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Clinical paper

The value of symptoms and signs in the emergent diagnosis of acute coronary syndromes☆

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ABSTRACT

Objective: Patient history and physical examination are widely accepted as cornerstones of diagnosis in modern medicine. We aimed to assess the value of individual historical and examination findings for diagnosing acute myocardial infarction (AMI) and predicting adverse cardiac events in undifferentiated Emergency Department (ED) patients with chest pain.
Methods: We prospectively recruited patients presenting to the ED with suspected cardiac chest pain. Clinical features were recorded using a custom-designed report form. All patients were followed up for the diagnosis of AMI and the occurrence of adverse events (death, AMI or urgent revascularization) within 6 months.
Results: AMI was diagnosed in 148 (18.6%) of the 796 patients recruited. Following adjustment for age, sex and ECG changes, the following characteristics made AMI more likely (adjusted odds ratio, 95% confidence intervals): pain radiating to the right arm (2.23, 1.24–4.00), both arms (2.69, 1.36–5.36), vomiting (3.50, 1.81–6.77), central chest pain (3.29, 1.94–5.61) and sweating observed (5.18, 3.02–8.86). Pain in the left anterior chest made AMI significantly less likely (0.25, 0.14–0.46). The presence of rest pain (0.67, 0.41–1.10) or pain radiating to the left arm (1.36, 0.89–2.09) did not significantly alter the probability of AMI.
Conclusions: Our results challenge many widely held assertions about the value of individual symptoms and signs in ED patients with suspected acute coronary syndromes. Several 'atypical' symptoms actually render AMI more likely, whereas many 'typical' symptoms that are often considered to identify high-risk populations have no diagnostic value.

1. Background

The patient history and physical examination are widely accepted as the cornerstones of diagnosis in modern medicine. The European Society of Cardiology (ESC) and American Heart Association (AHA) both recommend that the history and examination should be utilised in patients presenting to the Emergency Department (ED) with suspected acute coronary syndromes (ACS) in order to assess the likelihood of ACS and to evaluate prognosis.[1,2] For example, the AHA guidelines state that "chest or left arm pain or discomfort as the chief symptom reproducing prior documented angina" is associated with a high likelihood of ACS.[1] The ESC guidelines state that "the typical clinical presentation of NSTE-ACS is retrosternal pressure or heaviness radiating to the left arm, neck or jaw".[2] The guidelines also state that patients who have symptoms occurring at rest have a worse prognosis than those whose symptoms occur on exertion.

While these statements are based upon expert opinion, references to primary research are not provided. Previous reports have shown that certain clinical features do help to predict the presence or absence of ACS, although they cannot be used alone to confirm or exclude the diagnosis.[3–6] Much of this research was conducted in the pre-troponin era and has not been validated against modern gold standards for the diagnosis of AMI. Several studies were subjected to verification bias as not all included patients underwent gold standard investigations for AMI.[7,8] Other studies recruited carefully selected low risk[9,10] or high-risk[11,12] cohorts. One large study of 10,689 patients from the pre-troponin era did not investigate examination findings or specific symptoms such as the site, character and radiation of chest pain.[13]

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We therefore aimed to assess the value of individual symptoms and examination findings for predicting a diagnosis of acute myocardial infarction (AMI) or the occurrence of adverse events in patients who present to the ED with suspected cardiac chest pain.

2. Methods

We prospectively recruited patients in the ED at Manchester Royal Infirmary, a university-affiliated teaching hospital with an annual ED census of approximately 145,000 (comprising approximately 39,000 major cases, 43,000 minor injuries, 19,000 ophthalmological emergencies, 24,000 primary care emergencies, 13,000 presentations to the Walk in Centre and 7000 others). The study was approved by the Local Research Ethics Committee.

All patients aged >25 years who presented to the ED with suspected cardiac chest pain, with the most significant episode occurring within the last 24 h, were eligible for inclusion in the study. We excluded patients if they had another medical condition requiring hospital admission, renal failure needing dialysis, significant chest trauma with suspected myocardial contusion, if they were pregnant, did not speak English, were prisoners or if all means of follow-up would be impossible. All patients provided written informed consent.

Clinical data were recorded by the initial treating ED physician at the time of ED presentation using a custom-designed case report form (CRF). The presence or absence of each symptom or sign was denoted by the appropriate marking of yes/no check boxes on the CRF by the initial treating physician with the following exceptions. The presence of basal crackles was indicated by the appropriate annotations on the diagram of lung fields and their absence was indicated by the annotations "clear" or "no crackles". If neither had been indicated data was considered missing. Hypotension (systolic blood pressure $\leq$100 mmHg) was assessed at the time of presentation to the ED. The CRF asked the treating physician to report whether, in their opinion, the initial ECG demonstrated acute ischaemic features. If a yes/no check box contained no markings or ambiguous markings the data was considered missing. As biochemical results were not available at the point of assessment, recruiting physicians were blinded to troponin levels but were not blinded to other clinical information such as the ECG.

