Modified TIMI risk score cannot be used to identify low-risk chest pain in the emergency department: a multicentre validation study

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▸ Additional material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/emermed-2012-201323)

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Received 7 March 2012
Revised 28 December 2012
Accepted 7 January 2013
Published Online First
10 April 2013

To cite: Macdonald SPJ, Nagree Y, Fatovich DM, *et al*. *Emerg Med J* 2014;**31**:281–285.

ABSTRACT

Aim The Thrombolysis in Myocardial Infarction (TIMI) risk score (range 0–7), used for emergency department (ED) risk stratification of patients with suspected acute coronary syndrome (ACS), underestimates risk associated with ECG changes or cardiac troponin elevation. A modified TIMI score (mTIMI, range 0–10), which gives increased weighting to these variables, has been proposed. We aimed to evaluate the performance of the mTIMI score in ED patients with suspected ACS.

Methods A multicentre prospective observational study enrolled patients undergoing assessment for possible ACS. TIMI and mTIMI scores were calculated. The study outcome was a composite of all-cause death, myocardial infarction or coronary revascularisation within 30 days.

Results Of the 1666 patients, 219 (13%) reached the study outcome. Area under the receiver operating characteristic curve for the composite outcome was 0.80 (0.76 to 0.83) for the mTIMI score compared with 0.71 (0.67 to 0.74) for the standard TIMI score, p<0.001, but there was no significant difference for death or revascularisation outcomes. Sensitivity and specificity for the composite outcome were 0.96 (0.92 to 0.98) and 0.23 (0.20 to 0.26), respectively, at score 0 for TIMI and mTIMI. At score <2, sensitivity and specificity were 0.82 (0.77 to 0.87) and 0.53 (0.51 to 0.56) for mTIMI, and 0.74 (0.68 to 0.79) and 0.54 (0.51 to 0.56) for standard TIMI, respectively.

Conclusions mTIMI score performs better than standard TIMI score for ED risk stratification of chest pain, but neither is sufficiently sensitive at scores >0 to allow safe and early discharge without further investigation or follow-up. Observed differences in performance may be due to incorporation bias.

INTRODUCTION

Chest pain is a common presentation to the emergency department (ED). Among significant diagnoses to be considered is acute coronary syndrome (ACS). Most patients are found not to have a serious cause for their symptoms and can be discharged. Assessment involves clinical evaluation and interpretation of ECG and the results of cardiac biomarker testing to exclude myocardial infarction (MI) and identify high-risk patients who require admission. Clinicians are required not only to make an accurate diagnosis, but also to consider the risk of short-term cardiac events in deciding which patients are suitable for discharge from the ED. In those with negative ECG and biomarkers, further anatomic or functional testing is recommended to detect a small group of patients who have undiagnosed significant coronary artery disease. This may occur in the ED or at early outpatient review.[1]

A number of tools are available to identify patients with an acceptably low risk of cardiac events within 30 days (typically death, MI or urgent/unplanned coronary revascularisation) to allow discharge for outpatient follow-up. Among these is the Thrombolysis in Myocardial Infarction (TIMI) risk score.[2] Originally developed in patients with established ACS, the TIMI score has been validated in ED patients with undifferentiated chest pain.[3 4] The TIMI score is a simple and objective 8-point score, with higher scores correlating with increased risk of adverse events within 30 days. A recent meta-analysis of ED studies of TIMI risk score identified 10 studies incorporating 17 265 patients.[5] Although high TIMI scores were associated with increased risk of cardiac events, the accuracy was insufficient to determine patient disposition. The TIMI risk score was found to be inferior to the risk scores of Platelet glycoprotein IIb/IIIa in Unstable angina: Receptor Suppression Using Integrilin Therapy (PURSUIT) and Global Registry of Acute Coronary Events (GRACE) for predicting death and MI at 1 year in patients admitted to a coronary care unit with non-ST elevation ACS.[6] The GRACE score has been shown to predict death up to 1500 days after presentation among patients assessed for chest pain in ED.[7]

