

Manitoba Troponin Guideline

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Please Note: Numbers for the Dade Tnl assay presented in this document are currently being reviewed, the functional sensitivity of the assay (10%CV) may be higher than stated in this version of the document.

Prepared by:

Dr. John Sokal, CCFP (EM)

Chairperson, Standards Committee
WRHA Emergency Medicine Program
Assistant Medical Director, Department of Emergency Medicine
Health Sciences Centre

Dr. Laurel Thorlacius, PhD, FCACB

Medical Director, Clinical Biochemistry and Genetics
Diagnostic Services of Manitoba

Dr. James Tam, FRCPC

Head of Cardiology
Director of Echocardiography
Health Sciences Centre and St. Boniface General Hospital

Note: This document was originally prepared for use within the WRHA that uses Troponin T only, due to differences in laboratory instrumentation. As most of the content is the same for either TnT or TnI this document has been modified to reflect the assays in use in other parts of Manitoba. Troponin I and T are of equivalent diagnostic use. Values reported by different Troponin assays will not be identical.

Abbreviations:

| | |
|-------------------|---|
| AMI | acute myocardial infarction |
| AUC | area under the curve |
| CAD | coronary artery disease |
| CRF | chronic renal failure |
| CV | coefficient of variation |
| ED | emergency department |
| ESC/ACC | European Society of Cardiology / American College of Cardiology |
| LOS | length-of-stay |
| MR | mitral regurgitation |
| NLR | negative likelihood ratio |
| NPV | negative predictive value |
| NSTEMI | non-ST segment elevation MI |
| ROC | receiver operating curve |
| STEMI | ST segment elevation MI |
| th ile | percentile |
| TnI | troponin I |
| TnT | troponin T |

OVERVIEW

1. In patients with a low likelihood of ACS:

- ⇒ Troponin must be measured at least six (6) hours after the onset of chest pain.
- ⇒ Troponin measurement may be deferred until six (6) hours after the onset of pain.
- ⇒ Troponin samples may be measured two (2) hours apart when measured at least 6 - 9 hours after the onset of chest pain (e.g. sample one at 6 hours after the onset of pain, sample two at 8 hours).
- ⇒ If Troponin measured ≥ 9 (nine) hours is negative, AMI may be safely ruled-out in patients with a low likelihood of ACS.

2. Troponin is considered negative: (when measured ≥ 6 - 9 hours after the onset of chest pain)

| i-STAT Tnl | Dade Tnl | Bayer Tnl ultra | Roche TnT | |
|------------------|------------------|------------------|------------------|---|
| < 0.08 µg/L | < 0.07 µg/L | <0.04 µg/L | < 0.01 µg/L | |
| ≥ 0.08 µg/L | ≥ 0.07 µg/L | ≥ 0.04 µg/L | ≥ 0.01 µg/L | <u>and</u> not rising on 2 samples measured at least 2 hours apart <u>and</u> in context of alternate etiology for elevated troponin |

3. A rising troponin level is required in order to diagnose AMI.
4. In patients with background elevations of troponin (e.g. patients with CRF), two (2) measurements are required to demonstrate a rising pattern.
5. No single serum marker used alone has sufficient sensitivity or specificity to reliably identify or exclude AMI within 6 hours after symptom onset.
6. Discontinue the use of myoglobin, CK, and CK-MB as cardiac markers for the rule-out of AMI in the ED.
7. Do not utilize cardiac serum marker tests to exclude unstable angina.
8. Document the time of onset of chest pain on all patients.

Recommended Troponin testing protocol for a patient with a low likelihood of ACS

- ⇒ **Do not utilize cardiac serum marker tests to exclude unstable angina.**
(ACEP NSTEMI Clinical Policy, 2006)
- For the definition of unstable angina, see appendix A
- ⇒ **Document the time of onset of chest pain on all patients.**
- ⇒ If the time of onset of chest pain is not known, then the time of presentation must be utilized for cardiac marker interpretation.

