

Impact of myocardial infarction symptom presentation on emergency response and survival

Amalie Lykkemark Møller () ¹*, Elisabeth Helen Anna Mills () ², Filip Gnesin () ¹, Britta Jensen () ³, Nertila Zylyftari () ⁴, Helle Collatz Christensen⁵, Stig Nikolaj Fasmer Blomberg () ^{5,6}, Fredrik Folke () ^{4,5,6}, Kristian Hay Kragholm () ⁷, Gunnar Gislason () ^{4,8,9}, Emil Fosbøl¹⁰, Lars Køber^{6,10}, Thomas Alexander Gerds () ¹¹, and Christian Torp-Pedersen () ^{1,2}

¹Department of Cardiology, Nordsjællands Hospital, Dyrehavevej 29, Hillerød 2400, Denmark; ²Department of Cardiology, Aalborg University Hospital, Hobrovej 18-22, Aalborg 9100, Denmark; ³Department of Health Science and Technology, Aalborg University, Niels Jernes Vej 14, Aalborg 9220, Denmark; ⁴Department of Cardiology, Copenhagen University Hospital Herlev and Gentofte, Gentofte Hospitalsvej 1, Hellerup 2900, Denmark; ⁵Copenhagen Emergency Medical Services, Telegrafvej 5, Ballerup 2750, Denmark; ⁶Department of Clinical Medicine, University of Copenhagen, Blegdamsvej 3B, Copenhagen 2200, Denmark; ⁷Unit of Clinical Biostatistics and Epidemiology, Department of Cardiology, Aalborg University Hospital, Aalborg, Denmark; ⁸Department of Research, Danish Heart Foundation, Vognmagergade 7, Copenhagen 1120, Denmark; ⁹The National Institute of Public Health, University of Southern Denmark, Studiestræde 6, Copenhagen 1455, Denmark; ¹⁰Department of Cardiology, Copenhagen University Hospital, Rigshospitalet, Blegdamsvej 9, Copenhagen 2100, Denmark; and ¹¹Section of Biostatistics, Department of Public Health, University of Copenhagen Farimagsgade 5A, 1353, Copenhagen, Denmark

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Aims	We examined associations between symptom presentation and chance of receiving an emergency dispatch and 30-day mortality among patients with acute myocardial infarction (MI).
Methods and results	Copenhagen, Denmark has a 24-h non-emergency medical helpline and an emergency number 1-1-2 (equivalent to 9-1-1). Both services register symptoms/purpose of calls. Among patients with MI as either hospital diagnosis or cause of death within 72 h after a call, the primary symptom was categorized as chest pain, atypical symptoms (breathing problems, unclear problem, central nervous system symptoms, abdominal/back/urinary, other cardiac symptoms, and other atypical symptoms), unconsciousness, non-informative symptoms, and no recorded symptoms. We identified 4880 emergency and 3456 non-emergency calls from patients with MI. The most common symptom was chest pain (N = 5219) followed by breathing problems (N = 556). Among patients with chest pain, 95% (3337/3508) of emergency calls and 76% (1306/1711) of non-emergency calls received emergency dispatch. Mortality was 5% (163/3508) and 3% (49/1711) for emergency/non-emergency calls, respectively. For atypical symptoms 62% (554/900) and 17% (137/813) of emergency/non-emergency calls received emergency dispatch and mortality was 71%/75% for emergency/non-emergency calls. Standardized 30-day mortality was 4.3% for chest pain and 15.6% for atypical symptoms, and associations between symptoms and emergency dispatch remained in subgroups of age and sex.
Conclusion	Myocardial infarction patients presenting with atypical symptoms when calling for help have a reduced chance of receiving an emergency dispatch and increased 30-day mortality compared to MI patients with chest pain.
Keywords	Acute myocardial infarction • Symptom presentation • Emergency medical service • Medical helpline • Mortality • Emergency response

* Corresponding author. Tel: +45 20717014, Email: Amalie.lykkemark.moeller@regionh.dk

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Introduction

Acute myocardial infarction (MI) may present with a range of different symptoms and of varying intensity. The diagnosis of the disease can therefore be challenging, especially when the medical consultation is over the phone, and the cardinal symptom of chest pain is absent.^{1,2} The first pre-hospital contact for patients with MI is often a telephone consultation with either the emergency medical dispatch centre, general practitioner, local healthcare centre, or out-of-hours medical service.^{3–6} The ability of first medical contact to ensure fast referral of suspected MI patients to treatment is critical as pre-hospital delays might ultimately affect survival.^{1,7,8}

Previous research found that 90% of MI patients were dispatched to the highest priority after an emergency call and that symptoms including chest pain and breathing problems were associated with a higher priority dispatch compared to other symptoms.¹ This indicates that MI patients generally receive acute help when calling the emergency services, but it remains unknown whether this is true for non-emergency services.