Despite being straightforward and objective, a limitation of the TIMI score is that only one point is assigned for each of elevated cardiac biomarkers or ischaemic ECG changes, so it is possible to have low score despite having one of these known high-risk variables. Body *et al*[8] proposed a modified Thrombolysis in Myocardial Infarction (mTIMI) score, where a value of 5 is assigned to either or both of these variables if present, to improve accuracy. A validation study by Hess *et al*[9] found that although the mTIMI score was superior, it was not sufficiently accurate for practical use, having a sensitivity of 91% and specificity of 54% at a cut-off <2 for predicting cardiac events within 30 days. There were important differences between these two studies. Specifically, the Body *et al* study used a troponin 12 h after symptoms for the score calculations, whereas Hess *et al* used the first troponin result recorded. Both studies used a composite outcome of death, MI or revascularisation within 30 days, but in the Body *et al* study, MI diagnosed at the index presentation were excluded, whereas this was considered in the composite outcome in

Table 1 TIMI risk score and modified TIMI (mTIMI) risk scores

Variable	TIMI points	mTIMI points
Age >65 years	1	1
≥2 symptom episodes prior 24 h	1	1
Aspirin use in last 7 days	1	1
≥3 of smoker, hypertension, diabetes, hyperlipidaemia, family history of CAD (first-degree relative diagnosed at <65 years)	1	1
Known coronary artery stenosis >50%	1	1
Elevated cardiac biomarkers	1	5*
ECG ST deviation >0.5 mm	1	5*
Total	7	10

*The presence of either or both variables attracts value of five points giving a total possible mTIMI score of 10.
CAD, coronary artery disease; TIMI, Thrombolysis in Myocardial Infarction.

the Hess *et al* study. Derivation and validation studies took place in single, albeit different, academic institutions. Therefore, the practical utility of this proposed modification to the TIMI score remains unclear. Original and mTIMI scores are summarised in table 1.

We undertook the current study to investigate the comparative utility of the modified and original TIMI scores for predicting 30-day outcome in ED patients with possible ACS, in tertiary and general hospital settings. We used scores calculated using the initial troponin result, as per Hess *et al*,[9] because the ability to make early disposition decisions is clinically important in the ED.

METHODS

A prospective observational study of patients presenting to the ED with symptoms consistent with ACS was undertaken. The study cohort was enrolled in the Multiple Infarct Markers in Chest pain study, which was conducted at five EDs in Western Australia between September 2008 and June 2009. The methodology has been previously reported.[10] In brief, patients undergoing serial troponin testing for evaluation of suspected ACS, as determined by the treating clinician, were eligible for recruitment. Exclusion criteria were age less than 18 years, pregnancy, inability to consent or comply with follow-up and prior enrolment in the study within the preceding 30 days.

The participating hospitals were two tertiary adult and three general hospitals with mixed adult and paediatric presentations. Annual ED census ranged from 35 000 to 60 000 presentations per annum. The human research ethics committee at each hospital approved the study and the participants gave written informed consent. Clinical management including referral for follow-up investigations was determined by treating doctors based on their interpretation of clinical, ECG and troponin results. The TIMI score is not used routinely at the participating hospitals for ED risk stratification. Follow-up arrangements and further investigation practices varied between sites, ranging from admission and inpatient testing, early outpatient investigations or follow-up in primary care. The study was designed to reflect real-life practice in a range of clinical settings.

Data collection

Data collection complied with standardised reporting guidelines for ED studies of ACS.[11] A blinded investigator undertook the analysis of all ECGs recorded within the initial 2 h. Blood samples at presentation and up to 12 h from symptom onset were analysed in the hospital laboratory for troponin I or T (cTnI, cTnT). Troponin assays varied between sites. These were Abbott Architect cTnI (Abbott Australasia, Botany, NSW, Australia), Roche Elecsys cTnT (Roche Diagnostics Australia, Castle Hill, NSW, Australia), Siemens Centaur cTnI (Siemens Australia, Bayswater, Vic, Australia) and Roche Cardiac Reader cTnT. A troponin result was classified as positive if it exceeded the 99th percentile for the reference population for that assay. The analytical characteristics of these assays are detailed in the online supplementary appendix. Only the initial troponin result recorded was used in the TIMI or mTIMI score calculation.