Assess Likelihood of ACS:

Low Likelihood (e.g. 1% - 14% likelihood)

- chest pain, “probably not angina” in patients with one or no risk factors for CAD, but not diabetes
- T-wave flat or inverted < 1 mm
- normal ECG

Intermediate Likelihood (e.g. 15% - 84% likelihood)

- “definite angina” in patients with no risk factors
- “probable angina” in patients with one or more risk factors
- “probably not angina” in patients with diabetes or with two or three other risk factors
- patients with extracardiac vascular disease
- ST depression 0.5 – 1 mm
- T-wave inversion ≥ 1 mm

High Likelihood (e.g. 85% - 99% likelihood)

- known history of prior AMI or CAD
- “definite angina” in males ≥ 60 or females ≥ 70
- transient hemodynamic or ECG changes during pain
- ST elevation or depression ≥ 1 mm
- Marked symmetrical T-wave inversion in multiple leads

UCLA 2005 Chest Pain and ACS Patient Management Guideline

See Appendix B: WRHA algorithm for the management of patients with suspected ACS in the ED

See Appendix C: Likelihood that signs and symptoms represent an ACS

ESC/ACC Diagnostic Criteria for Acute Myocardial Infarction

Diagnostic Criteria for AMI

Typical rise and/or fall of biochemical markers (preferably troponin) with at least one value above the 99th percentile of the upper reference limit together with evidence of myocardial ischemia with at least one of the following:

- Symptoms of ischemia
- ECG changes indicative of new ischaemia [new ST-T changes or new left bundle branch block (LBBB)]
- Development of pathologic Q waves in the ECG
- Imaging evidence of loss of viable myocardium or NEW regional wall motion abnormality

*Myocardial infarction redefined – J Am Coll Cardiol 2000
Universal Definition of Myocardial Infarction – Circulation 2007*

See Appendix D

- Troponins are more specific than other biomarkers in detecting myocardial injury with associated skeletal muscle injury and have a higher sensitivity, allowing detection of small amounts of myocardial necrosis that would have gone undetected by creatine kinase and its MB fraction (Roger, 2006).
- The criteria acknowledge that elevations in biomarkers are fundamental to the diagnosis of AMI because symptoms may be atypical or nonexistent and ECG changes may be absent or nonspecific (Babuin, 2005).
- Troponins have replaced CK-MB as the preferred biochemical markers for the diagnosis of AMI (Roger, 2006; Korff, 2006).
- An indepth document outlining the new Universal definitoin of acute myocardial infarctions along with its subcategories is provided in Circulation 2007; 116: 2634 – 53..

Algorithm for risk stratification of patients with unstable angina and NSTEMI

| | <i>non-cardiac chest pain</i> | <i>stable angina</i> | <i>unstable angina</i> | <i>NSTEMI</i> | <i>STEMI</i> |
|-------------------------|-------------------------------|----------------------|-------------------------------|---------------|--------------|
| Clinical finding | atypical pain | exertional pain | rest pain, post-AMI, diabetes | ongoing pain | |
| ECG | negative | | ST-T wave changes | ST elevation | |
| TnT | negative | | positive | | |
| Risk assessment | low probability | low risk | medium - high risk | STEMI | |

Cannon – Circulation 2003

How do you interpret Troponin results?

Interpretation of Troponin values

| Troponin value | i-STAT Tnl µg/L | Dade Tnl µg/L | Bayer Tnl ultra | Roche TnT µg/L | Comment | Interpretation |
|--|-----------------|---------------|-----------------|----------------|---|---|
| Below 99 th ile | <0.08 | <0.07 | <0.04 | < 0.01 | Below 99 th ile. | No myocardial necrosis, if > 6 hrs after onset of symptoms. |
| Between (99 th ile) and functional sensitivity (10% CV) | 0.08 to 0.10 | 0.07 to 0.14 | 0.04 to 0.07 | 0.01 to 0.03 | Troponin present and can be distinguished from background but cannot be quantified repeatedly at this level | Possible myocardial injury, in the context of suspected ACS, repeat after two (2) hours (must be > 6 hrs after onset of symptoms) |
| Above functional sensitivity (10% CV or less) | >0.10 | >0.14 | >0.07 | > 0.03 | Definite myocardial necrosis, measurements are repeatable | NSTEMI when seen in the context of suspected ACS |