All patients had blood taken for troponin *T*-testing $\geq$12 h after symptom onset (Roche diagnostics, 99th percentile <0.01 ng/ml, CV $\leq$10% at 0.035 ng/ml). The timing of serial troponin testing was not dictated by the study protocol and was undertaken at the discretion of the responsible physicians. Patients were followed up after 48 h, 30 days and 6 months. Mortality data was initially checked using the National Health Strategic Tracing Service (NSTS) database, a national database that includes the mortality status of every patient registered with the NHS in England and Wales.[14] Electronic hospital records were then checked for every patient. This includes details of all ED attendances, all investigation requests and reports, all hospital admissions and all correspondence. Patients were then also contacted by telephone or visited. In the event that a patient was not contactable, their general practitioner was contacted. These patients were considered to have completed follow-up if the general practitioner had been in contact with the patient during the follow-up period and was able to divulge all relevant information. In the event that a patient had sought attention at another hospital, copies of all relevant records were obtained from that hospital.

2.1. Interobserver reliability

Interobserver reliability of each clinical variable was assessed by calculating kappa (κ) values in a convenience sample of patients who were assessed by two independent ED physicians, each of whom were blinded to the other's assessment and each recorded their assessment on a separate CRF. The sample size was calculated by consulting guidelines regarding sample size for reliability studies.[15] In order to demonstrate a κ of 0.6 with the minimal acceptable κ set at 0.3 we would require 44 patients to be assessed by two independent observers.

2.2. Outcome measures

The primary outcome was a diagnosis of AMI and the secondary outcome was the occurrence of adverse cardiac events within 6 months. As all patients had symptoms of ischaemia by virtue of the inclusion criteria, patients were considered to fulfil criteria for the diagnosis of AMI if they had a troponin *T* elevation $\geq$0.035 ng/ml.[16,17] An adverse event was defined as: death (all cause), AMI (including the index event) or the need for urgent coronary revascularization. Urgent revascularization was defined as percutaneous coronary intervention or coronary artery bypass grafting excluding those procedures that were undertaken on an elective basis. Patients who were found to have a new angiographic stenosis of $\geq$50% (as reported by the responsible interventional cardiologist) that was not amenable to revascularization were also considered to have developed this outcome.

2.3. Statistical analysis

We used binary logistic regression to calculate unadjusted odds ratios (OR) and 95% confidence intervals (CI), which represent a summary measure of the overall diagnostic value of each individual symptom or sign for diagnosing AMI and predicting outcome. Age, sex and the presence or absence of acute ischaemic ECG features were then entered as covariates in the logistic regression analysis in order to calculate adjusted ORs that take account of these covariates. Variables that did not predict outcome with $p < 0.05$ were not considered to present useful diagnostic or prognostic information and were not analysed further. For those symptoms and signs that did show some overall value for diagnosing AMI or predicting AMI ($p < 0.05$), sensitivities, specificities, positive and negative predictive values (PPV and NPV respectively), positive and negative likelihood ratios (LR+ and LR− respectively) were calculated. We also examined the relationships between individual symptoms and the type of AMI by classifying each AMI as either anterior or anterolateral; inferior, posterior or right ventricular; or non-ST elevation myocardial infarction (NSTEMI) on the basis of ECG changes. The prevalence of each individual symptom or sign among patients with each type of AMI was calculated and the proportions were compared by chi-squared test. All statistical analyses were undertaken using SPSS version 15.0 or MedCalc version 9.5.2.0.

3. Results

3.1. Overview of data collection

804 patients were recruited to the study between January 2006 and February 2007. 8 patients were excluded because they were found to meet pre-defined exclusion criteria, meaning that 796 patients were entered into the final analysis. No patients were lost to follow-up within 6 months.

148 (18.6%) patients were diagnosed with AMI on their index admission. Of those patients, 13 (8.8%) died and 101 (68.2%) needed urgent revascularization within 6 months. Of the 648 patients who did not have index AMI, 6 (0.9%) patients died within 6 months, 6 (0.9%) had AMI and 52 (8.0%) needed urgent revascularization.

Therefore, by the end of the 6-month follow-up period, a total of 19 patients had died (2.4%), 27 patients had AMI (excluding the index event, 3.4%) and 154 patients needed urgent coronary

Table 1
Baseline characteristics stratified according to whether the patients met diagnostic criteria for AMI during their index attendance.