Risk score calculation

The TIMI and mTIMI scores were calculated from the individual data elements, collected prospectively in the ED on a structured datasheet, which was completed by the doctor or a research nurse. The scores were not used clinically to influence management and the assignment of each of the variables was made without the knowledge of the patient's final outcome. Patients without a troponin result recorded were excluded because the scores could not be determined.

Study outcome

Outcome was all-cause mortality, MI or coronary revascularisation by either percutaneous coronary intervention or coronary artery bypass grafting at the index presentation or up to 30 days subsequently. MI was defined by a rise/fall pattern in serial troponin assays over 8–12 h after symptoms, along with associated ECG changes and/or symptoms consistent with ACS according to the established criteria.[12] A research nurse telephoned the participants at 30 days and obtained the data from hospital discharge summaries and specialists or primary care doctors as required. If patients could not be contacted, we checked the Perth metropolitan public hospital database, which is updated from the Western Australian Registry of Births, Deaths and Marriages, to identify any representations or deaths during the follow-up period. If no definite diagnosis was reached, this was classified as 'ACS not confirmed'. The outcome was adjudicated by two investigators based on all available information at 30 days, with a third refereeing in cases of disagreement. Since ECG changes and troponin elevation are components of the scores, as well as MI diagnosis, outcomes are reported as a composite 30-day outcome, and also death and combined death and revascularisation with index MI excluded, to assess the potential effect of incorporation bias.

Statistical analysis

The principal method of analysis was the comparison of the area under the receiver operator characteristic (ROC) curve for TIMI and mTIMI scores. Analyses were performed using STATA V.11 (Statacorp, College Station, Texas, USA). Continuous variables are reported as medians with interquartile ranges and analyses made using Mann–Whitney U-test for continuous and χ^2 test for categorical variables. A p value of <0.05 was considered significant.

RESULTS

A total of 1758 patients undergoing evaluation for possible ACS in the ED were enrolled. The age and sex distribution reflected that of all chest pain presentations (n=4946) to participating hospitals during the study period, as previously reported.[9] The baseline characteristics and outcomes at 30 days are given in table 2. Forty-four patients (2.5%) were lost to follow-up and a further 48 patients (2.7%) did not have troponin data to allow

Table 2 Participant characteristics (n=1758)

Study cohort	30-day outcome Yes (n=223)	No (n=1491)	p Value
Median age (IQR)	64 (54–75)	61 (49–73)	0.004*
Male, n (%)	166 (74)	791 (53)	<0.001*
Known coronary artery disease (CAD), n (%)			
Prior MI	26 (12)	150 (10)	0.46
Angina	12 (5.4)	84 (5.6)	0.88
Prior stenosis >50%	10 (4.5)	34 (2.3)	0.052
Angioplasty/stent	18 (8.0)	121 (8.1)	0.98
CABG	28 (12.5)	102 (8.8)	0.003*
Diabetes	51 (23)	268 (18)	0.08
Hypertension	128 (57)	777 (52)	0.14
Hyperlipidaemia	117 (52)	704 (47)	0.14
Renal failure (eGFR <60 ml/min/ 1.73 m^2)	53 (23)	276 (19)	0.056
Tobacco smoking in last 7 days	71 (32)	335 (22)	0.002*
Family history of CAD	115 (51)	743 (49)	0.63
Australian indigenous (Aboriginal and Torres Strait Islander)	11 (4.9)	35 (2.3)	0.026*
Aspirin use in past 7 days	105 (47)	577 (38)	0.017*

Reproduced from Macdonald *et al*[17] with permission. *p<0.05.
CABG, coronary artery bypass grafting; MI, myocardial infarction; eGFR, estimated glomerular filtration rate.