- The fact that any troponin elevation exceeding the 99th ile is associated with an increased cardiac risk (Venge, 2002; Lindahl, 2001) is reflected by the recommendation of this cutoff for diagnostic purposes (ESC/ACC diagnostic criteria for AMI).
- It is important to realize that no troponin assays currently available has a CV less than 10% for values less than the 99th percentile of a normal reference population. Values between the 99th ile and the level at which a 10% CV are reached have low positive predictive values, resulting in a considerable risk for diagnostic misclassification.
- A rising troponin level is required in order to diagnose AMI.
- In patients with background elevations of troponin (e.g. patients with CRF), two (2) measurements are required to demonstrate a rising pattern.
- Troponin is specific for heart cell damage - any detectable level indicates myocardial damage. However, the etiology may be other than ACS
- See Appendix E for the differential diagnoses of an elevated troponin.

In order to rule-out AMI in a patient with a low likelihood of ACS:

- **Tnl must be measured at least 6 hours after the onset of chest pain.**

| i-STAT Tnl µg/L | Dade Tnl µg/L | Bayer Tnl µg/L | Roche Tnl (ug/L) | Interpretation |
|-----------------|---------------|----------------|------------------|--|
| <0.08 | <0.07 | <0.04 | < 0.01 | Below 99 th ile. AMI can be ruled out |
| 0.08 to 0.10 | 0.07 to 0.14 | 0.04 to 0.07 | 0.01 to 0.03 | repeat TnT at least two (2) hours after previous sample ⇒ if not rising, consider alternate etiology for elevated troponin (see Appendix E) |
| >0.10 | >0.14 | >0.07 | > 0.03 | Myocardial necrosis - probable NSTEMI in setting of ACS |

- **If the repeat is less than the 99th ile - AMI is unlikely. But if clinical suspicion remains high, a third Tnl may be considered.**

No

Should Troponin *a/ways* be performed at the time of ED presentation?

- For patients with low likelihood of ACS, the diagnostic value of a Troponin drawn at the time of ED presentation (which is often less than 2 hours after the onset of chest pain) is very low and very unlikely to permit earlier consultation and/or admission decisions, or to improve ED throughput. The Troponin measurement may be deferred until six hours after the onset of chest pain, when a negative Troponin test result may be most helpful.
- In patients with recurrent chest pain, ECG abnormalities, or intermediate to high clinical suspicion, immediate treatment for presumed ACS should take place, including prompt consultation when appropriate. In these cases, performing Troponin earlier than six hours may be permissible.

What is the rationale for two hour intervals between Troponin samples?

- A recent study (MacRae, 2006) provided support for measuring TnT at six (6) hours after onset of chest pain and for two (2) hour intervals between TnT samples:
 - ⇒ A troponin (Tnl) assay in specimen sets having one specimen > 6 hours after the onset of chest pain gave an AMI prevalence equivalent to the AHA definition.
 - ⇒ When the time from onset of symptoms was included in the specimen selection algorithm, a *one hour interval* between troponin samples was sufficient provided that at least one specimen was collected > 6 hours after the onset of chest pain.