Additionally, MI and acute coronary syndrome patients experiencing chest pain before or upon arrival at the emergency department have been found to have lower mortality compared to patients without chest pain.^{9–11} The studies included the only hospital admitted patients and retrieved information of symptoms during hospital admission, possibly inducing bias by the selection of patients and retrospective recollection of symptoms.^{9–11}

There is sparse evidence of how the initial symptom presentation of MI patients affects the immediate response and survival across emergency and non-emergency calls. At the medical helpline (a 24-h medical service) and 1-1-2 emergency number in Copenhagen, Denmark, the symptom and purpose of calls are registered. Combined with public Danish registries, these data allow us to systematically identify the initial symptom presentation and immediate response of patients with an in-hospital diagnosis of MI or MI as cause of death. We aimed to investigate the association between the initial symptoms, as presented in telephone consultations, by patients later diagnosed with MI, and the chance of receiving an emergency dispatch and 30-day mortality.

Methods

Setting

The Danish health care system is public and tax-funded, therefore general practice, emergency, and non-emergency medical services, and hospital treatments are free of charge. In Copenhagen, Denmark, citizens with non-emergency medical conditions are advised to contact their general practitioner between 8 a.m. and 4 p.m. on weekdays, and otherwise dial 1-8-1-3 to a regional 24-h medical helpline (1813-medical helpline). The 1813-medical helpline is primarily staffed by nurses, but also medical doctors, and they can provide guidance, refer to emergency departments, or dispatch ambulances. In case of emergency, citizens should call the emergency number 1-1-2. At 1-1-2 nurses or paramedics evaluate the urgency and prioritize dispatch of ambulances. The 1813-medical helpline and the 1-1-2 emergency number is a combined co-located service, namely the Copenhagen Emergency Medical Service, serving 1.8 million individuals.¹² The 1813-medical helpline and the 1-1-2 emergency number use one integrated software system. Hereby, health care professionals at both

In Denmark, individuals with permanent residency are given a civil registration number.¹⁴ This number is registered when citizens call for help, for hospital procedures, deaths, and other public services allowing for the identification of patients.

or general practitioner before entering emergency departments.¹²

Population

We included all contacts to the 1813-medical helpline and 1-1-2 emergency number for citizens aged 30 or above between 1st January 2014 and 31st December 2018. Calls were defined as related to an MI if the patient received a primary diagnosis of MI [International classification of disease codes (ICD-10): I21] at the hospital (regardless of the subsequent cause of death), or had MI as primary cause of death no later than 72 h after a call. In-hospital diagnosis was identified using the Danish National Patient Registry and deaths were obtained using the Danish Register of Causes of Death.^{15,16} For patients with multiple calls the first call within 72 h before the MI was analysed.

Registration of symptoms

At the 1-1-2 emergency number and 1813-medical helpline, healthcare professionals register the one single criterion most appropriately describing the primary symptom/purpose of each call. The criterion is a proxy for the patient's symptoms and will be referred to as symptoms. Symptoms described by less than 100 MI patients were collapsed to other atypical symptoms (see specific symptoms under Table 1). The symptoms included for analysis consisted of chest pain, atypical symptoms (breathing problems, other cardiac symptoms (including palpitations, pacemaker problems, and fainting), central nervous system (CNS) symptoms (including vertigo, headache, and impaired consciousness), abdominal/back/urinary symptoms, unclear problem, and other atypical symptoms) and unconsciousness. For some patients, the criteria were either missing (no recorded symptom), primarily caused by medical doctors not systematically using the criteria mandatory for others or not informative of the patient's symptoms (non-informative symptoms). Non-informative symptoms were primarily orders of ambulances e.g. by general practitioners at the 1-1-2 emergency number, and typically misdials from other Danish regions at the 1813-medical helpline. Supplementary material online, Figure S1 shows the proportion of calls related to an MI out of all calls and Supplementary material online, Table S1 includes a full translation of the criteria into symptom categories.

