ORIGINAL ARTICLE

# The impact of the HEART score on the prevalence of cardiac testing and patient outcomes in a rural emergency department

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**Abstract**

**Introduction:** This study was conducted to examine the use of the HEART score for risk stratification of chest pain patients presenting to rural Ontario emergency departments (EDs), assessing both its validity in a rural context and its utility in health-care resource management.

**Methods:** This study was a retrospective chart review of adult patients presenting to the ED with chest pain. The HEART score was assessed for its ability to risk-stratify patients (high, moderate and low) in terms of the likelihood of a major adverse cardiac event (MACE) within 6 weeks. The prevalence of follow-up testing for each risk category of patients was then determined such that the potential impact on health resource management was estimated based on the number of tests ordered in low-risk patients.

**Results:** Of the 215 charts included, 24 (11.2%) patients experienced a MACE within 6 weeks. None of the patients with a low HEART score experienced a MACE. In comparison, the incidence of MACE in moderate- and high-risk groups was calculated to be 13.9% (95% confidence interval [CI] [5.91% and 21.89%, respectively]) and 66.7% (95% CI [46.54% and 86.86%, respectively]). Eighteen percent of the low-risk patients received follow-up testing with no positive results suggestive of acute coronary syndrome.

**Conclusion:** Our results provide external validation of the predictive value of the HEART score in determining the risk of MACE in patients presenting to a rural ED with chest pain. Our results also suggest that rates of follow-up testing in low-risk patients may be reduced in communities with limited access to resources.

**Keywords:** Emergency medicine, HEART score, ischemic heart disease, rural medicine

**Résumé**

**Introduction:** Examiner le recours au score HEART pour stratifier le risque lié à la douleur thoracique chez les patients qui se présentent aux services d'urgence des régions rurales de l'Ontario, en en évaluant la validité dans un contexte rural et l'utilité dans la gestion des ressources de santé.

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**Méthodologie:** Examen rétrospectif des dossiers de patients adultes s'étant présentés à l'urgence pour une douleur thoracique. Le score HEART a été évalué pour sa capacité de stratifier les patients en fonction du risque (élevé, modéré, faible) d'événement cardiaque indésirable majeur (ÉCIM) dans les 6 semaines suivantes. La prévalence des tests de suivi pour chaque catégorie de risque a ensuite été déterminée afin d'estimer l'impact potentiel sur la gestion des ressources de santé selon le nombre de tests demandés chez les patients à faible risque.
**Résultats:** Sur les 215 dossiers inclus, 24 (11,2 %) patients ont subi un ÉCIM dans les 6 semaines suivantes. Aucun des patients ayant obtenu un faible score HEART n'a subi un ÉCIM. Par ailleurs, l'incidence d'ÉCIM dans les groupes à risque modéré et élevé s'est élevée à respectivement 13,9 % (IC à 95 % [5,91; 21,89 %]) et 66,7 % (IC à 95 % [46,54; 86,86 %]). Dix-huit pour cent des patients à faible risque ont subi un test de suivi sans résultat évoquant un syndrome coronarien aigu.
**Conclusion:** Nos résultats ont validé de façon externe la valeur prédictive du score HEART dans la détermination du risque d'ÉCIM chez les patients qui se présentent à l'urgence rurale pour une douleur thoracique. Nos résultats laissent également croire que le taux de tests de suivi chez les patients à faible risque serait réduit dans les communautés dont l'accès aux ressources est limité.

**Mots-clés:** médecine rurale, médecine d'urgence, maladie cardiaque ischémique, score HEART

## INTRODUCTION

Chest pain is one of the most common presenting complaints to the emergency departments (EDs) in North America.[1,2] These presentations are seldom straightforward and often lead to significant hospital length of stay (LOS), congestion of the ED and invasive testing.[1] While many presentations may be suspicious for acute coronary syndrome (ACS), the majority are the result of benign conditions such as gastroesophageal reflux and musculoskeletal injury.[3,4] Only 15%–20% of patients have true ACS and many of these patients present atypically with symptoms such as anxiety or shortness of breath, masking underlying cardiac pathology.[3] Given this reality, chest pain represents a diagnostic challenge for the ED physician.