Consider discharge of patients with low likelihood of ACS if all of the following are met:

- no recurrent chest pain
- no ECG changes
- negative Troponin measured six (6) hrs after the onset of chest pain

3. Troponin is considered negative: (when measured ≥ 6 hours after the onset of chest pain)

| i-STAT Tnl | Dade Tnl | Bayer Tnl ultra | Roche TnT | |
|------------------|------------------|------------------|------------------|---|
| < 0.08 µg/L | < 0.07 µg/L | < 0.04 µg/L | < 0.01 µg/L | |
| ≥ 0.08 µg/L | ≥ 0.07 µg/L | ≥ 0.04 µg/L | ≥ 0.01 µg/L | <u>and</u> not rising on 2 samples measured at least 2 hours apart <u>and</u> in context of alternate etiology for elevated troponin |

No**Can single markers be utilized to safely rule out AMI *less than 6 hours* after the onset of chest pain?**

- No single serum marker used alone has sufficient sensitivity or specificity to reliably identify or exclude AMI within 6 hours after symptom onset (ACEP 2006 NSTEMI Clinical Policy).
- The ACEP 2006 NSTEMI Clinical Policy refers only to an option of performing myoglobin in conjunction with a more definitive cardiac marker (a level B recommendation).
- Use of a single marker such as myoglobin for the evaluation of chest pain should be avoided – a positive result only leads to additional lab testing because confirmation by a more definitive cardiac marker (troponin) will be needed (Eggers, 2004).

YES**Can TnT be utilized to safely rule out AMI ≥ 6 hours after the onset of pain?****Collinson P - Annal Clin Biochem 2006**

- TnT sample 1 was drawn at the time of presentation;
 - TnT sample 2 was drawn at six (6) hours from the onset of chest pain *and* at least two (2) hours after sample 1.
 - In this study, the optimal decision threshold from the ROC curves for TnT was 0.02 ug/L.
- ⇒ The sensitivity of TnT (0.02ug/L cutoff) exceeds 98% if measured at least six (6) hours after the onset of chest pain, with a negative predictive value (NPV) $\geq 99.9\%$ and a negative likelihood ratio (NLR) of 0.02.

| 6 hour Troponin T measurement (TnT 0.02 ug/L) | | | | | |
|---|----------------------------------|----------------------------------|----------------------------------|------------------------------------|---------------------------------|
| TnT sample 2 was drawn: | Sensitivity % (95%CI) | Specificity % (95%CI) | Negative Likelihood Ratio | Negative Predictive Value % | AUC (95%CI) |
| only between 6 to 12 hrs after the onset of chest pain | 100 (90.7 - 100) | 98.2 (96.6 – 99.2) | < 0.001 | 100 | 1.000 (0.966 – 1.000) |
| all times after 6 hrs | 98 (89.4-99.9) | 98.3 (97.1 – 99.1) | 0.02 | 99.9 | 0.989 (0.999 – 1.000) |

Interpretation:

If TnT measured ≥ 6 hours is negative, AMI may be safely ruled-out in patients with a low likelihood of ACS.

Maybe

Can Tnl be utilized to safely rule out AMI ≥ 6 hours after the onset of pain?

Due to the variety of Tnl assays on the market, and the fact that they are not all calibrated the same way and have different specifications for the 99th percentile of a normal population and 10% cv, a more conservative approach may be warranted. The 2007 "National Academy of Clinical Biochemistry Laboratory Medicine Practice Guidelines: Clinical Characteristics and Utilization of Biomchemical Markers in Acute Coronary Syndromes" state:

"Given the improvements in the analytic performance assay, testing up to 6 – 9 h after symptom onset is expected to deliver optimal sensitivity in most patients. However, in patients for whom these initial samples are negative and there is an intermediate or high clinical index of suspicion, or in whom plausibly ischemic symptoms have recurred, repeat testing at 12 – 24 h should be considered."

No

Does the measurement of CK provide any additional information?

Numerous studies have demonstrated that measurement of CK and its isoforms does not improve diagnostic accuracy for AMI or facilitate more rapid decision-making than Tnl or TnT alone.

No

Does the measurement of myoglobin provide any additional value?

