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ORIGINAL ARTICLE

Cost consequences of point-of-care troponin T testing in a Swedish primary health care setting

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Abstract

Objective. To evaluate the safety and cost-effectiveness of point-of-care troponin T testing (POCT-TnT) for the management of patients with chest pain in primary care. *Design*. Prospective observational study with follow-up. *Setting*. Three primary health care (PHC) centres using POCT-TnT and four PHC centres not using POCT-TnT in south-east Sweden. *Patients*. All patients ≥ 35 years of age, contacting one of the PHC centres for chest pain, dyspnoea on exertion, unexplained weakness and/or fatigue, with no other probable cause than cardiac, were included. Symptoms must have commenced or worsened during the previous seven days. *Main outcome measures*. Emergency referral rates, diagnoses of acute myocardial infarction (AMI) or unstable angina (UA), and costs were collected for 30 days after the patient sought care at the PHC centre. *Results*. A total of 196 patients with chest pain were included: 128 in PHC centres with POCT-TnT and 68 in PHC centres without POCT-TnT. Fewer patients from the PHC centres with POCT-TnT (n = 32, 25%) were emergently referred to hospital than from centres without POCT-TnT (n = 29, 43%; p = 0.011). Eight patients (6.2%) from PHC centres with POCT-TnT were diagnosed with AMI or UA compared with six patients (8.8%) from centres without POCT-TnT (p = 0.565). Two patients with AMI or UA were classified as missed cases from PHC centres with POCT-TnT and there were no missed cases from PHC centres without POCT-TnT. SKr290 000 was saved per missed case of AMI or UA. *Conclusion*. The use of POCT-TnT in primary care may be cost saving but at the expense of missed cases.

Key Words: *Acute myocardial infarction, general practice, point-of-care testing, primary care, Sweden, troponin T, cost*

Background

Increase in the serum level of the biomarker troponin T is a sensitive and specific sign of myocardial ischaemia [1]. The use of troponin T and other cardiac biomarkers for the workup of patients with chest pain in the emergency department (ED) is well established and has been investigated from an economic point of view [2]. There is great potential for readily available, reliable, troponin T testing in primary health care (PHC) to support the general practitioner's (GP) management of patients with chest pain. Studies on commercially available point-of-care troponin T (POCT-TnT) kits found that POCT-TnT may produce more accurate diagnosis of acute coronary syndromes and facilitate the diagnosis of unsuspected myocardial infarctions, limiting unnecessary referrals to the ED [3,4]. However, Planer et al. added that POCT-TnT can never replace clinical evaluation [3]. In a recent study, we found that the emergency referrals of patients with chest pain decreased in PHC

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The usefulness of point-of-care troponin T testing for the management of patients with chest pain in primary health care is controversial. This study shows that:

- It may be cost saving but at the expense of missed cases of acute myocardial infarction or unstable angina.

centres using POCT-TnT. However, diagnosis of acute myocardial infarctions (AMI) and unstable angina (UA) were occasionally missed among the POCT-TnT users [5].

A cost-effectiveness analysis assists decision-makers when choosing between alternatives in situations with limited resources. Decision-makers may want to cut costs and limit waste of resources such as unnecessary referrals from PHC to the ED. POCT-TnT as an aid in the diagnostic procedure may result in fewer false-positive referrals or missed cases with myocardial infarction or UA.

The aim of this study was to calculate the cost consequences for management of patients with chest pain with or without support from POCT-TnT in a PHC setting.