Several risk stratification tools have been developed for ACS patients.[4] The GRACE and TIMI scores are commonly applied in the coronary care units for high-risk ACS patients who would benefit from intensive therapy but neither has proven useful in risk-stratifying ED chest pain patients.[5,6] For use in the ED, these tools need to identify low-risk chest pain patients who can be safely discharged and thus reduce hospital admissions and unwarranted testing. To this end, the HEART score was developed in 2007 and has since outperformed other tools, stratifying patients based on the history, age, electrocardiogram (ECG) results, cardiac risk factors and their troponin levels.[7] Retrospective and prospective studies have since validated the score such that patients who are stratified as low risk can be discharged home safely, with only a 1.7% risk of having a major adverse cardiac event (MACE) within 6 weeks of presentation – defined by all-cause mortality, myocardial infarction or the need for coronary revascularisation.[5,8-12] Those patients stratified as moderate or high risk are followed more closely and undergo further diagnostic and therapeutic testing, as appropriate. Additional benefits of the HEART score have also been studied, including confirmation of prognostic utility up to 5 years and a high degree of interoperator reliability, and two systematic reviews have since determined excellent predictive value for this score.[13-16]

Previously, it has been found that more than 30% of chest pain patients evaluated with the HEART score have been stratified as low risk.[5,8] This presents a significant opportunity to reduce hospital admissions, ED LOS, specialist consultation and ancillary testing, and a previous economic cost-analysis study has predicted savings to the health-care system in the millions.[17-19]

Ischemic heart disease is the leading cause of death in the rural Muskoka region of Ontario, exceeding the provincial average.[20] The community also has a higher prevalence of cardiac risk factors such as obesity, high blood pressure and median age.[20] In addition to increased risk factors for heart disease, Muskoka's communities also rank higher than average in terms of their Rurality Index and due to its geographical location and size Muskoka has limited access to percutaneous coronary intervention (PCI).[21] The nearest referral centre for PCI is at the Southlake

Regional Health Centre in Newmarket, which is a distance of 140 and 180km from the Muskoka towns of Bracebridge and Huntsville, respectively. Given this reality, accurate risk stratification and efficient use of resources are important.

This study sought to validate the HEART score in a rural setting and determine if Muskoka ED physicians are risk-stratifying patients in accordance with the HEART score and the subsequent impact on patient outcomes as measured by the presence or absence of a MACE within 6 weeks of the index ED visit. This information also permitted discussion of the extent and benefit, if any, of testing that was completed in the low-risk group. Further testing in patients already classified as low risk is unlikely to contribute to patient care and may represent an opportunity to reduce the utilisation of ancillary tests.

## METHODS

### Ethics

This was a multicentre retrospective chart review of patients presenting to the ED between September 2015 and September 2016 and was approved by the Northern Ontario School of Medicine Undergraduate Research Ethics Board. Access to patient health information was granted by the Muskoka Algonquin Healthcare (MAHC) Group Manager of Health Information.

### Study design

The review was conducted in the Muskoka region of Northern Ontario at two community hospitals in Bracebridge and Huntsville.

A member of the health records staff searched the MAHC electronic medical record (EMR) system for all patients presenting to the ED in the specified time frame with the primary complaint of 'chest pain'. Eligible patients included those who were ≥ 18 years old and had no address within the catchment area of MAHC. Charts were excluded if patients left against medical advice or if they had evidence of an ST-segment elevation myocardial infarction (STEMI). This is congruent with the approach used by Backus *et al*.[5] Charts were also excluded if there were insufficient data to calculate a HEART score, such as those without a documented troponin level or ECG.

