Impact of the Cardiac Troponin Testing Algorithm on Excessive and Inappropriate Troponin Test Requests

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Abstract

Cardiac troponin (cTn) is a key biomarker for the assessment of myocardial injury, but overutilization of this test has increased workload and costs. We developed and implemented an algorithm to eliminate excessive utilization. Significant reduction was observed after the implementation of the algorithm in total cTnI requests (29.9%; \( P = .007 \)), requests from outpatient clinics (70.7%; \( P = .003 \)), and other wards (42.8%; \( P = .003 \)). Stat requests, the number of third requests, and more than 3 requests per patient were reduced significantly by 42.8% (\( P = .004 \)), 35.8% (\( P = .003 \)), and 49.4% (\( P = .008 \)), respectively. There was no significant change in cTnI orders from emergency and critical care departments. The cTnI testing algorithm reduced unnecessary orders for cTnI tests with no reduction in meeting patients' critical needs. Reduction in unnecessary and inappropriate requests reduces labor and test costs.

Acute coronary syndrome (ACS) is a complex syndrome that includes a broad spectrum of clinical symptoms reflecting acute cardiac ischemia. Acute myocardial infarction (AMI) is the leading cause of death in industrialized countries. Early diagnosis is critical to initiating appropriate therapy and saving lives. Biochemical cardiac markers have a solid role in the diagnosis, prognosis, and risk stratification of ACS. In response to the need for early identification of AMI, the European Society of Cardiology (ESC) and American College of Cardiology (ACC) redefined the criteria for AMI, in which cardiac troponin (cTn) was recommended as the first-line biochemical marker for the diagnosis of AMI. Since then, cTn has been considered the “gold standard” for the diagnosis of AMI, and the application of highly sensitive cTn assays has changed the diagnostic strategy and risk stratification of ACS. Moreover, this test recently was introduced into the decision algorithm for evaluation and management of patients suspected of having ACS.

Determination of blood troponin levels is an important diagnostic aid in identifying low-risk patients who can be discharged early and high-risk patients who must be treated aggressively. According to the recommendations of the ESC/ACC Committee for the Redefinition of Myocardial Infarction, troponin tests can be ordered for patients with acute chest pain at admission, 6 to 9 hours later, and again at 12 to 24 hours if results from earlier specimens are negative and the clinical index of suspicion is high. Practice guidelines dedicated to the assessment of patients with ACS exist in some institutes, but there are some limitations. The recommendations were based on consensus, without the aid of a quantitative framework, such as cost-effectiveness analyses. In addition, each institution may have different management and laboratory systems, which may influence compliance with the guidelines.
The cTn test has a key role in the diagnosis, prognosis, and risk stratification of ACS. However, overutilization and inappropriate requests for cTnI have created a heavy workload for laboratory staff, increased costs to the health care system, and unnecessarily increased the length of stay and costs for patients. Therefore, we developed a testing algorithm and implemented it in the Saskatoon Health Region, Saskatoon, Canada, in an attempt to improve patient care and professional practice. The objectives of this project were to reduce unnecessary and inappropriate troponin orders and to eliminate the costs associated with inappropriate cTn testing.

### Materials and Methods

#### Development and Implementation of Algorithm

The test algorithm was developed by a group of cardiologists, physicians, and laboratory professionals in the Saskatoon Health Region [Figure 1](#) and was implemented in all 3 tertiary hospitals and outpatient clinics in this region in mid April 2004. The working group conducted a review and evaluation of the literature on algorithms or guidelines for diagnosing ACS and managing acute chest pain. This document had been reviewed in a second working group meeting, at which consensus was reached on the detailed conclusions and recommendations.

Before implementing the algorithm, every step of the algorithm was discussed in detail among cardiologists, physicians, and laboratory professionals to make sure that the algorithm was compatible with their professional practice guidelines. Modifications of the algorithm were made based on discussions with cardiologists after a 2-week tentative implementation period. The efficacy of implementation of the algorithm was evaluated following PDSA (Plan, Do, Study, Act) cycles.

The cTnI test algorithm was developed to limit orders from outpatient clinics and nonemergency departments while maintaining ordering priority for cardiac care units (CCUs), intensive care units (ICUs), and trauma care units (TCUs). In other words, this algorithm did not limit appropriate cTnI requests by physicians from the CCU, ICU, and TCU (CITCU) in accordance with the ESC/ACC recommendations but excluded requests by family physicians and permitted up to 3 requests by non–emergency physicians from other departments or specialties. Because only a certain observation time is allowed in emergency departments (EDs), patients with positive cTnI results were admitted to the wards and patients with negative cTnI results were discharged or continued to be observed for a change in clinical course. Further cTnI requests after 2 consecutive negative cTnI test results needed consultation, but this limitation usually was defined loosely. To avoid reducing patient care quality, family physicians could order troponin tests after consultation with a clinical biochemist.