Outcomes

We examined two main outcomes for our analyses: the emergency response, which is the immediate action following calls, and 30-day mortality. The emergency response was divided into four categories. No referral for treatment included watchful waiting or referral to a general practitioner. Non-ambulance and self-transport/home visits included self-transport to hospital, non-emergency patient transport, and home visits. Non-urgent dispatch included the dispatch of non-emergency ambulances, which are mobile intensive care units primarily of type B (service aim: 90% arrives <25 min) but also C (service aim: 90% arrives <2 h) and emergency dispatch which is dispatch of emergency ambulances with lights and sirens [mobile intensive care units type A (service aim: 90% arrives <13 min)].¹⁷ Thirty-day all-cause mortality included all deaths occurring between the time of MI diagnosis and 30 days after.

Variables	Level	Chest pain 5219 (62.6)	Atypical symp 1.713 (20.5)	otoms				Unconscious 290 (3.5)		No recorded/ non-informative symptoms 1.114 (13.4)	
Symptom presentation		Chest pain	Abdominal/ back/urinary	Breathing problems	CNS symptoms	Other atypical symptoms ^a	Other cardiac symptoms	Unclear problem	Unconscious	Non-informative symptoms	No recorded symptoms	Total
Call type	1-1-2 emergency	5219 (62.6) 3508 (67.2)	152 (1.8) 40 (26.3)	556 (6.7) 388 (69.8)	194 (2.3) 131 (67.5)	341 (4.1) 118 (34.6)	139 (1.7) ≤15	331 (4.0) 218 (65.9)	290 (3.5) 286 (98.6)	163 (2.0) 73 (44.8)	951 (11.4) 113 (11.9)	8336 4880 (58.5)
Sex	number 1813-medical helpline Female	1711 (32.8) 1681 (32.2) 3538 (67.8)	112 (73.7) 58 (38.2) 94 (61.8)	168 (30.2) 261 (46.9) 295 (53.1)	63 (32.5) 91 (46.9) 103 (53 1)	223 (65.4) 156 (45.7) 185 (54.3)	134 (96.4) 53 (38.1) 86 (61.9)	113 (34.1) 143 (43.2) 188 (54.8)	≤15 79 (27.2) 211 (72 8)	90 (55.2) 66 (40.5) 97 (59.5)	838 (88.1) 359 (37.7) 597 (67 3)	3456 (41.5) 2947 (35.4) 5389 (64.6)
Age Previous ischaemic heart	n ac Median [IQR] Yes	67.5 [56.6–77.1] 1710 (32.8)	28 (18.4) 28 (18.4)	75.3 [66.0–82.8 751 (27.2)] 75.5 [63.6–85.5] 39 (20.1)	1 73.6 [59.7–84.5] 81 (23.8)	62.4 [52.6–73.9] 39 (28.1)	74.1 [62.7–83.9] 84 (25.4)	73.2 [63.1–83.0] 70 (24.1)	(2.72) (2.78.2) 69.2 [58.8–78.2] 23 (14.1)	67.4 [55.8–77.7] 67.4 [55.8–77.7] 249 (26.2)	68.9 [57.7–78.8] 2474 (29.7)
disease Previous myocardial	Yes	1175 (22.5)	18 (11.8)	96 (17.3)	21 (10.8)	61 (17.9)	24 (17.3)	49 (14.8)	36 (12.4)	5	160 (16.8)	1653 (19.8)
marcuon Previous arterial	Yes		BO (14.4)	610 (11 7)	35 (18.0)	35 (10 3)	16 (11 5)	42 (12 T)	58 (200)	11 (6.7)	111 (11 7)	1015 (12 2)
fibrillation		585 (11.2)	90 (14.7) 17 (11 2)	76 (13 7)	(10.0) 22	(5.01) 55	(ت.11) 61 < 15	42 (12 Z) 42 (12 Z)	55 (19 0)	<pre>11 (0.7) <15</pre>	101 (106)	(2.21) (101 968 (11 6)