Material and methods

Setting and practice recruitment

This multicentre research trial was performed in Östergötland County, situated in south-east Sweden, with approximately 425 000 inhabitants, three hospitals, and 44 PHC centres. In Sweden, health care is publicly funded and hospital care and primary health care are provided by county councils. PHC centres can also be run by private companies. At the time of the study, almost 40 of the PHC centres were run by the county council. All of these PHC centres were invited to participate in the study. In the County Council of Östergötland, there was no consensus on whether POCT-TnT should be used in primary health care or not at the time of this study. According to local practice, POCT-TnT was used in almost all PHC centres in the eastern part of the county and rarely used in the central and western parts. Seven PHC centres were recruited to the study, three with POCT-TnT and four without. Two of the three PHC centres with POCT-TnT were situated in the main village of a rural area and the third was in a suburban area. The median distance from these PHC centres with POCT-TnT to hospital was 26.5 km (range, 18–30 km). The median number of listed patients was 6501 (range, 6191–9255) and the median proportion older than 35 years was 60% (range, 60–63%) in July 2009. Two of the four PHC centres without POCT-TnT were situated in a main village of a rural area, one in a suburban area, and one on the outskirts of a larger town. The median distance from the PHC centres without POCT-TnT to hospital was 18.7 km (range, 3–49 km). The median number of listed patients was 8710 (range, 5313–15 515) and the median proportion older than 35 years was 61% (range, 45–63%) in July 2009.

Data collection

A total of 196 patients were included: 128 in the group PHC centres with POCT-TnT and 68 in the group without POCT-TnT (Table I). Data collection started in May 2009 and the last patient was included in January 2011. Data were collected for a 30-day period for each patient, beginning when the patient contacted the PHC centre and sought treatment for chest pain. The inclusion and exclusion criteria and patient flow are described in Figure 1. Details regarding patient enrolment are described elsewhere [5]. Sixty-one patients (32 from PHC centres with POCT-TnT and 29 from PHC centres without POCT-TnT) were referred as emergencies to hospital from the PHC centre. Their hospital medical records were reviewed. The same procedure was undertaken for the patients who were sent home after the GP's assessment for chest pain at the PHC centre and subsequently, within 30 days, sought treatment at the ED or were hospitalized (nine records from PHC centres with POCT-TnT and one from a PHC centre without POCT-TnT). Details of the end-point evaluation are described elsewhere [5]. In brief, all cases of AMI and UA diagnosed in conjunction with inclusion in the study and those diagnosed within the following 30 days and assessed as missed cases in PHC constitute the main outcome of the study.

Use of resources

Data on the use of resources were collected prospectively throughout the study. PHC and transport, hospitalizations, investigations, and interventions/pharmaceutical treatments were categorized as direct medical costs. The study had a societal perspective; however, the indirect costs, for example due to loss of production, were so small that they were excluded from the analysis.

Hospitalizations

The length (days) of each hospital stay and care level were recorded for all patients referred as emergencies from the PHC centre in conjunction with study

Table I. Clinical characteristics of chest pain patients managed in primary health care (PHC) centres with and without point-of-care Troponin T testing (POCT-TnT).

	Patients from PHC centres with POCT-TnT (n = 128), n (%)	Patients from PHC centres without POCT-TnT (n = 68), n (%)	p-value
Demographics			
Age, years mean ± SD	66 ± 14	65 ± 13	0.670
Male	71 (56)	42 (62)	0.396
Presenting symptom			
Chest pain	110 (86)	60 (88)	0.652
Weakness and/or dyspnoea on exertion, no chest pain	18 (14)	8 (12)	0.652
Risk factors			
Current smokers	15 (12)	10 (15)	0.787
Diabetes	20 (16)	5 (7.4)	0.098
Hypertension	47 (37)	28 (41)	0.541
Hypercholesterolemia	36 (28)	16 (24)	0.488
Cardiovascular disease			
Angina pectoris	22 (17)	10 (15)	0.655
Previous AMI	20 (16)	8 (12)	0.462
Coronary revascularization	16 (13)	6 (8.8)	0.438
Stroke	5 (3.9)	2 (2.9)	1.000
Heart failure	12 (9.4)	2 (2.9)	0.144
Aortic valve disease	6 (4.7)	3 (4.4)	1.000
Potential causes of increase in troponin T in the absence of overt ischaemic heart disease[1]	3 (2.3)	0 (0)	1.000
ECG			
Sinus rhythm	115 (89)	63 (91)	0.890
Atrial fibrillation	13 (9.4)	5 (7.4)	0.890

Note: [1]Hypertrophic cardiomyopathy, renal failure, or amyloidosis.

enrolment. The same information was recorded for patients dismissed from the PHC centre and later hospitalized due to chest pain or any heart-related symptoms during the subsequent 30 days. Readmission for such symptoms during the subsequent 30 days was also recorded.