The first three studies below are widely quoted as supporting the use of myoglobin:

McCord - Ann Emerg Med 2003

- The authors report that using myoglobin in combination with Tnl at 0 and 90 minutes had a sensitivity of 84.4% (NLR 0.25).
- The maximum sensitivity at 94% was reached at nine hours using a combination of Tnl, CK-MB, and myoglobin (*the likely reason for the low sensitivity is that an insensitive Tnl assay was used in this study*).

Interpretation: the maximum sensitivity attained is not sufficient

Sallach - Am J Cardio 2004

- This is the same study of population as McCord, suggesting a post-hoc analysis.
- Their results for a change of ≥ 20 ng/ml of myoglobin at 90 minutes after presentation produced 83.3% sensitivity and 86.6% specificity, 99.5% NPV and an NLR of 0.19 for AMI.
- The combined sensitivity of Tnl and myoglobin at 90 minutes after presentation was 97.3%.
- However, in both McCord and Sallach studies, the median time of presentation after the onset of chest pain was 4.3 hours, meaning that most of the delta measurements were performed at six hours or more after the onset of chest pain.

Interpretation: delta myoglobin performed at six hours after onset of chest pain has a lower sensitivity and NLR than a TnT performed at six hours

Ng - Am J Cardio 2001

- This study looked at using a combination of delta myoglobin, CK-MB, and Tnl in concert with clinical history and ECG.
- All AMI's were diagnosed within 90 minutes of presentation: 100% sensitivity, 94% specificity, 100% NPV.

- Over 50% of patients presented more than six hours after onset of pain, 98% of patients were male, and 40% of patients were discharged without complete recording of outcome.
Interpretation: unlikely to be applicable given reservations about methods

Eggers - Am Heart J 2004

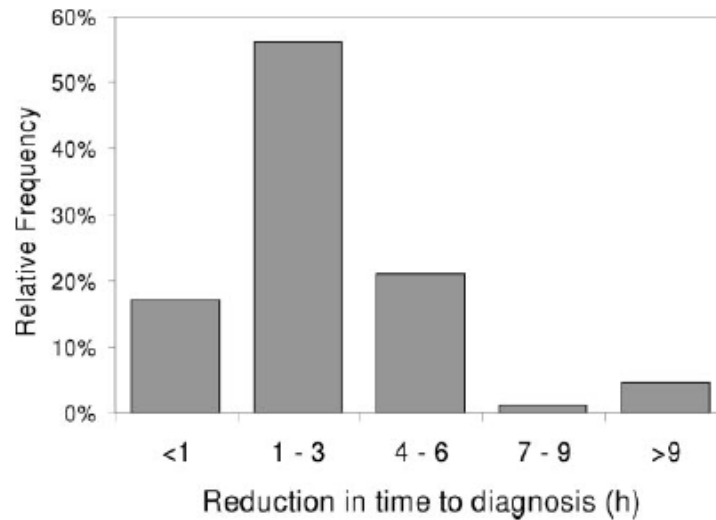
- Multi-marker strategies using TnI and myoglobin did not provide a superior overall diagnostic performance as compared to TnI alone.
- Even in patients with an onset of chest pain less than four hours before presentation, low TnI cutoffs demonstrated higher early sensitivities than myoglobin.
Interpretation: performance of myoglobin does not improve sensitivity or NLR

Recommendation: discontinue use of myoglobin as a cardiac marker.

- At six hours after the onset of chest pain, TnT alone has a sensitivity for the detection of AMI of >98%, which exceeds the sensitivity of other single markers or combinations of markers.
- Based on the above studies, there is insufficient evidence to justify the use of myoglobin as a cardiac marker.
- We found no studies that looked at the use of myoglobin alone for the rule-out of AMI.
- Therefore, the potential use of myoglobin as an early marker for rule-out of AMI is not supported.

Implications for ED throughput

Potential Reduction in the time to Diagnosis



Patient distribution in terms of the reduction in time (h) to achieve a diagnosis with the ≥ 6 h from onset protocol compared with the AHA case definition.