Previous heart failure	Yes	649 (12.4)	25 (16.4)	99 (17.8)	19 (9.8)	55 (16.1)	 15 15 	50 (15.1)	54 (18.6)	<15	105 (11.0)	1085 (13.0)
Diabetes (Type 2)	Yes	777 (14.9)	21 (13.8)	126 (22.7)	28 (14.4)	72 (21.1)	24 (17.3)	54 (16.3)	54 (18.6)	31 (19.0)	149 (15.7)	1336 (16.0)
Hypertension	Yes	1809 (34.7)	48 (31.6)	221 (39.7)	68 (35.1)	133 (39.0)	49 (35.3)	≤15	114 (39.3)	54 (33.1)	306 (32.2)	2924 (35.1)
Previous peripheral	Yes	500 (9.6)	≤15	100 (18.0)	17 (8.8)	42 (12.3)	≤15	34 (10.3)	32 (11.0)	≤15	84 (8.8)	848 (10.2)
vascular disease Previous cancer (not ma-	Yes	609 (11.7)	16 (10.5)	86 (15.5)	23 (11.9)	48 (14.1)	<15	47 (14.2)	35 (12.1)	17 (10.4)	110 (11.6)	1005 (12.1)
lignant melanoma)	2		(222.) 21	()			2	()		()	(2) 2	(
Previous moderate/sever	s Yes	301 (5.8)	≤15	42 (7.6)	<u><</u> 15	27 (7.9)	<15 15	22 (6.6)	21 (7.2)	15 15	55 (5.8)	499 (6.0)
renal disease												
Previous COPD	Yes	410 (7.9)	≤15 5, 5, 5, 5,	146 (26.3)	≤15 40 01 30	50 (14.7)	≤15 40 00 00	32 (9.7)	27 (9.3) 70 (67.0)	≤15 20 20 00	76 (8.0)	789 (9.5) 2221 (2.7 -
	Y es Decie	1305 (0.62) 21301 (0.62) 2131	56 (36.8) EE 724 7)	200 (36.0) 737 (44.3)	49 (25.3) 72 (40.2)	(30.8) 201	40 (28.8) (1 cc) 1 c	114 (34.4) (000) 000	(7:77) 6/	42 (25.8) 53 (35 4)	234 (24.6) 205 /24 4)	2224 (26.7) 2257 (25.7)
Equcational level	Dasic Intermediate	(7.1 C) 00C1 (7.1 C) 00C1	58 (38 7)	237 (41 .2) 217 (40 5)	74 (39 6)	126 (37.7) 173 (389)	51 (23.1) 63 (47.0)	120 (30.2) 174 (39 5)	135 (48 4)	(1.cc) cc 58 (38 4)	(4.1.5) C02 369 (40.6)	(7.55) 2002 2454 (43.7)
	Advanced	1215 (24.2)	37 (24.7)	82 (15.3)	37 (19.8)	67 (21.2)	40 (29.9)	70 (22.3)	41 (14.7)	40 (26.5)	254 (28.0)	1883 (23.6)
	Missing	205	≤15	20	<u>≤</u> 15	25	≤15 ,	17	≤15	≤15 ,	43	347
Ethnicity	Danish	4453 (85.4)	124 (81.6)	479 (86.3)	171 (88.1)	294 (86.5)	115 (82.7)	272 (82.2)	260 (89.7)	132 (81.5)	806 (84.9)	7106 (85.3)
	Immigrant	739 (14.2)	28 (18.4)	75 (13.5)	22 (11.3)	44 (12.9)	23 (16.5)	57 (17.2)	30 (10.3)	30 (18.4)	137 (14.4)	1185 (14.2)
	Descendant of	22 (0.4)	0 (0.0)	≤15	<15	≤15	≤15	≤15	0 (0:0)	0 (0.0)	<15	35 (0.4)
	immigrant											
	Missing	≤15	0	≤15	0	≤15	0	0	0	≤15	≤15	≤15
Country/continent of emigration	Denmark	4453 (85.4)	124 (81.6)	479 (86.3)	171 (88.1)	294 (86.5)	115 (82.7)	272 (82.2)	260 (89.7)	132 (81.5)	806 (84.9)	7106 (85.3)
0	Middle east or Asia	293 (5.6)	≤15	29 (5.2)	≤15	20 (5.9)	≤15	≤15	≤15	≤15	60 (6.3)	453 (5.4)
	America, Africa,	59 (1.1)	≤15	≤15	≤15	≤15	≤15	≤15	≤15	≤15	≤15	101 (1.2)
	or Oceania			1	!	:			;	1		1
	Europe Missing	409 (7.8) ≤15	16 (10.5) 0	43 (/./) ≤15	دا^_ 0	24 (7.1) ≤15	17 (12.2) 0	3/ (11.2) 0	17 (9.5) 0	19 (11./) ≤15	(∂./) (/.) ≤15	666 (8.0) ≤15

