Usefulness of Chest Pain Character and Location as Diagnostic Indicators of an Acute Coronary Syndrome

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This study assessed chest pain locations/symptoms among patients who presented with acute chest pain and how these compare with a clinical diagnosis of cardiac or noncardiac chest pain. A cluster analysis was undertaken to determine any pattern in the chest pain locations described by patients. Cluster analysis identified 4 distinct chest pain locations (upper chest, central retrosternal, central chest, and left chest and left arm). There was considerable location/symptom overlap between patients who had cardiac chest pain and those who had noncardiac chest pain. ©2005 by Excerpta Medica Inc.

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Acute chest pain is the second most common presentation to hospital emergency departments.[1] Each year in the United States, there are ~6 million patients admitted to the hospital for acute chest pain, with an annual economic cost to the health care system of $8 billion (United States currency).[2] The aim of this study was to determine how clusters (groups) of patients with respect to chest pain locations/symptoms compare with a clinical diagnosis of cardiac or noncardiac chest pain. The hypothesis was that chest pain characteristics alone are not useful in differentiating cardiac from noncardiac chest pain.

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This study was approved by the ethics committee of the Wentworth Area Health Service (Sydney, New South Wales, Australia). A consecutive sample of patients who presented with chest pain to a tertiary teaching and referral hospital (Emergency Department, Nepean Hospital, Penrith, New South Wales, Australia) over a 12-month period were enrolled in this cross-sectional methodologic study. Patients were followed through to general admission or to the chest pain clinic at Nepean Hospital. Admissions to these centers were monitored to capture patients who had been referred from other sources. Baseline characteristics of this cohort have been described elsewhere.[3]

Patients come from the Wentworth Area Health Service catchment area, which consists of a population of 307,787 (7.7% of the Sydney population) and is sociodemographically very similar to the Australian population according to 2001 census data, except that its inhabitants are slightly younger (30 vs 35 median years), and it has a slightly higher socioeconomic status based on income ($450 vs $350 median income per week). Ethnic status was not obtained, but most would be Caucasian based on data from the Australian Bureau of Statistics (www.abs.gov.au).

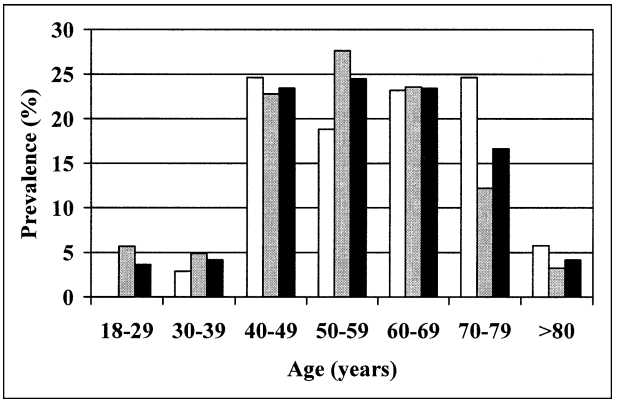

FIGURE 1. Cardiac chest pain *(white bars)*, noncardiac chest pain *(gray bars)*, and all chest pain *(black bars)* by age.

On presentation, subjects were invited to participate in the study. An information package was provided. This included the Chest Pain Questionnaire, a letter describing the study, and a patient consent form (which required a signature), which gives permission to access a patient's medical records. This instrument has been previously described and validated.[4,5]

All patients were asked to fill out the Chest Pain Questionnaire, including those who did not wish to undergo further diagnostic procedures. At initial presentation, patients who elected to undergo further diagnostic tests were assessed according to a standard protocol. This protocol is based on guidelines from the National Health and Medical Research Council (NHMRC) and is used for assessment of chest pain in the Nepean Hospital Emergency Department.[6,7] The NHMRC guidelines are based on those of the American College of Cardiology and American Heart Association, which were updated in 2002.[8] A detailed history and physical examination were included in these initial procedures. More specialized diagnostic tests, which are dependent on the origin of the pain (e.g., gastrointestinal and cardiac), were determined by the characteristics of each patient who presented. No clinical data on medications, electrocardiograms, additional risk factors (i.e., obesity, history of cerebrovascular disease, and family history of coronary heart disease) were collected or available for this particular study.