MacRae - Clin Chem 2006

The AHA Scientific Statement previously defined an adequate set of biomarkers as at least two measurements of the same marker taken at least six hours apart. The "AHA adequate set" was a set of markers measured over a six hour interval *from the time of ED presentation*, whereas in the study protocol the interval was timed *from the onset of chest pain*. For each of these sets, the required time to diagnosis was calculated as the time from the presentation specimen to the time of the second specimen in the set, without incorporating an assay turnaround time. The time to diagnosis for the candidate time-from onset specimen sets were subtracted from the identically calculated interval in the AHA-adequate sets to estimate the reduction in time to diagnosis afforded by the time-from-onset protocols.

For more detailed discussions of the cardiac markers, please refer to the following:

- Lippi, 2006
 - Jaffe, 2005
 - Carreiro-Lewandowski, 2006
 - Aviles, 2005
- } *reviews of markers of necrosis and ischemia*
- Collison, 2003
 - Korff, 2006
- } *reviews of troponins*
- Innes, 2006
- } *discussion of the clinical utility of new cardiac markers*

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Appendix A

Presentations of Unstable Angina

Table 3. Three Principal Presentations of UA

| | |
|-------------------|--|
| Rest angina* | Angina occurring at rest and prolonged, usually >20 minutes |
| New-onset angina | New-onset angina of at least CCS Class III severity |
| Increasing angina | Previously diagnosed angina that has become distinctly more frequent, longer in duration, or lower in threshold (i.e., increased by greater than or equal to 1 CCS class to at least CCS Class III severity) |

CCS Grading of Angina

Table 4. Grading of Angina Pectoris According to CCS Classification

| Class | Description of Stage |
|--------------|--|
| I | “Ordinary physical activity does not cause . . . angina,” such as walking or climbing stairs. Angina occurs with strenuous, rapid, or prolonged exertion at work or recreation. |
| II | “Slight limitation of ordinary activity.” Angina occurs on walking or climbing stairs rapidly; walking uphill; walking or stair climbing after meals; in cold, in wind, or under emotional stress; or only during the few hours after awakening. Angina occurs on walking >2 blocks on the level and climbing >1 flight of ordinary stairs at a normal pace and under normal conditions. |
| III | “Marked limitations of ordinary physical activity.” Angina occurs on walking 1 to 2 blocks on the level and climbing 1 flight of stairs under normal conditions and at a normal pace. |
| IV | “Inability to carry on any physical activity without discomfort—anginal symptoms may be present at rest.” |

ACC/AHA 2002 Unstable angina / NSTEMI guideline update

Appendix B

The WRHA algorithm for the management of patients with suspected ACS in the ED is under revision by WRHA ER and Cardiology Programs and will be circulated when available.

Appendix C

Likelihood that signs and symptoms represent an ACS

Table 5. Likelihood That Signs and Symptoms Represent an ACS Secondary to CAD

| Feature | High Likelihood <i>Any of the following:</i> | Intermediate Likelihood <i>Absence of high-likelihood features and presence of any of the following:</i> | Low Likelihood <i>Absence of high- or intermediate-likelihood features but may have:</i> |
|-----------------|---|--|---|
| History | Chest or left arm pain or discomfort as chief symptom reproducing prior documented angina Known history of CAD, including MI | Chest or left arm pain or discomfort as chief symptom Age >70 years Male sex Diabetes mellitus | Probable ischemic symptoms in absence of any of the intermediate likelihood characteristics Recent cocaine use |
| Examination | Transient MR, hypotension, diaphoresis, pulmonary edema, or rales | Extracardiac vascular disease | Chest discomfort reproduced by palpation |
| ECG | New, or presumably new, transient ST-segment deviation (≥ 0.05 mV) or T-wave inversion (≥ 0.2 mV) with symptoms | Fixed Q waves Abnormal ST segments or T waves not documented to be new | T-wave flattening or inversion in leads with dominant R waves Normal ECG |
| Cardiac markers | Elevated cardiac TnI, TnT, or CK-MB | Normal | Normal |

Braunwald E, Mark DB, Jones RH, et al. Unstable angina: diagnosis and management. Rockville, MD: Agency for Health Care Policy and Research and the National Heart, Lung, and Blood Institute, US Public Health Service, US Department of Health and Human Services; 1994; AHCPR Publication No. 94-0602.