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Additionally, we reported in-hospital procedures for hospitalized MI patients using the Danish National Patient Registry.¹⁵ We included coronary angiography (CAG), percutaneous coronary intervention (PCI), and coronary artery bypass grafting (CABG) up to 7 days after the call, time from hospital arrival to registration at cardiology ward, and differential diagnosis of MI [ST-elevation myocardial infarction (STEMI), non-ST elevation myocardial infarction (NSTEMI), and unknown]. The first three troponins measured up to 72 h after the call were included using the Register of Laboratory Results for Research.¹⁸ Troponin values are divided with threshold for comparison (see details under *Table 3*). See definitions of the in-hospital procedures in Supplementary material online, *Table* S2.

Patient characteristics

Information on age, sex, ethnicity, and country of emigration was retrieved from the Danish Civil Registration System.¹⁹ Educational level was retrieved from the Population Educational Registers and reported in three groups (International Standard Classification of Education values: 0–2: basic 3–4: intermediate and 5–8: advanced).²⁰ Comorbidities diagnosed up to 10 years prior to call were retrieved from the Danish National Patient Register.²¹ Diabetes was diagnosed if a hypoglycaemic drug had been claimed, hypertension was diagnosed if two classes of anti-hypertensive drugs had been claimed, and use of Non-Steroidal Anti-Inflammatory Drug (NSAID) and opioids were registered, all within 180 days of the call.²² See Supplementary material online, *Tables S3* and *S4* for specification of ICD-10 codes and Anatomical Therapeutic Chemical Classification System.

Data analysis

Counts and percentages were used to summarize categorical variables, and medians with interquartile ranges (IQR) for continuous variables. The proportion of patients receiving an emergency dispatch and dying during 30-day follow-up was estimated for each symptom category. Additionally, the proportion of patients receiving emergency dispatch was estimated in subgroups of sex and age groups (30–59, 60–69, 70–79, >79) with 95% confidence interval (CI). Thirty-day mortality for each symptom category was standardized to the distribution of age, sex, educational level, current diabetes, previous myocardial infarction, heart failure, and chronic obstructive pulmonary disease (COPD) among all MI patients. We estimated 95% CI using bootstrap with replacement. Data cells with fewer than 15 patients were reported as \leq 15 to avoid individually identifiable information. Data management and analysis were performed with R.²³

Ethics

In Denmark, registry-based studies do not require ethical approval. The study was registered with the Data Protection Agency of the Capital Region of Denmark, approval number: P-2019-191 and complied with the Declaration of Helsinki.

Results

Out of 2 284 359 calls with information of civil registration number (1813-medical helpline: 1 958 319, 1-1-2 emergency number: 326 040), we identified 8982 calls regarding an MI between 1st January 2014 and 31st December 2018. After the exclusion of 213 calls due to suspected death at time of call, 8769 calls regarding 8336 MI's were identified for 7778 patients. Among these, 6% (464/7778) of patients had two MI's or more and for 5% of the MI's (375/8336) more than one call was identified. The first call for each MI was kept for analysis, resulting in 8336 calls for 7778 patients with an MI diagnosis or MI as cause of death no later than 72 h after a call (*Figure 1*).

Characteristics of patients with MI by symptom presentation are shown in *Table 1*. In total 42% (3456/8336) of MI patients called the 1813-medical helpline, the median age was 68.9 25th–75th percentile [57.7, 78.8] and 64.6% (5389/8336) were male. Previous ischaemic heart disease (33%) and myocardial infarction (23%) were the most common among MI patients with chest pain. Cancer (16%) and COPD (26%) were the most common among patients with breathing problems (*Table 1*). Among calls with information of symptom presentation, 72% (5219/7222) presented with chest pain and 24% (1713/ 7222) with atypical symptoms. Among atypical symptoms breathing problems (8%, 556/7222) was the most common.

Symptom presentation

In Figure 2, the symptom presentation of MI patients is shown in subgroups of age and sex for the 1-1-2 emergency number and 1813medical helpline, respectively (excluding calls with non-informative and no recorded symptoms). The prevalence of chest pain was highest among males aged 30–59 calling the 1-1-2 emergency number (85%, 826/973), and lowest among females older than 79 calling the 1813-medical helpline (49%, 130/265). Other atypical symptoms were predominantly found among the elderly, especially women, at the 1813-medical helpline (*Figure 2*).

 Table 2
 Observed and standardized 30-day mortality according to symptom presentation for patients with myocardial infarction

Variables	Observed 30-day mortality (95% confidence interval)	Standardized 30-day mortality (95% confidence interval)
Chest pain	3.9% (3.4–4.5%)	4.3% (4.2–4.3%)
Atypical symptoms	19.1% (17.2–21.0%)	15.6% (15.4–15.9%)
Unconscious	71.3% (65.8–76.3%)	64.9% (64.5–65.4%)
No recorded or non-informative symptoms	11.0% (9.3–13.1%)	11.9% (11.7–12.1%)

The 30-day mortality is standardized to the whole MI population according to age, sex, educational level, previous MI, COPD, heart failure, and current diabetes. For this analysis, 347 patients with no information of education were excluded. N = 7989.