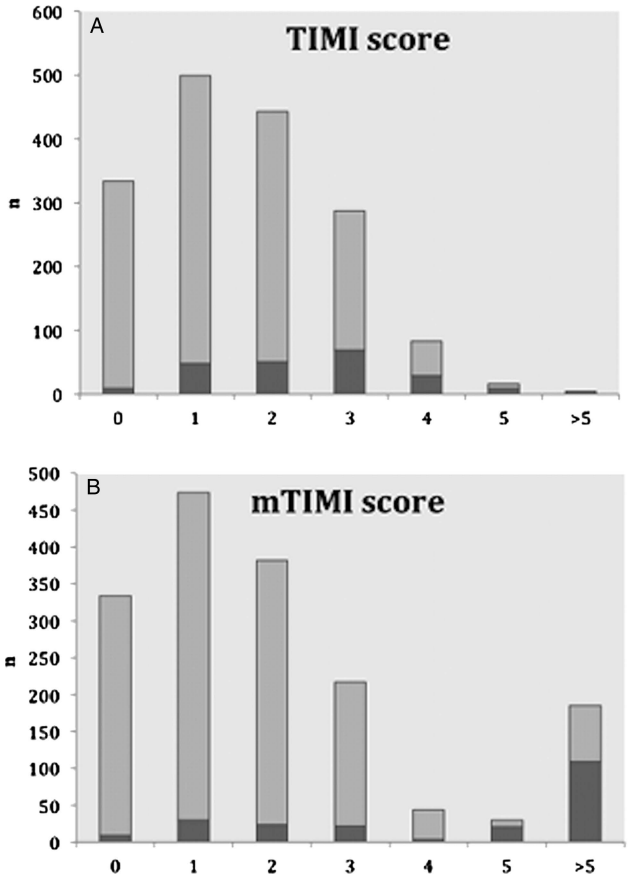

Figure 1 Distribution of scores with rates of 30-day events (dark bars) for the standard (A) Thrombolysis in Myocardial Infarction (TIMI) score and (B) modified TIMI(mTIMI) score (n=1666).

calculation of the TIMI risk scores, including 4 patients who underwent revascularisation, leaving 1666 available for analysis. None of those lost to follow-up died or re-presented to a metropolitan public hospital in Western Australia within 30 days. Of the 1666, 219 patients (13%) reached the study outcome within 30 days.

Of the 11 patients (0.7%) who had died at 30 days, 7 had confirmed MI. Three non-cardiac deaths were due to sepsis, leukaemia and metastatic carcinoma, and one more patient died of complications during coronary angiography.

Forty-seven patients who did not have MI at the index presentation underwent coronary revascularisation. Thirty-eight of these were admitted directly at the index presentation, four had abnormal investigations following discharge leading to angiography or intervention and five had unplanned re-admission to hospital with non-ST elevation ACS.

Figure 1 shows the distribution, and rates of 30-day events, of the standard TIMI and mTIMI scores. The comparative ROC curves are presented in figure 2. Area under the curve was 0.71 (0.67 to 0.74) for the standard TIMI score and 0.80 (0.76 to 0.83) for mTIMI, p<0.001. Cumulative 30-day event rates for standard TIMI score at each cut point were for score 0, 2.7%; score <2, 7.3%; score <3, 9.2%; score <4, 12.7% and score <5, 12%. In contrast, event rates for mTIMI were for score 0, 2.7%; score <2, 5.1%; score <3, 5.6%; score <4, 6.4% and score <5, 6.5%.

The overall performance of the two scoring systems for 30-day outcome is shown in table 3. Approximately 19% of the patients had score zero and around half had score <2 by both methods.

We also analysed the relative score performance for death alone, and for death and revascularisation with MI excluded, to assess the effect of any incorporation bias associated with ECG changes and troponin being used to determine the scores, as well as defining MI. These data are presented in table 4. For death (n=11), area under the ROC curve was 0.86 (0.74 to 0.96) for the standard TIMI score and 0.88 (0.78 to 0.99) for mTIMI, p=0.35. In addition, 47 patients underwent previously unplanned coronary revascularisation, but were not diagnosed with MI. When only death and revascularisation in the absence of index MI are considered (n=51), the respective ROC curve areas are 0.61 (0.53 to 0.68) and 0.60 (0.52 to 0.68), p=0.40.