#### Database Creation

The evaluation was conducted throughout the health region in chemistry laboratories, EDs, CITCUs, cardiology wards, other clinical wards, and outpatient clinics where troponin tests were ordered. cTnI request data were obtained from the laboratory information system on a monthly basis for 6 months before and after implementation of the algorithm. Total cTnI requests, cTnI requests from the ED and CITCU, other wards, outpatient clinics, the third consecutive request per patient, more than 3 requests per patient, stat requests, number of patients, number of tests per patient, costs for the test, and labor costs were included in the database. The expected improvement following the introducing of the algorithm was assessed during a 6-month period. Significant changes between prealgorithm and postalgorithm periods were determined by using the Mann-Whitney U test and SPSS software, version 14.0 (SPSS, Chicago, IL).

#### Results

The monthly test distribution [Figure 2](#) showed that the number of total test requests, the number of requests from outpatient clinics and other locations, third consecutive requests, and more than 3 requests per patient were reduced significantly after implementation of the algorithm. However, these numbers climbed slightly during the last 2 months (September and October 2004; Figure 2).

Before implementation of the testing algorithm, 60.8% of the requests came from the ED and CITCU, 32.8% from other

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**Figure 1** Cardiac troponin I (cTnI) algorithm. The cTnI assay was performed on the Abbott AxSYM. A cTnI value of ≥2.0 ng/mL (≥2.0 µg/L) is defined as positive and a value of <2.0 ng/mL (<2.0 µg/L) as negative. CITCU, cardiac care unit, intensive care unit, and trauma care unit.
wards, and 6.4% from outpatient clinics. After implementation of the algorithm, the proportion of test requests from other wards decreased, to 26.8% of the total, and test requests from outpatient clinics declined to 2.7%.

Table 1. With implementation of the algorithm, a significant reduction in the total number of requests was observed compared with the number before implementation of the algorithm (29.9%; \( P = .007 \)). Similarly, the total number of requests from outpatient clinics and other locations decreased by 70.7% (\( P = .003 \)) and 42.8% (\( P = .003 \)), respectively. The number of stat requests was reduced by 42.8% (\( P = .004 \)). More important, the total number of third consecutive requests and more than 3 requests

![Figure 2](image-url) Monthly troponin I test requests for 6-month periods before and after implementation of the testing algorithm. The total number of test requests, requests from outpatient clinics and other locations, third consecutive requests, and more than 3 requests per patient were reduced significantly after implementation of the algorithm. Tests from the emergency department (ED) and cardiac care, intensive care, and trauma care units (CITCU) and number of tests per patient showed no significant change. The dotted vertical line indicates implementation of the algorithm.

<table>
<thead>
<tr>
<th>Troponin Request and Locations</th>
<th>Before New Algorithm</th>
<th>After New Algorithm</th>
<th>% Change</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>ED + CITCU</td>
<td>11,459 (60.8)</td>
<td>9,314 (70.5)</td>
<td>–18.7</td>
<td>.153</td>
</tr>
<tr>
<td>Other wards</td>
<td>6,185 (32.8)</td>
<td>3,539 (26.8)</td>
<td>–42.8</td>
<td>.003</td>
</tr>
<tr>
<td>Family medicine</td>
<td>1,213 (6.4)</td>
<td>355 (2.7)</td>
<td>–70.7</td>
<td>.003</td>
</tr>
<tr>
<td>Third consecutive request for 1 patient</td>
<td>1,022</td>
<td>656</td>
<td>–35.8</td>
<td>.003</td>
</tr>
<tr>
<td>&gt;3 Requests per patient</td>
<td>859</td>
<td>435</td>
<td>–49.4</td>
<td>.008</td>
</tr>
<tr>
<td>Total No. of requests</td>
<td>18,857</td>
<td>13,208</td>
<td>–29.9</td>
<td>.007</td>
</tr>
<tr>
<td>No. of stat requests</td>
<td>5,300</td>
<td>3,034</td>
<td>–42.8</td>
<td>.004</td>
</tr>
<tr>
<td>No. of patients</td>
<td>13,466</td>
<td>9,677</td>
<td>–28.1</td>
<td>.01</td>
</tr>
<tr>
<td>No. of tests per patient</td>
<td>1.40</td>
<td>1.36</td>
<td>–2.9</td>
<td>.153</td>
</tr>
<tr>
<td>No. of MIs diagnosed</td>
<td>399</td>
<td>407</td>
<td>+2.0</td>
<td>.485</td>
</tr>
<tr>
<td>Test cost</td>
<td>169,785</td>
<td>119,043</td>
<td>–29.9</td>
<td>.007</td>
</tr>
<tr>
<td>Labor cost</td>
<td>282,975</td>
<td>198,405</td>
<td>–29.9</td>
<td>.007</td>
</tr>
</tbody>
</table>

cTnI, cardiac troponin I; ED + CITCU, emergency department, cardiac care unit, intensive care unit, and trauma care unit; MI, myocardial infarction.