Variable	Total (*N* = 796)	Diagnosed with AMI (*N* = 148)	Not diagnosed with AMI (*N* = 648)
Age in years, mean (standard deviation)	58.9 (14.2)	63.1 (13.2)	57.9 (14.3)
Men (%)	481 (60.4)	104 (70.3)	377 (58.2)
Previous angina (%)	258 (32.4)	35 (23.6)	223 (34.4)
Previous myocardial infarction (%)	195 (24.5)	32 (21.6)	163 (25.2)
Hypertension (%)	399 (50.1)	73 (49.3)	326 (50.3)
Hyperlipidaemia (%)	379 (47.6)	57 (38.5)	322 (49.7)
Diabetes mellitus (%)	141 (17.7)	23 (15.5)	118 (18.2)
Smoking (%)	247 (31.0)	69 (46.6)	178 (27.5)
Family history of ischaemic heart disease (%)	379 (47.6)	63 (42.6)	316 (48.8)
Previous coronary intervention (%)	160 (20.1)	22 (14.9)	138 (21.3)
Peripheral vascular disease (%)	15 (1.9)	3 (2.0)	12 (1.9)
Cerebrovascular disease (%)	76 (9.5)	14 (9.5)	62 (9.6)
Grade of treating physician (%)			
Senior house officer[a]	71 (8.9)	13 (8.8)	58 (9.0)
Registrar[b]	724 (91.0)	135 (91.2)	589 (90.9)
Consultant (attending)	1 (0.1)	0	1 (0.2)

[a] ≥1 and typically < 5 years postgraduate medical experience.
[b] Typically 4–9 years postgraduate medical experience.

revascularization (19.3%). In total 179 patients (22.9%) developed an adverse event (death, AMI or the need for urgent revascularization) during 6-month follow-up. Key baseline characteristics of the patients are shown in Table 1. Altogether, 526 (66%) patients described their ethnic origin as British White, 115 (15%) were Asian Pakistani, Asian Indian or Asian Other, 36 (5%) were Irish White, 27 (3%) were Black Caribbean, 74 (9%) were of any other ethnic origin and 17 (2%) patients did not wish to answer the question.

The presence or absence of chest wall tenderness was not recorded for 1 patient. There were no other missing data. The prevalence of each clinical feature varied from 0.8% to 87.1% (see web appendix, Table 5). The majority (440, 55.3%) of patients had previously experienced similar episodes of the chest pain, although in 47.5% of these cases the pain had not been identified as myocardial ischaemia. Most subjects (87.1%) experienced chest pain at rest.

3.2. Interobserver reliability

Table 2 demonstrates the interobserver reliability of variables with a kappa score ≥0.6. The degree of reliability varied, with 4 variables showing near perfect agreement ($\kappa \geq 0.8$), 16 showing substantial agreement (κ 0.6–0.8), 3 showing moderate agreement (κ 0.4–0.6), 2 showing slight agreement (κ 0.2–0.4) and 5 showing poor or slight agreement ($\kappa < 0.2$).[18]

3.3. Diagnostic value for AMI

The association between individual clinical features and the diagnosis of AMI is shown in Fig. 1. 11 clinical features had statistically significant ($p < 0.05$) diagnostic value. The sensitivities, specificities and predictive values of those clinical features are shown in Table 3. Sweating observed by the ED physician was the strongest predictor of AMI (adjusted OR 5.18, 95% CI 3.02–8.86). Reported vomiting was also a fairly strong predictor of AMI (adjusted OR 3.50, 1.81–6.77). Pain located in the left anterior chest was found to be the strongest negative predictor of AMI (adjusted OR 0.25, 0.14–0.46). Surprisingly, patients who described the pain as being the same as previous myocardial ischaemia were significantly less likely to be having AMI (adjusted OR 0.42, 0.26–0.69).

Table 6 (web appendix) demonstrates the relative prevalence of each symptom or sign stratified by type of AMI. Patients with STEMI were significantly more likely to have pain lasting >1 h than patients with NSTEMI, with the median symptom duration being 120 min in patients with STEMI, 90 min in patients with NSTEMI and 60 min

Table 2
Interobserver reliability of clinical variables with a kappa score ≥0.6.

Clinical feature	Number with two independent ratings	Absolute agreement (%)	κ	95% CI
Previously identified as ischaemic pain	38	97.3	0.92	0.78–1.00
Acute ischaemic ECG features	37	94.6	0.87	0.70–1.00
Sweating observed	31	96.8	0.84	0.16–1.00
Rest pain	41	95.1	0.81	0.54–1.00
Duration over 1 h	39	89.7	0.80	0.60–0.99
Pain radiates to back	43	95.3	0.78	0.47–1.00
Pain radiates to jaw, neck or throat	43	93.0	0.73	0.43–1.00
Pain character: sharp/stabbing	42	92.9	0.73	0.43−−1.00
Pain: left anterior	43	88.4	0.72	0.47–0.95
Pain: central	43	88.3	0.71	0.47–0.94
Reported nausea	43	86.0	0.69	0.45–0.92
Reported vomiting	43	97.7	0.66	−0.01–1.00
Pain radiates to left shoulder/arm	43	86.0	0.65	0.40−−0.91
Pain radiates to right shoulder/arm	43	95.3	0.65	0.16–1.00
Worsening angina	36	97.2	0.65	−0.02–1.00
Chest wall tender	34	97.1	0.65	−0.02–1.00
Basal crackles	35	94.3	0.64	0.15–1.00
Any radiation	43	81.4	0.63	0.39–0.86
Reported sweating	43	83.3	0.63	0.39–0.86
Pain character: dull	42	83.3	0.62	0.37–0.88
Reported paraesthesiae	43	90.7	0.62	0.26–0.98