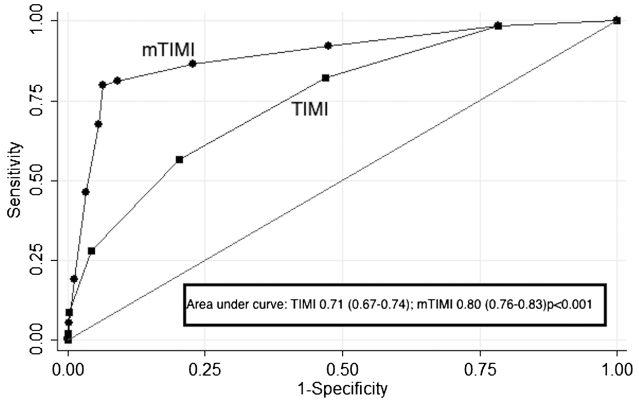

Figure 2 Receiver operating characteristic curves for standard and modified Thrombolysis in Myocardial Infarction (mTIMI) scores for combined death, MI and revascularisation at 30 days (n=1666).

Table 3 Sensitivities, specificities, positive (LR+) and negative (LR−) likelihood ratios (95% CIs) of standard and modified TIMI scores for prediction of 30-day death, myocardial infarction or coronary revascularisation at different cut-points

Cut-point	Standard TIMI	Modified TIMI
<1		
Sensitivity	0.96 (0.92 to 0.98)	0.96 (0.92 to 0.98)
Specificity	0.23 (0.20 to 0.26)	0.23 (0.20 to 0.26)
LR+	1.24 (1.19 to 1.29)	1.24 (1.19 to 1.29)
LR−	0.18 (0.10 to 0.35)	0.18 (0.10 to 0.35)
<2		
Sensitivity	0.74 (0.68 to 0.79)	0.82 (0.77 to 0.87)
Specificity	0.54 (0.51 to 0.56)	0.53 (0.51 to 0.56)
LR+	1.59 (1.45 to 1.76)	1.76 (1.62 to 1.92)
LR−	0.48 (0.37 to 0.61)	0.33 (0.25 to 0.46)
<3		
Sensitivity	0.51 (0.44 to 0.57)	0.71 (0.65 to 0.77)
Specificity	0.81 (0.79 to 0.83)	0.78 (0.76 to 0.80)
LR+	2.63 (2.22 to 3.11)	3.22 (2.83 to 3.66)
LR−	0.61 (0.53 to 0.70)	0.37 (0.29 to 0.46)
<4		
Sensitivity	0.19 (0.15 to 0.25)	0.61 (0.55 to 0.67)
Specificity	0.96 (0.95 to 0.97)	0.91 (0.90 to 0.93)
LR+	4.55 (3.15 to 6.56)	7.08 5.81 to 8.63)
LR−	0.84 (0.79 to 0.90)	0.42 (0.34 to 0.50)

TIMI, Thrombolysis in Myocardial Infarction.

DISCUSSION

In this prospective multicentre study of patients undergoing ED assessment for possible ACS, we found that the mTIMI risk score was superior to the original score for risk stratification and prediction of 30-day death, MI or revascularisation. A score of zero by both methods identified a group with a low (2.7%) risk of 30-day events. However, only a minority (19%) of patients met these criteria. While the area under the ROC curve was significantly greater for the mTIMI score, at cut points other than score zero, both scores were insufficiently sensitive to allow safe exclusion of ACS based upon the initial troponin result. In a secondary analysis, there was no significant difference in the area under the ROC curve for predicting non-MI death and revascularisation, and no difference was noted between the scores for all-cause death alone. While this latter finding may be a type II error due to the small number of patients who died, it seems likely that the superior performance for mTIMI in predicting the composite outcome is due to the inclusion of index MI, and thus incorporation bias.