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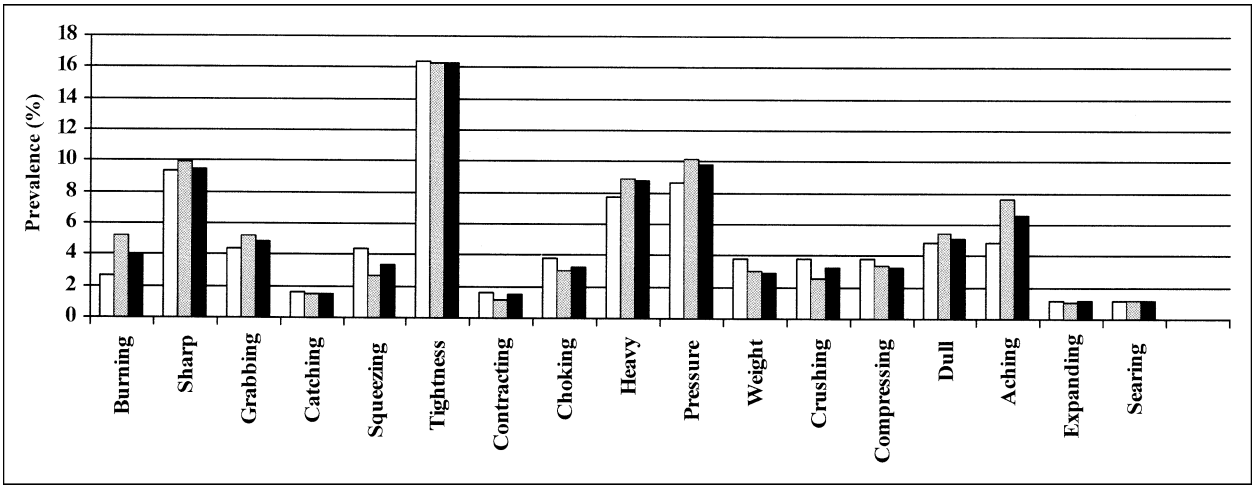

FIGURE 2. Descriptions of cardiac chest pain *(white bars)*, noncardiac chest pain *(gray bars)*, and all chest pain *(black bars)*.

TABLE 1 Cluster Analysis of Factors Identified in the Patient Sample (mean factor scores by cluster)

	Clusters			
Chest Pain Location*	Central Chest	Left Chest and Arm	Central Retrosternum	Upper Chest
A	0.00	0.11	0.06	0.83
B	0.13	0.46	0.10	0.78
C	0.06	0.54	0.17	0.95
D	0.81	0.08	0.02	0.20
E	0.90	0.49	0.39	0.61
F	0.94	0.38	0.10	0.29
G	0.13	0.00	0.03	0.02
H	0.26	0.08	0.15	0.12
I	0.16	0.05	0.05	0.00
J	0.10	0.00	0.05	0.00
K	0.06	1.00	0.00	0.02
L	0.10	0.22	0.02	0.05

*Diagrammed in Figure 3.

The "gold standard" used in this study is based on the emergency physicians and the cardiologists (who were blinded to data from the Chest Pain Questionnaire) who diagnosed and treated patients from this cohort with acute chest pain. Diagnoses of an acute coronary syndrome were based on clinical and diagnostic tests undertaken (e.g., creatine kinase-MB and troponin levels), which were assessed on a case-by-case basis.[9,10]

Cardiac chest pain was defined as a diagnosis by a physician as being due to acute myocardial infarction or ischemic heart disease or was classified as probably having an ischemic origin based on NHMRC diagnostic pathways and protocols. Noncardiac chest pain was defined as chest pain that had not been diagnosed as acute myocardial infarction or ischemic heart disease by a physician. Gastroesophageal reflux disease was defined as heartburn and/or acid regurgitation occurring at least weekly. Diabetes mellitus was defined as a blood sugar level >7.8 mmol/L. Smoking status was determined as nonsmoker, current smoker, or never smoked. High cholesterol level was defined as a total cholesterol level >5.5 mmol/L. High blood pressure was defined as >140/90 mm Hg. Dyspnea was defined as shortness of breath.