Data were extracted by three research assistants into a standardised template and charts were scored as per the HEART criteria. Age, troponin results, risk factors and ECG findings were the objective findings obtained from EMRs. A patient's history relied on the original HEART score description of nonsuspicious versus suspicious factors and was also obtained from the medical records as documented by the ED physician.[22] Characteristics suspicious for ACS included retrosternal pain, perspiration, nausea and response to nitrates, whereas nonsuspicious characteristics included pleuritic or reproducible pain. Patients with scores of 0–3 were categorised as low risk, scores of 4–6 were categorised as moderate risk and scores of 7–10 were deemed high risk.[22]

Follow-up testing (including stress tests, angiography or follow-up with an internal medicine specialist) and any return visits to the ED were noted from the hospital EMR and from family practitioner records for up to 6 weeks following the index visit, as per the previous validation studies.[22] To ensure that the index visit did not represent a 'follow-up' visit from a previous ED presentation, the patient's charts were also reviewed 6 weeks prior to the index visit for any chest pain presentations to the ED. Any uncertainty in analysis or HEART score was flagged for team discussion to mitigate inter-rater reliability. Data were de-identified using the hospital medical record number to ensure patient confidentiality.

### Outcome measures and statistics

Statistical analysis was performed with XL Stat (Version 2017.1). The primary outcomes of this study were to determine: (1) the incidence of a MACE for all risk groups (low, moderate and high), including both point estimates and 95% confidence intervals (CIs), (2) the diagnostic discriminative strength of the HEART score for MACE events by computing the area under the receiver operating characteristic curve and (3) the association between individual components of the HEART score and MACE events using Fisher's exact test.[5,10] Statistical significance was defined as $P = 0.05$, two sided. The frequency of additional ancillary testing in each risk category was considered a secondary outcome.

Descriptive statistics were given as average ± standard deviation or percentage.

Differences between the groups were assessed by means of the Student *t*-test when normally distributed; for scalar data, we used the Fisher's exact test, or in the case of ordinal data, the Cochran–Armitage trend test was used.

We estimated that a sample size of 354 charts was required for a 5% margin of error with a 95% CI.

## RESULTS

A total of 800 charts were obtained, from which 284 charts were excluded because the patients did not meet the age criteria, did not reside in the MAHC catchment area or left before being seen by a physician. In addition, a small proportion of the charts were mislabelled at triage as 'chest pain' when the patients had actually sought emergency care for a different reason. One hundred and twenty-one charts were extracted from outside the defined time period, and thus, they were excluded from the analysis. Eighteen patients presented with a STEMI and 97 charts did not contain enough data to calculate a HEART score, including an ECG or troponin. The remaining 280 charts were included in the prevalence analysis, but a further 65 charts were lost to follow-up, giving a final sample of 215 charts available for validity analysis [Figure 1], with a margin of error of 6.4%.

Patients' demographics are listed in Table 1, consisting predominantly of older men with several ACS risk factors.

Of the 215 charts included in the validation analysis, 24 (11.2%) patients experienced a MACE, which included NSTEMI, PCI and coronary artery bypass graft within 6 weeks of the index admission. None of the low-risk patients experienced a MACE. Ten patients (13.9%) with a moderate-risk score experienced a MACE, while 14 patients (66.7%) with a high-risk score experienced a MACE. Overall, there was a statistically significant association between the HEART score and the occurrence of MACE events, demonstrated in Figure 2. The relation was close to linear between HEART scores 5 and 9. The calculated C-score was 0.96 (CI 0.93–0.99), confirming an excellent ability to discriminate in this setting.

An analysis of each component of the HEART score and correlation with MACE, as depicted in Table 2, demonstrates history, ECG and troponin which are the most statistically significant independent predictors of MACE ($P < 0.00001$), correlating to the previous analyses.[23] The average HEART score in the MACE versus without MACE group was 6.9 and 2.8, respectively.