*Data are given as number (percentage) unless otherwise indicated. Data were obtained on a monthly basis for 6 months before and after implementation of the algorithm. Costs are in Canadian dollars.
per patient were reduced significantly by 35.8% \( (P = .003) \) and 49.4% \( (P = .008) \), respectively.

There was no significant change in the incidence of MI diagnosed before and after implementation of the algorithm. Owing to the reduction in the total number of test requests, testing costs and labor costs each were reduced by 29.9% \( (P = .007 \text{ for each}) \). The total number of patients on whom cTnI testing was performed was reduced by 28.1% \( (P = .01) \). There was no significant change in cTnI ordering from the ED and CITCU \( (P = .153) \) or the number of tests requested per patient \( (P = .153) \) (Table 1) \( \text{Figure 3} \).

**Discussion**

With the successful implementation of the algorithm, significant reductions in test requests from outpatient clinics and wards other than the ED and CITCU and cost reductions were achieved. Unnecessary and inappropriate (ie, a third consecutive or >3) requests also were reduced. The reduction in these requests eased the workload and cut test and labor costs. Reducing unnecessary testing and shortening stay times also is beneficial for patients.

Test requests from the ED and CITCU did not change significantly, reflecting no limitation of critical patient care. Moreover, implementation of the algorithm did not reduce the incidence of diagnosed MI. These data indicate that implementation of the algorithm reduced unnecessary orders for cTnI tests but did not reduce patient care quality. The application of this algorithm in practice not only can allow rapid and accurate assessment of patients with acute chest pain but also can lead to significant cost savings.\(^{15}\) Appropriate application of the cTnI test in accordance with our algorithm can reduce testing requests, which, in turn, reduces laboratory workload and testing costs.

The algorithm provides a decision support tool for determining the need to order cTnI testing. As shown in Figure 2, the number of test requests increased slightly during the last 2 months of the study period. This increase suggests that physician compliance with the algorithm failed to some extent. It also may be due to technologist failure to track and cancel inappropriate orders following the testing algorithm. Another possibility might be seasonal variation. To improve this, we would refine and reimplement the algorithm to be used in clinical settings as a decision support tool for determining the need to order cTnI testing.\(^{17}\) We will again follow the PDSA approach\(^ {15}\) to evaluate the improvement. During implementation and PDSA evaluation, intensive interactions between clinical biochemists and physicians will be conducted. After several cycles of PDSA and expansion of the implementation of the test algorithm, a better algorithm will be developed and implemented in the health region.\(^ {18},^{19}\) Successful implementation will offer the possibility of extension to other health regions, which will reduce costs, improve patient care, and improve professional practice to a larger extent.

The downside of implementation of the algorithm, in the beginning, was that we needed to spend more time communicating with physicians about the reasons we wanted to implement the algorithm and its importance for their patients and practice. We also received more calls to explain the algorithm and approve the test requests, particularly from outpatient clinics, the ED, and other wards. The other downside, in the beginning, was that laboratory technologists had to spend time tracking orders and canceling inappropriate requests. Although we observed significant savings after implementation of the algorithm, the time spent tracking and canceling orders and responding to consultations should be considered as costs, and these costs should be subtracted from the savings. Thus, the actual savings may be compromised by the costs for tracking, canceling, and consultation. But in the long term, with better compliance with the algorithm, we expect the number of calls to decrease. The adoption of clinical practice guidelines and implementation of the algorithm in the short term can be time-consuming and costly, but in the long term, it is cost-effective and a critical step toward standard practice.\(^ {20}\)

The cTnI testing algorithm changed practice to some extent. It reduced unnecessary orders for cTnI tests, yet did...
not seem to reduce the quality of patient care because there was no significant impact on requests from the ED and CITCU. The reduction of unnecessary and inappropriate requests reduces patient stay and, in this way, improves patient care. The reduction in test ordering also reduces labor costs and costs to the patient. Thus, this study indicates that the new cTnI algorithm is effective and efficient.

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References