"Cluster analysis" is a generic term that describes a subset of statistical procedures that can be used to create a classification.[11–15] These procedures start with a dataset that contains information (e.g., chest pain locations) about a sample of entities (e.g., patients who have chest pain) and attempts to sort these entities into relatively homogenous and mutually exclusive groups (or clusters). In this study, cluster analysis was used to sort patients into "chest pain" clusters or groups based on similarities in reported symptoms.

A k-means cluster analysis was applied (which involves first specifying the number of clusters desired, i.e., k) by using factors that had been extracted from principal components analysis as the basis for forming the cluster solution.[11–15] Analysis commenced with a 2-cluster solution and proceeded by generating increasingly complex cluster solutions (i.e., 3, 4, 5, and 6 clusters). The choice of 2 clusters as a starting point was based on the expectation of ≥2 chest pain clusters that would reflect cardiac and noncardiac chest pain groups. For more detailed information on cluster methods, see Eslick et al.[15]

Patient demographic and clinical characteristics are reported as means ± SD or confidence intervals for numerically scaled features and percentages for discrete characteristics. Chi-square tests were used to compare univariate groups with odds ratios (ORs) and 95% confidence intervals (CIs). All p values calculated were 2-tailed; the α level of significance was set at 0.05.

Of patients who presented with acute chest pain, 212 (84 women and 128 men; mean age 57 ± 14 years, range 18 to 90) were recruited into this study. Overall, there was no significant difference with respect to age or gender. Men who had cardiac chest pain were slightly older than women, but this was not statistically significant (62 vs 59 years, p = 0.4). There was no difference in age between men and women who had noncardiac chest pain (55 vs 55 years, p = 0.9).

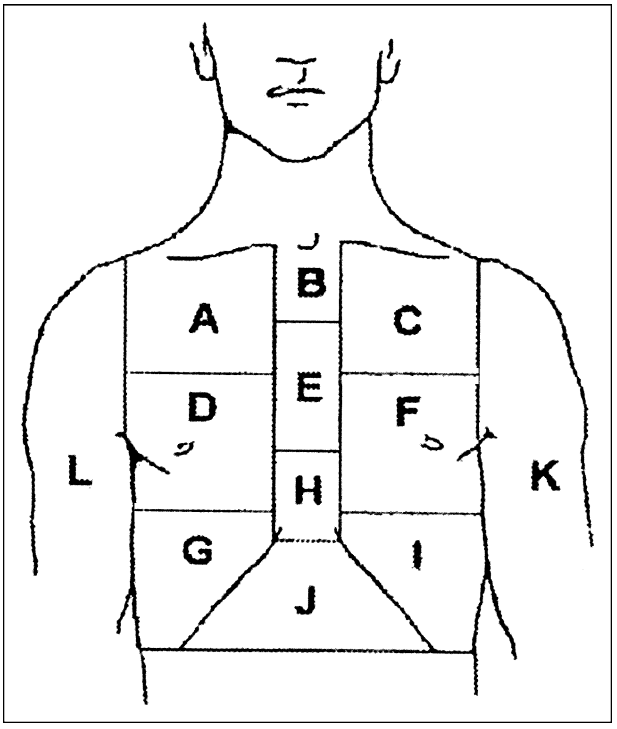

FIGURE 3. Locations of chest pain according to the cluster analysis that is presented in Table 1.