In the original study of the mTIMI score in ED patients with chest pain, Body *et al*[8] found sensitivity of 96% and specificity of 51% for 30-day outcome using a cut point of <2. In a subsequent validation study, Hess *et al*[9] found sensitivity to be 91% and specificity 54% at the <2 cut point and 80% and 73% respectively, for mTIMI at the cut point <3. Of note, this second study used only the initial troponin measurement to calculate the TIMI and mTIMI scores rather than a serial measurement at 12 h post symptoms. We adopted this approach in our study because this is a clinically relevant decision point for the ED. The rapid identification of low-risk patients may allow an accelerated work-up and early discharge thereby improving the efficiency. Both groups conclude that mTIMI score zero identifies a very low-risk group who may be suitable for ED discharge. However, at all other cut-points, sensitivity is insufficient to exclude ACS without further testing. Of course, score zero by either method defines the same patient group.

The TIMI score was originally developed in a high-risk population with non-ST elevation ACS, in order to guide clinical management,[2] rather than as a diagnostic tool. A number of studies have examined its use in the ED. Most ED patients with chest pain do not have ACS. However, subsequent cohort studies of ED patients with undifferentiated chest pain have demonstrated a clear relationship between high TIMI scores and risk of medium-term coronary events.[3 4] A meta-analysis of 10 studies involving 17 265 ED patients found that a score of zero had 97% sensitivity for 30-day events, but was insufficiently sensitive at higher scores.[5] Although useful for identifying high-risk patients, who require escalated therapy and admission, TIMI score is not sufficiently sensitive to identify patients suitable for early discharge from the ED without further testing. Other authors have attempted to optimise the use of the TIMI score for ED risk stratification of chest pain presentations. Campbell *et al* combined TIMI score with a clear alternative diagnosis to identify low-risk patients, but found a 30-day cardiac event rate of 2.9% for patients with TIMI score 0 and an apparent clear-cut non-cardiac diagnosis.[13] Than *et al*[14] combined TIMI score 0 with a 2-hour serial multiple biomarker panel that was over 99% sensitive for 30-day events.

Table 4 Comparison of outcomes (death alone, death and revascularisation with index MI excluded and combined all-cause death, MI and revascularisation) within 30 days at each score level for standard (TIMI) and modified (mTIMI) Thrombolysis in Myocardial Infarction scores

	0	1	2	3	4	5	>5	Total
TIMI								
Total, n	334	499	443	287	83	16	4	1666
Death n (%) (all cause)	0 (0)	1 (0.2)	1 (0.2)	3 (1.0)	5 (6.0)	0 (0)	1 (20)	11 (0.6)
Death/revascularisation, n (%) (without index MI)	3 (1)	13 (2.6)	14 (3.2)	15 (5.2)	6 (7.2)	0 (0)	0 (0)	51 (3)
Death/revascularisation /MI, n (%)	9 (2.7)	48 (9.6)	51 (11)	69 (24)	29 (35)	9 (56)	4 (100)	219 (13)
mTIMI								
Total, n	334	474	382	217	44	30	185	1666
Death, n (%) (all-cause)	0 (0)	1 (0.2)	0 (0)	0 (0)	2 (4.5)	0 (0)	8 (4.3)	11 (0.6)
Death/revascularisation, n (%) (without index MI)	3 (1)	13 (2.7)	12 (3.1)	10 (4.8)	3 (6.8)	0 (0)	10 (5.4)	51 (3)
Death/revascularisation/MI, n (%)	9 (2.7)	30 (6.3)	24 (6.3)	22 (10)	4 (9.1)	21 (70)	109 (60)	219 (13)

MI, myocardial infarction; TIMI, Thrombolysis in Myocardial Infarction.