Investigations and interventions

Investigations (coronary catheterization, echocardiogram, exercise test, myocardial perfusion scintigraphy, computed tomography scan and measurement of fractional flow reserve) and interventions (percutaneous coronary interventions, coronary artery bypass graft) performed during the study period were registered.

Costing

In Sweden, a national cost per patient (CPP) project has been undertaken to create CPP databases in several county councils, and Östergötland County Council has been prominent in this work. The CPP database in Östergötland includes data on costs for each health care contact made by each patient. Previous studies have proved its use in research [6–8]. The CPP database was used to collect unit costs regarding health care consumption and unit costs were also retrieved from each of the three hospitals and checked by clinical economists. The mean cost was calculated for each resource component (Table II).

Statistical analysis

Patients consulting their GP for chest pain in three PHC centres with POCT-TnT were compared with patients consulting for chest pain in four PHC centres without POCT-TnT. The Pearson chi-squared test and Fisher's exact test were used for nominal variables. The independent samples t-test was used for continuous variables and to compare the costs of health care consumption. The confidence intervals presented in Table IV were estimated using bootstrap analysis. All statistical analyses were performed in SPSS Statistics 20 and 22. Significant p-values were < 0.05.

Ethics

The study was approved by the Regional Ethical Review Board in Linköping, Sweden, Dnr M101-09, T98-09 and Dnr 2010/211-32. Written informed consent was obtained from all patients before study enrolment.

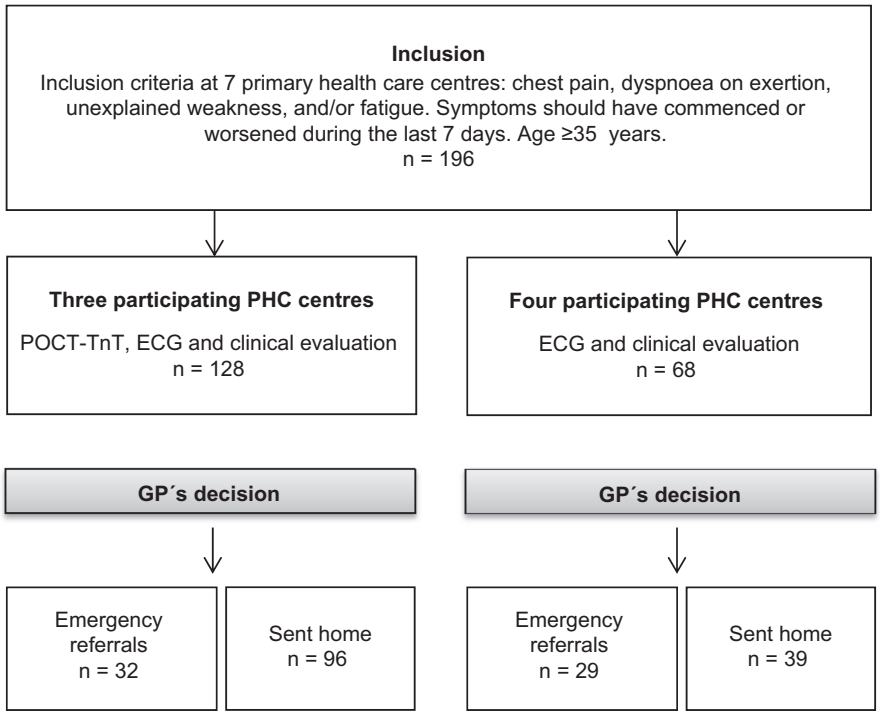

Figure 1. Flow chart of patients in primary health care centres (PHC centres), three with and four without point-of-care troponin T testing (POCT-TnT). Exclusion criteria: severely affected patients, other probable cause of chest pain than cardiac, for example, costal fracture or gastro-oesophageal reflux.