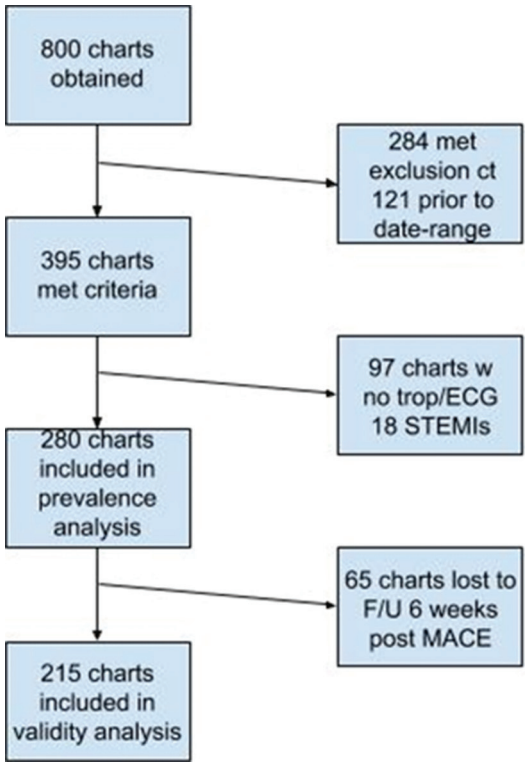



**Figure 1: Flowchart depicting chart extraction.**

**Table 1: Baseline characteristics for Muskoka Algonquin Healthcare group versus Backus, 2010**

| Characteristic | MAHC | Backus, 2010 |
|---|---|---|
| Age, mean±SD | 58.8±16.9 | 61.3±15.7 |
| Male, % | 57.1 | 57.3 |
| Hx atherosclerosis | 24.6 | 19.9 |
| Previous MI | 6.1 | 20.5 |
| Hx DLD | 24.6 | 26.0 |
| Hx HTN | 33.6 | 36.5 |
| Smoker | 21.4 | 29.2 |
| Diabetes | 12.1 | 19.9 |
| Fam Hx CAD | 3.6 | 31.9 |

MAHC: Muskoka Algonquin Healthcare group, SD: Standard deviation, HTN: Hypertension, CAD: Coronary artery disease, DLD: Dyslipidemia, Fam: Family history, Hx: History

The analysis of the frequency and efficacy of follow-up testing for each risk group is detailed in Table 3. Follow-up testing included any form of stress testing or coronary angiography.

None of the patients in the low -risk category, who had follow-up testing, had positive results or subsequent MACE. In comparison, almost all patients (19/21) in the high-risk group received follow-up testing.

In the moderate-risk group, approximately 60% of the patients received follow-up testing. Over two-thirds of these patients received stress tests, only 6 of which were positive and only one ultimately had positive angiography. An additional 11 patients who received stress testing had an equivocal result, secondary to a new left bundle branch block or inability to complete the testing due to fatigue or pain. Thirteen cases received immediate coronary angiography, without prior stress testing, and all had positive test results.

## DISCUSSION

As the Canadian population ages, the medical community will increasingly require evidence-based tools as clinical adjuncts to provide high-quality and efficient care to patients. This is particularly true in rural and northern communities where resources are often limited and where patients often have poorer health status.[20] This 'geographical burden' not only affects access to care but patients may also travel large distances and incur significant costs to receive ancillary testing and specialist follow-up.[24]

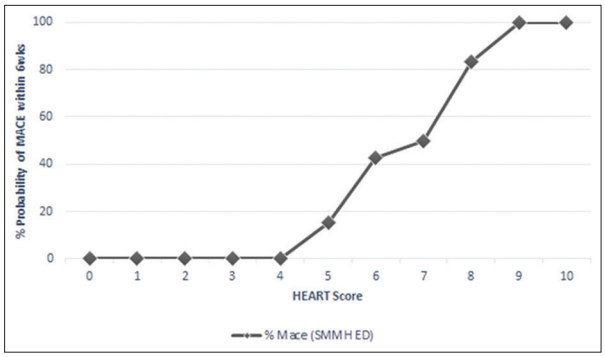



**Figure 2: Association between assigned HEART score and probability of subsequent MACE.**

Our results show a statistically significant association between the HEART score and the occurrence of MACE. This is demonstrated in our study population, given that 67% of the patients who scored as high risk went on to suffer a MACE. As such, any high-risk patients should undergo further testing, as did over 90% of our high-risk group.

The precise nature of follow-up for the moderate-risk patients depended on the individual clinician, but importantly, this risk category suggests uncertainty and that some form of follow-up testing should be completed.[5,8] Our results reflected well on the use of the HEART score criteria in this regard, with approximately 60% of those classified as moderate risk receiving follow-up testing of varying degrees, with 23% having a positive finding.