Variables	Level	Chest pain (N = 5156)	Atypical symptoms (N = 1556)	Unconscious (N = 112)	No recorded or non-informative symptoms (N = 1051)	Total (N = 7875)
Maximal troponin (of the first three troponins) ^a	Median [IQR]	41.8 [5.1–195.5]	38.9 [6.1–183.6]	114.5 19.7–296.0]	35.8 [4.1–209.3]	41.4 [5.3–197.1]
First troponin ^a	Median [IQR]	2.8 [1.0–9.8]	6.5 [1.8–34.1]	6.5 [3.2–20.6]	4.6 [1.2–19.4]	3.5 [1.1–14.2]
Hours from call to first troponin	Median [IQR]	1.4 [1.1–1.8]	1.9 [1.3–4.2]	1.3 [1.1–1.6]	1.6 [1.2–2.8]	1.4 [1.1–2.2]
	Missing	246	131	≤15	63	450
Admitted to cardiology ward during admission	Yes	5054 (98.0)	1466 (94.2)	104 (92.9)	1014 (96.5)	7638 (97.0)
Time from hospital arrival to cardiology ward	Directly to cardiology	2634 (52.2)	470 (32.2)	61 (59.2)	367 (36.3)	3532 (46.4)
	<2 h	956 (19.0)	291 (19.9)	25 (24.3)	235 (23.2)	1507 (19.8)
	2–4 h	768 (15.2)	236 (16.2)	≤15	179 (17.7)	1188 (15.6)
	4–12 h	389 (7.7)	214 (14.7)	≤15	135 (13.4)	742 (9.7)
	>12 h	295 (5.9)	249 (17.1)	≤15	95 (9.4)	647 (8.5)
	Missing	114	96	≤15	40	259
Any invasive procedure (CAG, PCI or CABG) within 7 days of call	Yes	4117 (79.8)	902 (58.0)	84 (75.0)	771 (73.4)	5874 (74.6)
PCI within 7 days of call	Yes	2793 (54.2)	496 (31.9)	62 (55.4)	496 (47.2)	3847 (48.9)
Coronary angiography within 7 days of call	Yes	4075 (79.0)	897 (57.6)	84 (75.0)	764 (72.7)	5820 (73.9)
MI diagnoses	Unknown	1092 (21.2)	457 (29.4)	28 (25.0)	286 (27.2)	1863 (23.7)
	NSTEMI	2321 (45.0)	725 (46.6)	26 (23.2)	520 (49.5)	3592 (45.6)
	STEMI	1743 (33.8)	374 (24.0)	58 (51.8)	245 (23.3)	2420 (30.7)
30-day mortality	Dead	149 (2.9)	174 (11.2)	29 (25.9)	60 (5.7)	412 (5.2)

Table 3 In-hospital procedures for hospitalized patients with myocardial infarction

In-hospital procedures for 7875 hospital admitted MI patients, excluding 461 patients included in the population based on MI as cause of death.

^aTroponins values are shown as proportion above threshold (troponin/threshold), as patients received different types of troponin testing otherwise not comparable. Thus, troponins equal to 1 is exactly the level of the threshold, and troponins of 40 would equal a troponin value forty times higher than the threshold. Numbers are shown as count (%) unless otherwise specified. N = 7875.

CABG, coronary artery bypass grafting; CAG, coronary angiography; IQR, interquartile range; NSTEMI, non-ST elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-elevation myocardial infarction.

Emergency response

In *Figure 3*, the emergency response and 30-day mortality for patients with MI are shown by symptom for the 1-1-2 emergency number and 1813-medical helpline, separately. Overall, 89% (4330/4880) calling the 1-1-2 emergency number and 52% (1789/ 3456) calling the 1813-medical helpline received emergency dispatch. Among MI patients with chest pain, 95% (3337/3508) and 76% (1306/1711) received an emergency dispatch at the 1-1-2 emergency number and 1813-medical helpline, respectively. Among atypical symptoms, the proportion receiving an emergency dispatch was on average 62% (544/900) at the 1-1-2 emergency number and 17% (137/813) at the 1813-medical helpline. Unconscious patients received emergency dispatch in 99% (283/ 289) and 100% (\leq 15/ \leq 15) of calls to the 1-1-2 emergency number and 1813-medical helpline.

In Figure 4, the proportion of MI patients receiving emergency dispatch is shown for each symptom in subgroups of age and sex. The proportion of MI patients receiving emergency dispatch was highest for unconsciousness (96–100%) followed by chest pain (82–91%). Emergency dispatches were rare for other cardiac symptoms (0-31%), other atypical symptoms (5-32%), and abdominal/back/ urinary symptoms (5-36%).