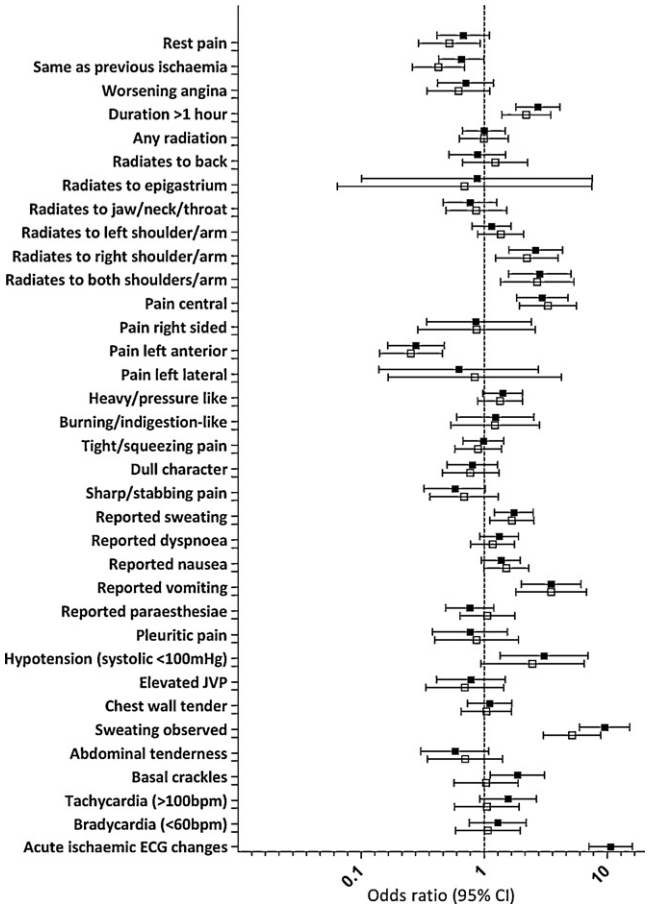

Fig. 1. Value of individual clinical features for diagnosing AMI, derived by logistic regression. Filled squares denote unadjusted ORs; open squares indicate ORs adjusted for age, sex and ischaemic ECG changes.

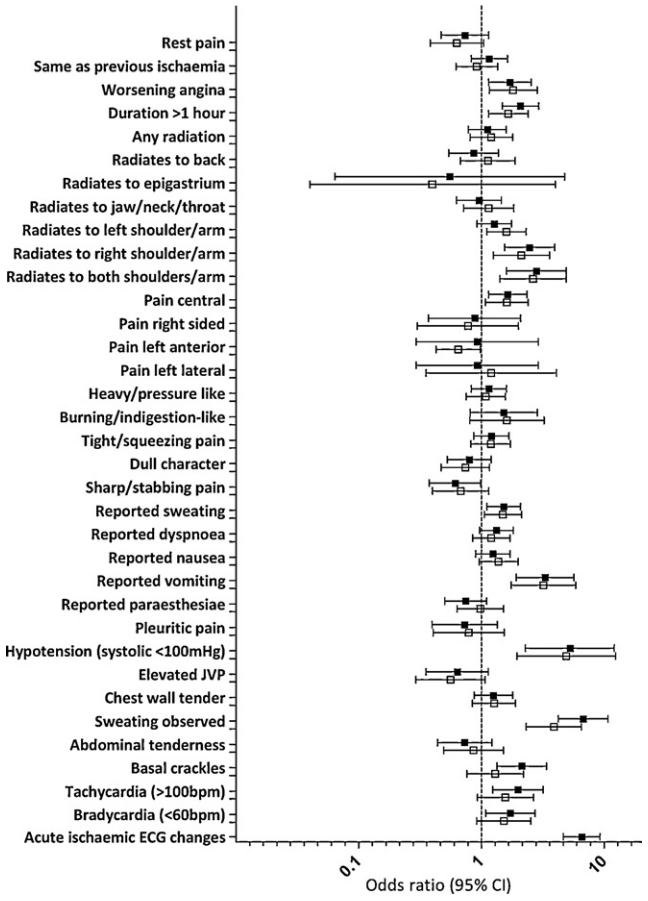

Fig. 2. Value of individual historical features for predicting the occurrence of adverse events within 6 months. Filled squares denote unadjusted ORs (bivariate correlations); open squares denote ORs adjusted for age, sex and ischaemic ECG changes.