The analysis of low-risk patients provided the most convincing evidence that the HEART score is effective in risk-stratifying patients and may save valuable health-care resources. None of the

**Table 2: The relationship between the five predefined elements of the HEART score and the occurrence of major adverse cardiac event and secondary endpoints**

| | Points | | | | | | *P* |
|---|---|---|---|---|---|---|---|
| | No MACE (*n*=191 | | | MACE (*n*=24) | | | |
| | 0 | 1 | 2 | 0 | 1 | 2 | |
| History | 90 (47.1) | 79 (41.4) | 22 (11.5) | 0 (0) | 11 (45.8) | 13 (54.2) | <0.00001 |
| ECG | 144 (75.4) | 47 (24.6) | 0 (0) | 8 (33.3) | 12 (50) | 4 (16.7) | <0.00001 |
| Age | 42 (22) | 77 (40.3) | 72 (37.7) | 2 (8.3) | 3 (12.5) | 19 (79.2) | <0.001 |
| Troponin | 182 (95.3) | 6 (3.1) | 3 (1.6) | 7 (29.2) | 6 (25) | 11 (45.8) | <0.00001 |
| RIsk factors | 63 (33) | 73 (38.2) | 55 (28.8) | 2 (8.3) | 5 (20.8) | 17 (70.8) | <0.001 |
| Heart score (mean±SD) | | 2.8±1.3 | | | 6.9±1.3 | | |

MAHC: Muskoka Algonquin Healthcare group, SD: Standard deviation, ECG: Electrocardiogram

**Table 3: Prevalence of follow-up testing and respective outcomes**

| | Low risk (0-3) | Moderate risk (4-6) | High risk (7-10) |
|---|---|---|---|
| #follow-up tests and percentage cases of respective group | 22 (18) | 43 (59.7) | 18 (85.7) |
| Normal | 19 | 18 | 4 |
| Equivocal/unable to complete | 3 | 15 | 0 |
| Positive | 0 | 10 | 14 |

low-risk patients had a MACE or positive results on follow up. In Ontario, remuneration for a single stress test is approximately $100 according to the Ministry of Health and Long-Term Care Schedule of Benefits for physicians.[25] Each coronary catheterisation with angiography costs a minimum of $400.[25] Therefore, significant funds may be saved without affecting patient outcomes, which has been proposed by the original authors of the score.[3] These figures underestimate the resource burden, given that they do not account for hospital administrative costs and also do not account for the burden patients experience from travel, missed work, stress and anxiety and adverse health outcomes associated with unnecessary ancillary testing.

Our results suggest that ED physicians in Muskoka are effectively risk-stratifying patients in the high- and moderate-risk categories since all patients who suffered a MACE were already referred for cardiac testing or intervention. However, these same physicians should feel confident that low-risk patients do not require follow-up testing.

### Limitations

Limitations of this retrospective chart review include a small sample size and data extraction from only two small centres. Several factors also contributed to high attrition, including the loss of charts missing a component of the HEART score (such as a documented ECG or troponin) and the inability to follow up with a subset of patients who did not have a designated family physician in the catchment area.

We were also dependent on third-party information. We attempted to minimize this limitation by reviewing medication lists to ensure that the past medical history was properly documented. The score itself also provides some confidence that missing risk factors did not significantly affect our results since the maximum score is reached once a patient has three risk factors or any atherosclerosis.

## CONCLUSION

This study sought to validate the HEART score in a rural setting and to determine what, if any, benefit might arise from adherence to its recommendations (i.e. early discharge of low-risk patients and fewer tests). Our results suggest that the HEART score criteria proved capable of effectively stratifying patients presenting to a rural ED with chest pain, with minimal adverse outcomes, and a stricter adherence to such a validated risk stratification tool may reduce health-care expenditure and the burdens of follow-up testing without negatively affecting patients' outcomes in the near term.

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**Conflicts of interest:** There are no conflicts of interest.

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