Results

A total of 196 patients were included: 128 from PHC centres with POCT-TnT and 68 from PHC centres without POCT-TnT. In comparison, there were slightly more men in the group from PHC centres without POCT-TnT and slightly more patients with diabetes and previously diagnosed cardiovascular diseases in the group from PHC centres with POCT-TnT. However, the differences were not statistically significant (see Table I). Fewer patients from the PHC centres with POCT-TnT (n = 32, 25%) were emergently referred to hospital than from centres without POCT-TnT (n = 29, 43%; p = 0.011).

Table II. Mean unit costs used to value resource use, at 2009 prices.

Resource	Unit cost (SKr)
Primary care and transport	
PHC centre visits (per visit)	1715
Troponin T tests (per test)	172
Ambulance transport (per km)	73
Other means of transportation (per km)	1.85
Hospitalization	
Emergency department (per visit)	3008
Coronary care unit (per day)	10 000
Cardiology/medical ward (per day)	4665
ICU/thoracic ICU (per day)	28 000
Investigations	
Coronary catheterization	11 301
Echocardiogram	2203
Exercise test	1687
Computerized tomography scan	6060
Fractional flow reserve measure	7000
Interventions	
PCI bare metal stent	22 383
PCI drug-eluting stent	27 483
Coronary artery bypass graft	154 098

Notes: ICU = intensive care unit; PCI = percutaneous coronary intervention.

Patients with AMI and UA

Eight patients (6.2%) from PHC centres with POCT-TnT were diagnosed with AMI or UA compared with six patients (8.8%) from centres without POCT-TnT (p = 0.565) (Table III).

In all, 135 patients were sent home by the GP after clinical evaluation in the PHC centre; 10 of these

Table III. Patients with chest pain with AMI or UA from PHC centres with and without POCT-TnT.

Diagnosis	PHC centres with POCT-TnT (n = 128)	PHC centres without POCT-TnT (n = 68)	p-value
AMI, *n* (%)	4 (3.1)[1]	5 (7.4)	0.280
UA, *n* (%)	4 (3.1)[1]	1 (1.5)	0.660

[1]One of these patients was judged to be a missed case in PHC.

patients were admitted to the ED or hospitalized due to chest pain, dyspnoea, fatigue, or any other heart-related symptoms within 30 days. One of these patients was from a PHC centre without POCT-TnT and was not diagnosed as AMI or UA. The other nine patients were from the PHC centres with POCT-TnT; two were diagnosed as AMI and one as UA. Two of these patients, one with AMI and one with UA, were considered missed cases according to a review by one cardiologist and one GP (see Table III) [5].

The mean cost for all patients diagnosed with AMI or UA after emergency referral from the PHC centres was SKr103 100 for patients from PHC centres with POCT-TnT and SKr115 300 for patients from PHC centres without POCT-TnT. Costs were calculated for a 30-day period after inclusion.

Significantly more patients in the group without POCT-TnT were referred to the ED ($p = 0.011$); however, no missed cases were found in this group. The mean cost for the two patients who were considered missed cases was SKr51 500 (total cost SKr103 000). The mean CPP emergently referred from PHC centres and who were not diagnosed with AMI or UA was SKr20 300 for PHC centres with POCT-TnT and SKr13 300 for PHC centres without POCT-TnT.