Despite the appeal of simplicity, the TIMI score has demonstrated limitations. Aragam *et al*[15] found TIMI score inferior to the GRACE score for risk stratification of patients with ACS. Sanchis *et al*[16] developed a score to risk stratify ED patients with chest pain, which performed significantly better than TIMI score for predicting adverse outcomes. We have compared the National Heart Foundation (NHF) of Australia/Cardiac Society of Australia and New Zealand (CSANZ) guideline and TIMI score for ED risk stratification of ACS using the same cohort of patients as the present study.[17] The NHF/CSANZ guideline was superior to TIMI score in predicting 30-day events.

Although the mTIMI score represents a statistically significant improvement over the original in the present study, its ability to identify patients who are at sufficiently low risk to be discharged without further follow-up is limited. Our findings reinforce that ECG and troponin are the most useful predictors of 30-day outcome. Therefore, TIMI and mTIMI scores are of limited value for risk stratification in patients with normal ECG and negative troponin.

Limitations

There are a number of limitations to the present study. Consecutive patients were not enrolled. Potential recruits not enrolled were logged and no significant differences were found in age and sex distributions from the study cohort.[17] Bias may arise in the use of composite outcomes,[18] in particular, where coronary revascularisation is an end point. High-risk patients are more likely to have investigations leading to intervention. However, the TIMI and mTIMI scores were calculated on the basis of objective data points and were not used to influence clinical decisions. Arrangements for follow-up investigations varied between study sites. Of note, 34% of the patients in this observational study did not have any investigations subsequent to their ED stay to definitively rule out coronary disease.

While the 99th percentile cut-point for each assay was used to define a positive result, as determined by the respective hospital laboratory, there are differences in the analytical properties of these assays. None of the assays in use at the time of the study were high-sensitivity (HS) troponin assays. The availability of HS troponin assays may allow for rapid exclusion of MI among ED patients with chest pain.[19]

CONCLUSIONS

In this multicentre ED study, the mTIMI score outperformed the standard TIMI score for predicting 30-day cardiac events. However, it is not sufficiently sensitive to allow safe discharge without further investigations or follow-up, other than for score zero. In addition, the improved performance of the mTIMI score appears to be solely related to its ability to predict index MI due to the greater weight given to the troponin and ECG variables. The mTIMI score adds nothing to the ability to identify patients at risk of short-term ACS who do not have ECG changes or troponin elevation detected in the ED.

Acknowledgements The present report is a substudy of the Multiple Infarct Markers in Chest Pain (MIMIC) study. Participating hospitals and site investigators were Armadale Health Service (I Dey, H Flavell), Fremantle Hospital (YN), Joondalup Health Campus (P Bailey, SPJM), Rockingham General Hospital (F Loutsky) and Royal Perth Hospital (SGAB, DMF, SPJM).

Contributors SPJM had the study idea. All authors enrolled patients and oversaw data collection. SPJM and YN analysed the data. SPJM drafted the manuscript and all authors contributed to its revision. All authors approved the final version.

Funding The MIMIC study was funded entirely by a grant from the Western Australian Department of Health Innovation Fund. Alere (Inverness Medical Innovations) Australia, Inc provided loan of analytical devices for the biomarker tests used in the MIMIC study but had no role in the conduct, analysis or reporting of the study.

Competing interests SPJM and YN have spoken at meetings sponsored by Alere (Inverness Medical Innovations) Australia Inc, although no payment was received or expenses claimed. SPJM has received materials from Alere to conduct independent research projects. DMF and SGAB declare no competing interests. All authors are employees of the Health Department of Western Australia and/or the University of Western Australia.

Ethics approval Royal Perth Hospital Human Research Ethics Committee.