Mortality

Thirty-day mortality for MI patients with chest pain was 5% (163/3508) and 3% (49/1711) at the 1-1-2 emergency number and 1813-medical helpline (*Figure 3*). Among MI patients with atypical symptoms, on average 23% (206/900) and 15% (125/813) died after calling the 1-1-2 emergency number and 1813-medical helpline, respectively. Notably, patients with other cardiac symptoms had low mortality (0–6%) compared to the remaining atypical symptoms. Mortality was 71% (204/286) and 75% (\leq 15/ \leq 15) for unconscious patients at the 1-1-2 emergency number and 1813-medical helpline, respectively (*Figure 3*).

Among MI patients dying within 30 days, 44% had presented with atypical symptoms, of which breathing problems were the most common. See the distribution of symptoms among MI patients dying with 30-days in Supplementary material online, *Figure* S2.

The standardized 30-day mortality was 4.3% 95% CI (4.2–4.3%) for MI patients with chest pain and 15.6% 95% CI (15.4–15.9%) for MI



Figure 1 Flowchart illustrating the study population and exclusions. C, number of calls; N, number of patients. Final exclusions include calls for myocardial infarction patients where the health care professional at the Copenhagen Emergency Medical Service presumed that the patient was dead at the time of call. These suspected deaths are defined from either (1) the health care professional had chosen a criteria of 'Possible death' or added 'mors', 'possible death' or 'death' to the electronic medical record, (2) the patient's time of death was registered to have happened before time of call. Overall, 1.53% (5020/326 040) of calls to the 1-1-2 emergency number and 0.19% (3749/1 958 319) of calls to the 1813-medical helpline were regarding an myocardial infarction.

patients with atypical symptoms, i.e., differences in 30-day mortality between MI patients presenting with chest pain and atypical symptoms persisted, though mortality differences were smaller compared to the observed 30-day mortality [Chest pain 3.9% 95% CI (3.4–4.5%) and atypical symptoms: 19.1% 95% CI (17.2–21.0%)] (*Table 2*).

In-hospital procedures

In *Table 3*, in-hospital procedures are shown for 7875 hospitalized MI patients excluding the 461 patients included with MI as cause of death. Myocardial infarction patients with atypical symptoms had a longer time from call to first troponin (median 1.9 h) compared to all



Figure 2 Symptom presentation of patients with myocardial infarction in calls to the 1-1-2 emergency number and 1813-medical helpline by age and sex. The figure illustrates the symptom presentation of the 7222 calls with available information of symptom presentation in subgroups of sex and age groups for the two services (excluding non-informative and no recorded symptoms, N = 1114). The proportion of boxes is equivalent to the proportion of the symptom in given subgroup. CNS, central nervous system.

other symptoms, and 32% were directly referred to a cardiology ward compared to 52% of patients with chest pain and 59% of unconscious patients. Among MI patients, 58% with atypical symptoms, 79% with chest pain, and 75% of unconscious patients received CAG within 7 days of the call (*Table 3*).

Sensitivity analysis

We examined differences in mortality between hospitalized MI patients with chest pain and atypical symptoms according to whether patients received CAG. Overall, hospitalized MI patients not receiving CAG had increased 30-day mortality compared to those receiving CAG, at least for patients older than 55 (Supplementary material online, *Figure S3* (left side)). Similar association was found in a healthy subpopulation of MI patients without comorbidities (Supplementary material online, *Figure S3* (right side)). Among MI patients receiving CAG, patients with atypical symptoms (30–69: 1–4%, >70: 6–28%) still had increased 30-day mortality compared to patients with chest pain (30–69: 0–2%, >70: 2–15%).

To evaluate the possible risk of selection bias, we investigated if the selection of calls affected our results. We found similar results using three alternative populations (i) last call for each MI, (ii) first call for first MI between 2014 and 2018, and (iii) all calls for all MI's (Supplementary material online, *Table S5*).

Discussion

Principal findings

Among MI patients with information of symptoms, 24% presented with atypical symptoms when calling for help at the 1-1-2 emergency number and 1813-medical helpline. Myocardial infarction patients presenting with atypical symptoms had a lower chance of receiving an emergency dispatch, especially when calling the 1813-medical helpline, and increased 30-day mortality compared to patients with chest pain.

Recent literature has identified symptoms of MI patients retrospectively after hospital admission and estimated prevalence of atypical symptoms ranging from 12–13% in MI populations^{6,24} to 23% in NSTEMI patients.²⁵ As patients might develop chest pain close to or upon hospital arrival, these estimates might differ from what is observed during first medical contact. Our study indicates that atypical symptoms might be somewhat more common pre-hospital than indicated by literature investigating symptoms retrospectively.