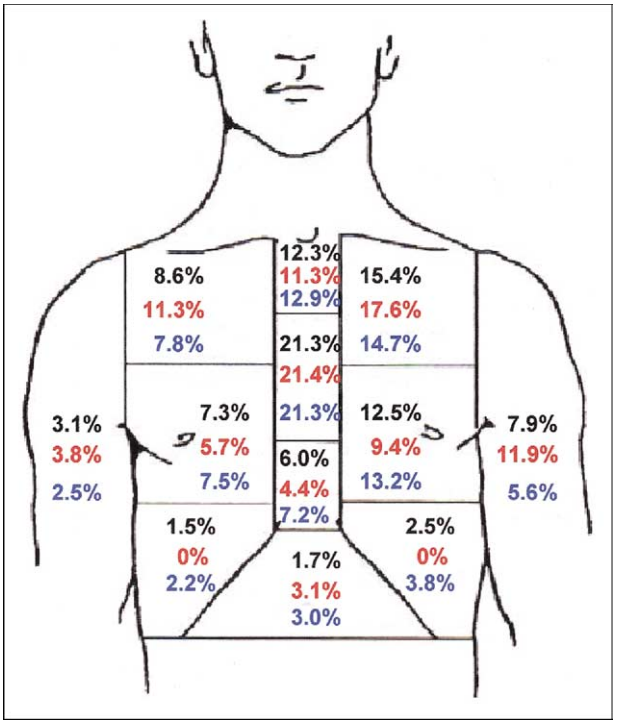

FIGURE 4. Location and prevalence of chest pain. All chest pain *(top)*, cardiac chest pain *(middle)*; noncardiac chest pain *(bottom)*.

As shown in Figure 1, all-cause chest pain peaked among patients who had noncardiac chest pain and were 50 to 59 years old, whereas those who had cardiac chest pain produced a bimodal distribution that peaked in 2 age groups, 40 to 49 and 70 to 79 years. Noncardiac chest pain was present in a larger

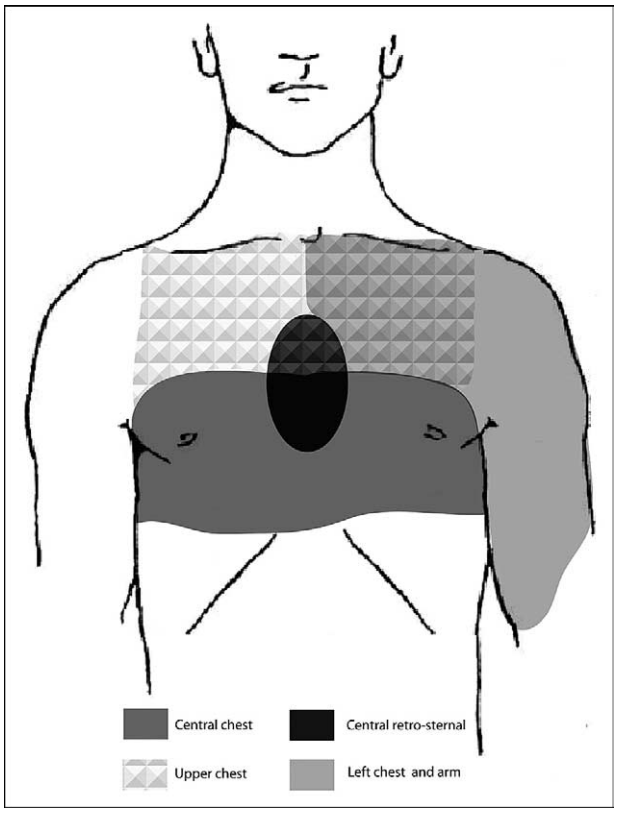

FIGURE 5. Cluster locations of acute chest pain.

proportion of younger groups (18 to 29 and 30 to 39 years old) compared with cardiac chest pain.

Prevalences of noncardiac chest pain were 54% (95% CI 45 to 63) among men and 45% (95% CI 37 to 55) among women (men vs women, $p = 0.2$). Men were ~3 times more likely to have cardiac chest pain compared with women (OR 2.60, 95% CI 1.35 to 4.99). Of all participants, only 71 (33%, 95% CI 27 to 40) reported being diagnosed by a physician as having a myocardial infarction, and 18 (8%, 95% CI 5 to 13%) fulfilled Rose's questionnaire criteria for angina.