in patients without AMI). Patients with anterior or anterolateral STEMI were significantly more likely to describe their pain as heavy or pressure-like and significantly less likely to describe their pain as dull in nature compared to patients with NSTEMI and no AMI. Patients with NSTEMI were no more likely than patients without AMI to report nausea, although patients with STEMI were significantly more likely to report this symptom. Hypotension was most likely in patients with inferior, right ventricular or posterior STEMI, whereas elevated jugular venous pressure was most likely in patients with anterior or anterolateral STEMI. Tachycardia was significantly more likely to be present in patients with anterior or anterolateral STEMI compared to all other groups, whereas bradycardia was significantly more likely in patients with inferior, right ventricular or posterior STEMI.

3.4. Prognostic value for prediction of adverse events

Fig. 2 demonstrates the ORs of individual clinical features for predicting adverse events within 6 months. The sensitivities, specificities and predictive values of the clinical features that were statistically significant predictors are shown in Table 4. Again, sweating observed (adjusted OR 3.88, 2.31–6.51) and associated vomiting (adjusted OR 3.20, 1.75–5.84) were found to be the strongest positive predictors. The predictive value of pain radiating to the right arm or shoulder (adjusted OR 2.12, 1.25–3.58) was found to be greater than that of pain radiating to the left arm or shoulder (adjusted OR 1.60, 1.10–2.31). Pain radiating to both arms or shoulders had greater predictive value than either (adjusted OR 2.80, 1.60–4.89). Although they were not found to be of value for

Table 3
Characteristics of each predictive clinical feature as a diagnostic test for AMI.

Predictor	Sensitivity, % (95% CI)	Specificity, % (95% CI)	PPV, % (95% CI)	NPV, % (95% CI)	LR+ (95% CI)	LR− (95% CI)
Same as previous ischaemia	22.3 (15.9–29.9)	69.4 (65.7–73.0)	14.3 (10.0–19.5)	79.7 (76.1–82.3)	0.73 (0.53–1.01)	1.12 (1.01–1.24)
Duration >1 h	77.0 (69.4–83.5)	44.9 (41.0–48.8)	24.2 (20.4–28.3)	89.5 (85.7–92.6)	1.40 (1.25–1.56)	0.51 (0.38–0.70)
Pain radiates to right shoulder/arm	18.9 (13.0–26.2)	91.8 (89.4–93.8)	34.6 (24.4–46.0)	83.2 (80.3–85.9)	2.31 (1.52–3.53)	0.88 (0.81–0.96)
Pain radiates to both shoulders/arms	13.5 (8.5–20.1)	94.8 (92.7–96.3)	37.0 (24.3–51.3)	82.8 (79.8–85.4)	2.58 (1.53–4.34)	0.91 (0.85–0.98)
Pain central	85.1 (78.4–90.4)	34.1 (30.5–37.9)	22.8 (19.4–26.5)	91.0 (86.6–94.2)	1.29 (1.18–1.41)	0.44 (0.29–0.65)
Pain left anterior	11.5 (6.8–17.8)	68.2 (64.5–71.8)	7.6 (4.5–11.9)	77.1 (73.5–80.5)	0.36 (0.23–0.57)	1.30 (1.20–1.40)
Reported sweating	59.5 (51.1–67.4)	54.3 (50.4–58.2)	22.9 (18.8–47.5)	85.4 (81.7–88.7)	1.30 (1.11–1.52)	0.75 (0.61–0.92)
Reported vomiting	16.2 (10.7–23.2)	94.8 (92.7–96.3)	41.4 (28.6–55.1)	83.2 (80.3–85.8)	3.09 (1.89–5.05)	0.88 (0.82–0.95)
Hypotension	6.8 (3.3–12.1)	97.7 (96.2–98.7)	40.0 (21.2–61.3)	82.1 (79.2–84.7)	2.92 (1.34–6.37)	0.95 (0.91–1.00)
Basal crackles	16.2 (10.7–23.2)	90.6 (88.1–92.7)	28.2 (19.0–39.0)	82.6 (79.6–85.3)	1.72 (1.11–2.67)	0.92 (0.86–1.00)
Sweating observed	36.5 (28.7–44.8)	94.3 (92.2–96.0)	59.3 (48.5–69.5)	86.7 (83.9–89.1)	6.39 (4.38–9.33)	0.67 (0.60–0.76)
Acute ischaemic ECG changes	71.0 (62.9–78.1)	81.3 (78.1–84.3)	46.5 (39.8–53.2)	92.5 (90.0–94.5)	3.80 (3.14–4.60)	0.36 (0.28–0.46)

Table 4
Characteristics of predictive clinical features as diagnostic tests for predicting index AMI or adverse events within 6 months.