The costs for patients in the group with POCT-TnT were slightly lower compared with the other group but the difference was not significant (Table IV). The cost for POCT-TnT users was SKr4538 lower per patient at the expense of two missed cases of AMU/UA, which makes the intervention cost saving but less effective (SKr290 000 per missed case).

Discussion

The results show that the total cost for patients with POCT-TnT was lower; however, the strategy proved to be less effective as two patients in the POCT-TnT group were sent home and had a serious heart event within 30 days.

The strength of the study was the prospective design and thorough follow-up regarding AMI and UA diagnosis and costs. A weakness, indicating that the results must be interpreted with caution, is the small number of cases of AMI and UA and the study was not randomized. Randomization was not possible for practical reasons because the intervention with POCT-TnT had been done beforehand. PHC centres in the groups with or without POCT-TnT were fairly well matched concerning demographics and distance to hospital. The enrolment of PHC centres was based on the willingness of the GPs to participate in the study. Thus, interest in the study questions and willingness to put some extra time into the work with study patients should have been fairly equal in the two study groups. A limitation of the study was that the recruitment of patients in PHC

Table IV. Mean cost per patient (SEK) at 2009 prices.

	PHC centres with POCT-TnT ($n = 128$)	PHC centres without POCT-TnT ($n = 68$)	Mean difference (95% confidence interval[1])
Primary care and transport:	2106	2115	−10 (−455 to 358)
PHC centre	1862	1892	
Troponin T test	172	–	
Ambulance transport	65	215	
Other means of transportation	6	9	
Hospitalization:	5744	7264	−1520 (−8650 to 4028)
Emergency department	235	442	
Coronary care unit	78	1471	
Cardiology/medical ward	4774	4528	
ICU/thoracic ICU	656	824	
Investigations:	1375	1769	−394 (−1799 to 830)
Coronary catheterization	706	997	
Echocardiogram	327	356	
Exercise test	185	223	
Computed tomography scan	47	89	
Fractional flow reserve	109	103	
Interventions:	2023	4861	−2838 (−11 174 to 3420)
PCI bare metal stent	175	329	
PCI drug-eluting stent	644	–	
Coronary artery bypass graft	1204	4532	
Total cost	11247	16 010	−4763 (−20 046 to 7257)

Notes: ICU = intensive care unit; PCI = percutaneous coronary intervention. [1]Confidence intervals calculated using bootstrap analysis.

centres with POCT-TnT was much higher than in PHC centres without POCT-TnT. We do not know if this imbalance was due to a true difference in patients presenting with applicable symptoms or if it was due to a difference in study awareness, i.e. that the possibility of analysing troponin T instantly made GPs and nurses more aware of the study. We aimed to compensate for this imbalance through repeated personal visits and reminders via telephone calls.

Tomanaga et al. [4] reported a more accurate risk stratification of acute coronary syndromes with POCT-TnT than in a control group. However, also in their study, sensitivity was higher in the control group compared with the POCT-TnT group (100% and 90%, respectively). The sensitivity in our study is associated with wide confidence intervals due to the low number of events, which is another limitation. Planer et al. [3] suggested that the POCT-TnT kit may be cost-effective mainly for ruling out myocardial infarctions in PHC, due to the low cost of the kit. We have observed that it may be cost saving from a short-term perspective but less effective compared with not using it. In a meta-analysis, Goodacre et al. [2] found that dismissal after a negative troponin test may be more cost-effective than the standard 10-hour troponin test despite a significant minority of missed myocardial infarctions. However, this is an ED strategy that cannot be applied without discussion in a PHC setting. It is possible that the POCT-TnT may be used as a kind of reassurance that the patient does not have AMI or UA. This diagnostic strategy may be questionable and comparable with the use of C-reactive protein as a diagnostic marker for serious bacterial infections in small children, where it is of limited value especially during the first 12 hours of sickness [9].