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

1 Chew DP, Aroney CN, Aylward PE, *et al*. 2011 Addendum to the National Heart Foundation of Australia and Cardiac Society of Australia and New Zealand. Guidelines for the Management of Acute Coronary Syndromes (ACS). *Heart Lung Circ* 2011;20:487–502.
2 Antman EM, Cohen M, Bernink PJ, *et al*. The TIMI risk score for unstable angina/non-ST elevation MI: a method for prognostication and therapeutic decision making. *JAMA* 2000;284:835–42.
3 Chase M, Robey JL, Zogby KE, *et al*. Prospective validation of the Thrombolysis in Myocardial Infarction Risk Score in the emergency department chest pain population. *Ann Emerg Med* 2006;48:252–9.
4 Pollack CV Jr, Sites FD, Shofer FS, *et al*. Application of the TIMI risk score for unstable angina and non-ST elevation acute coronary syndrome to an unselected emergency department chest pain population. *Acad Emerg Med* 2006;13:13–18.
5 Hess EP, Agarwal D, Chandra S, *et al*. Diagnostic accuracy of the TIMI risk score in patients with chest pain in the emergency department: a meta-analysis. *CMAJ* 2010;182:1039–44.
6 De Araujo Goncalves P, Ferreira J, Aguiar C, *et al*. TIMI, PURSUIT and GRACE risk scores: sustained prognostic value and interaction with revascularisation in NSTE-ACS. *Eur Heart J* 2005;26:865–72.
7 McLean S, Philips A, Carruthers K, *et al*. Use or the GRACE score by cardiology nurse specialists in the emergency department. *Br J Card Nurs* 2010;5:91–5.
8 Body R, Carley S, McDowell G, *et al*. Can a modified thrombolysis in myocardial infarction risk score outperform the original for risk stratifying emergency department patients with chest pain? *Emerg Med J* 2009;26:95–9.
9 Hess EP, Perry JJ, Calder LA, *et al*. Prospective validation of a modified thrombolysis in myocardial infarction risk score in emergency department patients with chest pain and possible acute coronary syndrome. *Acad Emerg Med* 2010;17:368–75.
10 Macdonald SP, Nagree Y, Fatovich DM, *et al*. Serial multiple biomarkers to rapidly risk stratify suspected Acute Coronary Syndrome: Multiple Infarct Markers in Chest Pain (MIMIC) study. *Emerg Med J* 2013;30:149–54.
11 Hollander JE, Blomkalns AL, Brogan GX, *et al*. Standardized reporting guidelines for studies evaluating risk stratification of ED patients with potential acute coronary syndromes. *Acad Emerg Med* 2004;11:1331–40.
12 Thygesen K, Alpert JS, White HD. Universal definition of myocardial infarction. *Eur Heart J* 2007;28:2525–38.
13 Campbell CF, Chang AM, Sease KL, *et al*. Combining Thrombolysis in Myocardial Infarction risk score and clear-cut alternative diagnosis for chest pain risk stratification. *Am J Emerg Med* 2009;27:37–42.
14 Than M, Cullen L, Reid CM, *et al*. A 2-h diagnostic protocol to assess patients with chest pain symptoms in the Asia-Pacific region (ASPECT): a prospective observational validation study. *Lancet* 2011;377:1077–84.
15 Aragam KG, Tamhane UU, Kline-Rogers E, *et al*. Does simplicity compromise accuracy in ACS risk prediction? A retrospective analysis of the TIMI and GRACE risk scores. *PLoS One* 2009;4:e7947.
16 Sanchis J, Bodi V, Nunez J, *et al*. New risk score for patients with acute chest pain, non-ST-segment deviation, and normal troponin concentrations: a comparison with the TIMI risk score. *J Am Coll Cardiol* 2005;46:443–9.
17 Macdonald SP, Nagree Y, Fatovich DM, *et al*. Comparison of two clinical scoring systems for Emergency Department risk stratification of suspected acute coronary syndrome. *Emerg Med Australas* 2011;23:717–25.
18 Tomlinson G, Detsky AS. Composite end points in randomized trials: there is no free lunch. *JAMA* 2010;303:267–8.
19 Body R, Carley S, McDowell G, *et al*. Rapid exclusion of acute myocardial infarction in patients with undetectable troponin using a high-sensitivity assay. *J Am Coll Cardiol* 2011;58:1332–13.

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Emerg Med J 2014 31: 281-285 originally published online April 10, 2013
doi: 10.1136/emermed-2012-201323