Predictor	Sensitivity, % (95% CI)	Specificity, % (95% CI)	PPV, % (95% CI)	NPV, % (95% CI)	LR+ (95% CI)	LR− (95% CI)
Worsening angina	22.3 (16.9–28.5)	85.6 (82.5–88.4)	35.9 (27.7–44.7)	75.3 (71.9–78.6)	1.55 (1.13–2.14)	0.91 (0.84–0.98)
Duration >1 h	71.6 (65.0–77.5)	45.3 (41.2–49.4)	32.1 (27.9–36.5)	81.5 (76.9–85.6)	1.31 (1.17–1.46)	0.63 (0.50–0.79)
Pain radiates to right shoulder/arm	17.1 (12.3–22.8)	92.3 (89.8–94.3)	44.4 (33.4–55.9)	75.5 (75.2–78.6)	2.22 (1.47–3.34)	0.90 (0.84–0.96)
Pain radiates to both shoulders/arms	12.3 (8.2–17.5)	95.2 (93.2–96.8)	48.2 (34.5–62.2)	75.1 (71.8–78.1)	2.57 (1.55–4.29)	0.92 (0.87–0.97)
Pain central	76.8 (70.5–82.3)	33.2 (29.4–37.1)	29.3 (25.5–33.3)	79.8 (74.2–84.7)	1.15 (1.05–1.26)	0.70 (0.53–0.92)
Pain left anterior	20.9 (15.6–27.0)	69.4 (65.5–73.1)	19.7 (14.7–25.6)	70.9 (67.0–74.6)	1.14 (1.04–1.24)	0.68 (0.51–0.91)
Pain sharp/stabbing	10.9 (7.0–15.9)	83.3 (80.0–86.2)	19.0 (12.5–27.2)	72.2 (68.6–75.7)	0.65 (0.42–1.00)	1.07 (1.01–1.14)
Reported sweating	55.9 (49.0–62.7)	54.5 (50.4–58.6)	30.7 (26.2–35.6)	77.4 (73.1–81.4)	1.23 (1.06–1.43)	0.81 (0.68–0.96)
Reported vomiting	14.2 (9.8–19.7)	95.2 (93.2–96.8)	51.7 (38.2–65.1)	75.5 (72.2–78.5)	2.97 (1.82–4.85)	0.90 (0.85–0.95)
Hypotension	7.6 (4.4–12.0)	98.5 (97.1–99.3)	64.0 (42.5–82.0)	74.7 (71.5–77.7)	4.93 (2.21–10.98)	0.94 (0.90–0.98)
Bradycardia	15.6 (11.0–21.3)	90.3 (87.6–92.5)	36.7 (26.8–47.5)	74.8 (71.4–78.0)	1.61 (1.08–2.39)	0.93 (0.88–1.00)
Tachycardia	15.6 (11.0–21.3)	91.5 (88.9–93.6)	39.8 (29.2–51.1)	75.0 (71.7–78.2)	1.83 (1.21–2.76)	0.92 (0.87–0.98)
Basal crackles	16.6 (11.8–22.3)	91.5 (88.9–93.6)	41.2 (30.6–52.4)	75.3 (71.9–78.4)	1.94 (1.30–2.90)	0.91 (0.85–0.97)
Sweating observed	28.0 (22.0–34.5)	94.5 (92.4–96.2)	26.5 (23.5–29.7)	64.8 (54.1–74.6)	5.11 (3.42–7.63)	0.76 (0.70–0.83)
Acute ischaemic ECG changes	58.3 (51.3–65.0)	82.4 (79.1–85.4)	54.4 (47.7–61.0)	84.6 (81.3–87.4)	3.31 (2.69–4.08)	0.51 (0.43–0.60)

diagnosing AMI, bradycardia, tachycardia and crackles at the lung bases were each found to be weak but statistically significant predictors of adverse events.

4. Discussion

Our results demonstrate that while a number of clinical features can be used to shift the prior probability, none can be used alone to reliably confirm or exclude AMI or the occurrence of adverse events. Some 'atypical' symptoms (notably pain radiating to the right arm or shoulder) were shown to render AMI and the occurrence of adverse events significantly more likely. Others (for example, pleuritic pain, burning or indigestion-like pain and right sided chest pain) had no diagnostic or prognostic value. Several 'typical' symptoms were found to have no significant diagnostic or prognostic value (including radiation to the jaw, neck, throat, left arm or left shoulder and pain with a tight, squeezing, heavy or pressure-like character). Surprisingly, pain located in the left anterior chest and pain same as the previous myocardial ischaemia both identified patients with a lower probability of AMI.