The results in our study can be illustrated using the cost-effectiveness plane (Figure 2) [10]. Quadrants II and IV are unproblematic; however, quadrants I and III are interesting. Our results can be placed in quadrant III (shaded area) with the interpretation that using POCT-TnT in PHC is less effective (and possibly more expensive over time, thus placing it in quadrant IV) compared with not using it. Therefore, is the loss in health (i.e. the two missed cases) worth the savings of not referring all patients?

This study has highlighted that a vast number of patients who contact the PHC complaining of chest pain are referred to the ED. As a consequence, resources might be wasted. As reported earlier, the use of POCT-TnT may reduce emergency referrals but in its current form, only at the expense of missed cases of AMI or UA [5].

Is it worth saving SKr580 000 per 128 patients and relying on a diagnostic test whereby two cases of AMI or UA are missed? Failure to diagnose a patient may cause irreversible damage to an individual resulting in medical costs as well as reduced quality of life. Had an ideal point-of-care cardiac biomarker been available, a total cost of SKr13 300 per patient could have been reduced for the patients who were referred to the ED as a precaution from PHC centres without POCT-TnT. This reasoning can be compared with health economic assessments concerning drugs, e.g. prevention of new myocardial infarctions with new more efficient and much more expensive antiplatelet drugs (see quadrant I, Figure 2). For example, a new and expensive antiplatelet drug can be justified by showing that the cost per quality-adjusted life year gained is acceptable [11].

Since 2009, highly sensitive troponin T has become standard in hospital laboratories, providing a detection limit of 0.003 μg/L. The POCT-TnT instrument used in our study had a detection limit of 0.03 μg/L [5]. The current level used to indicate

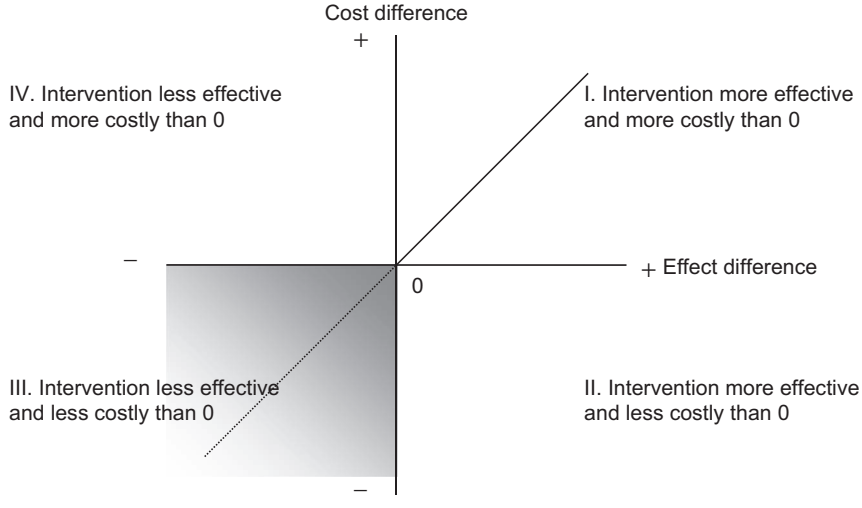

Figure 2. The cost-effectiveness plane (Drummond et al. 2005 [10]).

AMI is 0.015 μg/L; this difference may indicate a risk of missing an AMI.

Management of patients with chest pain in primary health care is a challenge and should be based mainly on the history and clinical signs. Well-known risk assessment tools for the evaluation of cardiovascular risk may be misleading, especially in women where the risk may be underestimated [12].

There is a need for biochemical markers, mainly to rule out AMI and UA in PHC [13]. However, our study shows that the POCT-TnT kit currently available does not improve the sensitivity of clinical management based on evaluation of the history and clinical signs.

Conclusion

We have observed that the use of POCT-TnT in PHC as a diagnostic aid for ruling out AMI and UA may be cost saving from a short-term perspective but at the expense of missed cases. New tests for cardiac biomarkers in PHC should be preceded by a large enough randomized study that includes a health economic evaluation.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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