels was performed. These 12 visits were performed by seven patients of the repeated group. Five of these seven patients had a known psychosomatic disorder without any other cardiovascular diseases or risk factors and therefore, a troponin-T testing was not indicated. Patients' age also seemed to be a relevant factor. The younger the patient, the less likely a testing of troponin-T levels was performed. Five of the 12 visits were performed by patients younger than 30 years of age. Final reasons for chest pain in these 12 visits in the repeated group were musculoskeletal disorders (five visits), psychosomatic disorders (three visits), hypertensive crisis (one visit), cardiac arrhythmia (one visit), gastroesophageal reflux (one visit) and respiratory infection (one visit). Furthermore, in nine of these 12 visits, an ECG was performed without any signs of cardiac ischemia. All three visits in which no ECG was performed were made by one patient with chest pain. This was a 20-year-old man who had suffered from a pneumothorax the year before. In each of his ED re-visits, the cause of the chest pain was of musculoskeletal etiology.

In only 17 of the 252 ED visits performed by the control group, no testing of troponin-T levels was performed (6.7%). This higher performance of the troponin-T tests in the control group was mostly due to sicker patients suffering more frequently from cardiovascular risk factors and needing therefore more often a troponin-T testing. However, these 17 visits that did not receive troponin-T testing showed similar characteristics compared to the repeated group. Hence, the factor age also seemed to be a relevant indicator: five and nine of these 17 ED visits were performed by patients aged ≤ 30 years and ≤ 40 years

respectively. Nine visits were due to musculoskeletal, four to psychosomatic, two to hypertensive crisis, one to gastrointestinal and one to pulmonary disorders. While in 13 of these 17 visits, an ECG was performed (all with normal findings). In these four visits without an ECG, patients' age varied from 26 to 74 years and musculoskeletal or psychosomatic disorders (twice each) were found to be the causes for chest pain.

No data were found in the literature investigating the rate of in-hospital ischemia testing in repeated ED patients with chest pain. In two of the nine repeated ED patients who were admitted to the hospital, a cardiac ischemia testing (coronary angiography and stress-testing once each) was performed during the hospital stay. Both patients were male and had a known history of two-vessel cardiac artery disease (CAD). They were 47 and 64 years old, had normal ECGs and troponin-T levels and had a final diagnosis of hypertensive crisis and psychosomatic disorder respectively. These two patients were the only ones with a known history of CAD in the repeated group. In the remaining seven admitted cases in which no in-hospital cardiac ischemia testing was performed, the final reasons for chest pain were pulmonary embolism, atrial fibrillation, supraventricular tachycardia (once each) and thoracic pain syndrome (four times). During all of these visits, a negative ECG had been performed and the levels of troponin-T were always negative with the exception of a slight elevation in the case of atrial fibrillation.

Strengths and Limitations

One of the strengths of this study is its low selection bias within the repeated chest pain patients with the only exclusion criteria being under 18 years of age and having less than two ED visits due to chest pain within one year. Since the USZ has an interventional cardiologist on call 24/7, many patients with chest pain were primarily assigned to the USZ by the paramedics. Therefore, the study sample is well represented and the results are generalizable.

A limitation is that this study is a single-centre-study. It is likely that recurrent ED visits to other nearby hospitals by these patients were not registered. Up to 58% of repeated ED patients are known to visit more than one ED [74]. Furthermore, as a result of the retrospective design, there is a possibility of incomplete data. However, since the cardiac workup was mostly done in-house, the data of the primary and secondary endpoints were complete.

Conclusions

No AMI in the repeated ED visitors presenting recurrently due to chest pain were missed. Chest pain in repeated ED visitors was mostly caused by psychological, musculoskeletal or rheumatologic disorders. If the cause was of cardiac origin, it was either due to hypertensive crisis or cardiac arrhythmia. Nevertheless, repeated ED visitors with chest pain must be seriously investigated each time at presentation and cardiac causes need to be excluded.

Conflict of Interest

There is no conflict of interest in any of the authors

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