Figure 3 Emergency response and 30-day mortality by symptom presentation for patients with myocardial infarction. Number of patients, percentage receiving: no referral for treatment, non-ambulance and self-transport/home visits, non-urgent dispatch and emergency dispatch, and percentage of deaths by symptom presentation. The column 'Overall' summarizes the information for the 1-1-2 emergency number and 1813-medical helpline. CNS, central nervous system. *N* = 8336.

Clawson et al.¹ estimated that 90% of MI patients calling 9-1-1 received an emergency ambulance, which aligns with our finding for calls to the 1-1-2 emergency number, where 89% of MI patients received the emergency dispatch. This is not assumed to be representative to all MI patients calling for help, as chance of receiving emergency dispatch was markedly lower (52%) at the 1813-medical helpline to which 42% of MI patients called. Calling the 1813-medical helpline, a non-emergency service, when having an MI could indicate that the patient was unaware of the severity of their symptoms or experienced milder symptoms. Mild symptoms might be correlated to a smaller or less progressed infarction, which aligns with the overall lower 30-day mortality observed among patients calling the 1813-medical helpline compared to the 1-1-2 emergency number. Previous research found that self-perceived

cardiac symptoms decreased the risk of pre-hospital delay, indicating that the patient's own perception of symptoms is important to ensure early recognition.²⁶ Future research should investigate the potential of educational campaigns to improve help-seeking behaviour among MI patients.

Myocardial infarction patients with atypical symptoms were less likely to receive CAG. Thus, type 2 infarctions might contribute to observed differences in mortality between MI patients with chest pain and atypical symptoms, as type 2 infarctions more often present with atypical symptoms including dyspnoea and have increased mortality compared to type 1 infarction.^{27,28} Among MI patients receiving CAG, differences in mortality between atypical symptoms and chest pain persisted, although differences were smaller and predominantly among the elderly.



Figure 4 The proportion of patients with myocardial infarction receiving an emergency dispatch in subgroups of age and sex according to symptom presentation with 95% confidence intervals. For each symptom, proportion of myocardial infarction patients receiving emergency dispatch is shown across age groups (x-axis) and by sex indicated by colour. Vertical lines represent the 95% confidence intervals, and dots represents the mean. CNS, central nervous system. *N* = 8336.

We expected that mortality would increase when patients did not receive the emergency dispatch. This held true for patients with chest pain but not for other cardiac symptoms. Here, mortality was low, though few received the emergency dispatch. Conversely, most patients with CNS symptoms received an emergency dispatch at the 1-1-2 emergency number, but 27% died. A possible explanation is that Danish guidelines recommend that suspected cardiac patients are fast-tracked to cardiology departments or cardiac catheterization lab if symptoms or pre-hospital electrocardiogram support MI suspicion.²⁹ Chest pain and other cardiac symptoms might raise pre-hospital suspicion of cardiac disease, possibly increasing the chance of fast referral to the cardiology department, ultimately reducing time to revascularization.

Limitations

A general limitation to interpretation is the observational nature of the study.

Some uncertainty is expected when defining MI using registries, but validation studies indicate high validity. Positive predictive values were 99% and 88% for the first time and recurrent MI using the Danish National Patient Registry, and 62–86% using the Danish Register of Causes of Death.^{30,31}

The unique system for handling emergency and non-emergency calls in the Capital Region of Denmark enables us to systematically identify symptoms reported in relation to later diagnosis. Extrapolation to other health care systems might require more evidence or adaption.

Implications

To improve pre-hospital recognition of MI patients, greater awareness of patients presenting without chest pain is needed at emergency and non-emergency medical services, especially regarding calls from elderly patients where atypical presentations are common. Although we found an association between atypical symptoms among MI patients and a lower chance of emergency dispatch and 30-day mortality, still, it remains unknown whether increase in emergency dispatches alone would in fact improve survival among MI patients with atypical symptoms. Future research should investigate which pre-hospital mechanisms have a causal effect on mortality in order to advocate possible changes in pre-hospital policies.

Conclusion

We found that patients with MI presenting with atypical symptoms when calling for help had a lower chance of receiving an emergency dispatch compared to MI patients with chest pain, especially when calling a non-emergency medical service. Myocardial infarction patients with atypical symptoms had increased 30-day mortality compared to MI patients with chest pain.

Supplementary material

Supplementary material is available at European Heart Journal: Acute Cardiovascular Care.

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