To determine the characteristics of chest pain that subjects were describing, questions were asked concerning the type and location of chest pain ("What is the best word to describe the chest pain you are experiencing?") More than 1 answer could apply. The most common responses were "tightness," "pressure," "sharp," "heavy," and "aching" (Figure 2). Location and prevalence of chest pain were based on a diagram (Table 1 and Figures 3 and 4) and subjects circled the letter/letters that best indicated the location of their chest pain. Locations B, E, or H met the criteria for "sternal" chest pain (n = 206), locations G, I, J, K, and L met the criteria for arm/abdominal locations (n = 87), and the remainder were defined as other chest pain areas (n = 229). Among patients who had nonretrosternal chest pain, 83% had noncardiac pain and 17% had cardiac pain. Among those who had retrosternal chest pain, 77% had noncardiac pain and 23% had cardiac pain.

Patients who had cardiac chest pain were 2 times as likely to report severe to very severe chest pain than

moderate chest pain (OR 2.06, 95% CI 1.05 to 4.10), whereas patients who had noncardiac chest pain were more likely to report moderate chest pain. Mean durations of chest pain were 15 to 30 minutes in the noncardiac group and 5 to 15 minutes in the cardiac group. On average, the frequency of chest pain symptoms described occurred <1 time/month in the noncardiac and cardiac groups. There was no association between diabetes and cardiac or noncardiac chest pain (14% vs 14%, OR 0.92, 95% CI 0.35 to 2.52). Neither cardiac chest pain (OR 1.43, 95% CI 0.72 to 2.91) nor noncardiac chest pain (OR 0.70, 95% CI 0.34 to 1.39) was associated with smoking status. In addition, there was no association between diabetes and smoking status (smoking vs nonsmoking, OR 0.68, 95% CI 0.29 to 1.67). Those who had cardiac chest pain were 2 times as likely to have hypercholesterolemia (OR 2.07, 95% CI 1.03 to 4.17) compared with those who had noncardiac chest pain. No statistically significant differences were found between cardiac and noncardiac chest pain in relation to high blood pressure ($p = 0.35$). No difference was observed in rates of patients who had noncardiac/cardiac pain and dyspnea (12% vs 16%, $p = 0.73$). There was a significant difference among patients who had noncardiac/cardiac chest pain and heartburn (56% vs 40%, $p = 0.04$). Those who had noncardiac chest pain were ~2 times more likely to have heartburn than were those who had cardiac chest pain (OR 1.89, 95% CI 1.03 to 3.46). There was no difference between patients who had noncardiac chest pain and dysphagia and those who had cardiac chest pain and dysphagia (33% vs 21%, $p = 0.07$). Those who had noncardiac chest pain did not differ significantly with respect to gastroesophageal reflux from those who had a cardiac cause for their chest pain.

Results of the k-means analysis appear in Table 1. The sample yielded a complex cluster structure with 4 location groupings. These groupings were central chest, left chest and arm, central retrosternal, and upper chest (Figure 5). Most clusters represented single anatomic chest locations; however, there was overlap of locations. The prevalence among patients who had cardiac chest pain for each cluster was highest among those who had pain in the left chest and arm (54.5%), in the central retrosternum (34%), in the upper chest (33.3%), and in the central chest (23.1%). In comparison, cluster characteristics of patients who had noncardiac chest pain were the central chest (76.9%), the upper chest (66.7%), the central retrosternum (66%), and the left chest and arm (45.5%).

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The present study suggests that patients who present to hospital emergency departments with acute chest pain suggestive of an acute coronary syndrome have considerable overlap with patients who present with noncardiac chest pain (and vice versa). Chest pain is a heterogeneous symptom.[16] Therefore, characteristics of chest pain such as pain location and patient description may not be useful in differentiating acute coronary syndromes from noncardiac chest pain. This study used a cluster analysis technique to determine how patients' chest pain locations cluster and the likely clinical interpretations of such groupings. There were 4 clusters (groups) of chest pain locations among this patient sample that reported acute chest pain, which included the central chest, left chest and left arm, sternum, and upper chest.

Moreover, the scientific methods involved using a k-means (nonhierarchical) cluster analysis. Cluster analysis is not entirely new to medicine, but this is the first time that a cluster analysis method has been used in a clinical cardiology patient setting (based on a MEDLINE and Current Contents search involving the key term *cluster analysis*). This is somewhat surprising because of the advantages of this technique in interpreting patterns among patients who have symptoms (e.g., acute chest pain).[13–15]

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