4.1. Limitations

It is important to exercise some caution in the interpretation of these findings. This study was conducted in a single inner city ED in the northwest of England. Variations in symptomatology among patients from different ethnic groups has been well documented.[19,20] Whether our findings can be generalised to wider patient groups can therefore only be determined by similar research in heterogeneous cohorts. It should also be noted that our findings cannot be extrapolated to patients outside the ED, as varying degrees of patient selection are likely to significantly alter the predictive value of clinical features. Further, it is important to recognise that the diagnostic value of some features may be higher among cohorts of patients with all undifferentiated non-traumatic chest pain (regardless of the suspicion of ACS). Some clinical features (for example, a pleuritic nature) undoubtedly influence the decision to suspect cardiac pain. It is also important to recognise that our analysis only permitted simple yes/no classification with regard to each symptom or sign. While this was the only feasible means to enable this analysis, it is possible that in true clinical practice the strength of response or intensity of a particular symptom may enhance its diagnostic value.

For practical and ethical reasons we excluded patients if they were unable to speak English or provide written informed consent. Our results may have limited application for these patients, particularly with regard to symptoms that rely upon good channels of communication between physician and patient.

4.2. Implications and comparison with previous research

These results challenge current thinking regarding the diagnostic and prognostic values of many clinical features in patients with suspected cardiac chest pain presenting to the ED. For example, the assertion by the ESC that chest pain occurring at rest identifies a high-risk group of patients does not appear to be valid in the undifferentiated ED population. Rest pain was documented in 87% of our cohort and its presence carried neither diagnostic nor prognostic value.

Similarly, it would appear that the statement within AHA guidelines that "chest or left arm pain. . . reproducing prior documented angina [is associated with] a high likelihood of ACS" does not appear to be valid in the ED population. We found that pain same as the previous myocardial ischaemia identified a population who were significantly less likely to be having AMI than the remainder of the cohort and no more likely to have an adverse event within 6 months. Perhaps the previous experiences of these patients have led to them being more likely to seek emergency medical attention when their symptoms recur. They may, for example, be afraid that they may be about to experience another 'heart attack' on experiencing a transient or mild episode of chest pain. Alternatively they may have been advised by healthcare professionals to seek help at the earliest opportunity should the symptoms recur.

'Typical' cardiac chest pain is also usually described as central or substernal in location and, less often, as a left-sided chest pain. Many patients seem concerned if they experience pain in the left side of the chest because they perceive that the pain is located in the same place as the heart. We found that patients with central chest pain were more likely to be having AMI and had a worse prognosis than the remainder of the cohort. Meanwhile, patients with left anterior chest pain were less likely to be having AMI and had a better prognosis than other patients. Interestingly, pain experienced in the right side of the chest or in the left lateral chest did not have predictive value for AMI or adverse events, although the wide confidence intervals suggest that these analyses may have been underpowered.

Associated symptoms including vomiting and sweating were found to carry significant predictive value, results that are consistent with previous investigations in the pre-troponin era.[3,4] Sweating observed by the treating physician was an even stronger positive predictor of AMI and adverse events than sweating as

reported by the patient. There are several possible explanations for this. Sweating (or diaphoresis) is a sign of activation of the sympathetic nervous system, a common response to pain and to the acute reduction in cardiac output associated with AMI.[21,22] Perhaps patients who reported sweating but were not observed to be sweating in the ED had less activation of the sympathetic nervous system, for example due to more transient or less severe pain or a less marked reduction in cardiac output.

We found that enquiry into the radiation of pain also yielded potentially valuable clinical information. Interestingly radiation to both arms or shoulders was a stronger predictor of AMI and adverse events than radiation to the right arm or shoulder, which in turn was a stronger predictor than radiation to the left arm or shoulder. While these findings may appear surprising, they are in fact remarkably consistent with previous similar research.[3,4,10]

Some may wonder whether these findings begin to question the validity of current definitions of 'typical' cardiac chest pain in the medical literature. However, taken from a different perspective, 39.2% of the patients who had AMI reported pain radiating to the left arm or shoulder. 18.9% of patients with AMI reported radiation to the right arm or shoulder. Because radiation to the right arm or shoulder was less common among patients without AMI (8.2%), this feature was able to facilitate a degree of differentiation between patients with and without AMI. However, the frequency of radiation to the left arm or shoulder in patients with AMI was comparable to that in patients without AMI (36.0%). Therefore, while our findings cannot be used to reject the theory that pain radiating to the left arm or shoulder is a 'typical' symptom of AMI, they indicate that the presence or absence of this feature gives us little capacity to discriminate between patients with and without AMI in the ED.

5. Conclusions

Our findings challenge many widely held assertions about the value of individual symptoms and signs in ED patients with suspected ACS. Symptoms that are known to be 'typical' or 'atypical' of ACS may actually have little ability to differentiate the ED population with chest pain. Notably, several 'atypical' symptoms actually render the diagnosis of ACS more likely, whereas many 'typical' symptoms that are often considered to identify high-risk populations have no diagnostic value.

Conflict of interests

None declared.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.resuscitation.2009.11.014.

References

1. Anderson JL, Adams CD, Antman EM, et al. ACC/AHA 2007 guidelines for the management of patients with unstable angina/non-st-elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on practice guidelines (writing committee to revise the 2002 guidelines for the management of patients with unstable angina/non-st-elevation myocardial infarction) developed in collaboration with the American College of Emergency Physicians, the Society for Cardiovascular Angiography and Interventions, and the Society of Thoracic Surgeons Endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation and the Society for Academic Emergency Medicine. Journal of the American College of Cardiology 2007;50:e1–157.
2. Bassand JP, Hamm CW, Ardissino D, et al. Guidelines for the diagnosis and treatment of non-ST-segment elevation acute coronary syndromes. The Task Force for the diagnosis and treatment of non-ST-segment elevation acute coronary syndromes of the European Society of Cardiology. European Heart Journal 2007;28:1598–660.
3. Panju AA, Hemmelgam BR, Guyatt GH, Simei DL. The rational clinical examination: is this patient having a myocardial infarction. JAMA 1998;280:1256–63.
4. Bruyninckx R, Aertgeerts B, Bruyninckx P, Buntinx F. Signs and symptoms in diagnosing acute myocardial infarction and acute coronary syndrome: a diagnostic meta-analysis. British Journal of General Practice 2008;58:e1–8.
5. Swap CJ, Nagurney JT. Value and limitations of chest pain history in the evaluation of patients with suspected acute coronary syndromes. Journal of the American Medical Association 2005;294:2623–9.
6. Chun AA, McGee SR. Bedside diagnosis of coronary artery disease: a systematic review. American Journal of Medicine 2004;117:334–43.
7. Baxt WG, Shofer FS, Sites FD, Hollander JE. A neural computational aid to the diagnosis of acute myocardial infarction. Annals of Emergency Medicine 2002;39:366–73.
8. Graff L, Palmer AC, La Monica P, Wolf S. Triage of patients for a rapid (5-minute) electrocardiogram: a rule based on presenting chief complaints. Annals of Emergency Medicine 2000;36:554–60.
9. Goodacre SW, Angelini K, Arnold J, Revill S, Morris F. Clinical predictors of acute coronary syndromes in patients with undifferentiated chest pain. QJM 2003;96:893–8.
10. Goodacre S, Locker T, Morris F, Campbell S. How useful are clinical features in the diagnosis of acute, undifferentiated chest pain? Academic Emergency Medicine 2002;9:203–8.
11. Albarran J, Durham B, Gowers J, Dwight J, Chappell G. Is the radiation of chest pain a useful indicator of myocardial infarction? A prospective study of 541 patients. Accident & Emergency Nursing 2002;10:2–9.
12. Vodopiutz J, Poller S, Schneider B, Lalouschek J, Menz F, Stollberger C. Chest pain in hospitalized patients: cause-specific and gender-specific differences. Journal of Women's Health 2002;11:719–27.
13. Pope JH, Ruthazer R, Beshansky JR, Griffith JL, Selker HP. Clinical features of Emergency Department patients presenting with symptoms suggestive of acute cardiac ischemia: a multicenter study. Journal of Thrombosis & Thrombolysis 1998;6:63–74.
14. Department of Health. The National Health Service Strategic Tracing Service database. National Health Service Strategic Tracing Service [2009 [cited 2009 July 5]. Available from: URL:http://www.connectingforhealth.nhs.uk/systemsandservices/nsts.
15. Walter SD, Eliasziw M, Donner A. Sample size and optimal designs for reliability studies. Statistics in Medicine 1998;17:101–10.
16. Thygesen K, Alpert JS, White HD. On behalf of the Joint ESC/ACCF/AHA/WHF Task Force for the Redefinition of Myocardial Infarction. Universal definition of myocardial infarction. Circulation 2007;116:2634–53.
17. The Joint European Society of Cardiology/American College of Cardiology Committee. Myocardial infarction redefined—A consensus document of The Joint European Society of Cardiology/American College of Cardiology Committee for the redefinition of myocardial infarction. European Heart Journal 2000;21:1502–13.
18. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33:159–74.
19. Summers RL, Cooper GJ, Carlton FB, Andrews ME, Kolb JC. Prevalence of atypical chest pain descriptions in a population from the southern United States. The American Journal of the Medical Sciences 1999;318:142.
20. Canto J, Fincher C, Kiefe CI, et al. Atypical presentations among medicare beneficiaries with unstable angina pectoris. American Journal of Cardiology 2003;90:118–9.
21. Graham LN, Smith PA, Stoker JB, Mackintosh AF, Mary DASG. Time course of sympathetic neural hyperactivity after uncomplicated acute myocardial infarction. Circulation 2002;106:793–7.
22. Jardine DL, Charles CJ, Ashton RK, et al. Increased cardiac sympathetic nerve activity following acute myocardial infarction in a sheep model. The Journal of Physiology 2005;565:325–33.