Braunwald – AHCPR Publication No. 94-0602
ACC/AHA 2002 Unstable angina / NSTEMI guideline update

Appendix D

Definition of Myocardial Infarction by Joint ESC/ACCF/AHA/WHF Task Force for the Redefinition of Myocardial Infarction as reported in Thygesen 2007

Definition of myocardial infarction

Criteria for acute myocardial infarction

The term myocardial infarction should be used when there is evidence of myocardial necrosis in a clinical setting consistent with myocardial ischaemia. Under these conditions any one of the following criteria meets the diagnosis for myocardial infarction:

- Detection of rise and/or fall of cardiac biomarkers (preferably troponin) with at least one value above the 99th percentile of the upper reference limit (URL) together with evidence of myocardial ischaemia with at least one of the following:
 - Symptoms of ischaemia;
 - ECG changes indicative of new ischaemia [new ST-T changes or new left bundle branch block (LBBB)];
 - Development of pathological Q waves in the ECG;
 - Imaging evidence of new loss of viable myocardium or new regional wall motion abnormality.
- Sudden, unexpected cardiac death, involving cardiac arrest, often with symptoms suggestive of myocardial ischaemia, and accompanied by presumably new ST elevation, or new LBBB, and/or evidence of fresh thrombus by coronary angiography and/or at autopsy, but death occurring before blood samples could be obtained, or at a time before the appearance of cardiac biomarkers in the blood.
- For percutaneous coronary interventions (PCI) in patients with normal baseline troponin values, elevations of cardiac biomarkers above the 99th percentile URL are indicative of peri-procedural myocardial necrosis. By convention, increases of biomarkers greater than 3 × 99th percentile URL have been designated as defining PCI-related myocardial infarction. A subtype related to a documented stent thrombosis is recognized.
- For coronary artery bypass grafting (CABG) in patients with normal baseline troponin values, elevations of cardiac biomarkers above the 99th percentile URL are indicative of peri-procedural myocardial necrosis. By convention, increases of biomarkers greater than 5 × 99th percentile URL plus either new pathological Q waves or new LBBB, or angiographically documented new graft or native coronary artery occlusion, or imaging evidence of new loss of viable myocardium have been designated as defining CABG-related myocardial infarction.
- Pathological findings of an acute myocardial infarction.

Criteria for prior myocardial infarction

Any one of the following criteria meets the diagnosis for prior myocardial infarction:

- Development of new pathological Q waves with or without symptoms.
- Imaging evidence of a region of loss of viable myocardium that is thinned and fails to contract, in the absence of a non-ischaemic cause.
- Pathological findings of a healed or healing myocardial infarction.

Appendix E

Differential Diagnosis of Elevated Troponin

Table 1 Examples of reported elevations of cardiac troponin

| | | |
|---|---|--|
| Primary ischaemic cardiac injury | | |
| Thrombotic coronary artery occlusion caused by platelets/fibrin | ST elevation MI Non-ST elevation MI (previously non-Q wave AMI plus troponin positive unstable angina) | |
| Secondary ischaemic cardiac injury | | |
| Coronary intervention | Primary PTCA | Distal embolisation from clot or atheroma; side branch occlusion |
| | Elective PTCA | Distal embolisation from atheroma or debris; side branch occlusion |
| | CABG | Global ischaemia from inadequate perfusion, myocardial cell protection or anoxia |
| Sympathomimetics | Cocaine Catecholamine storm | Head injury, stroke, intracerebral bleed |
| Pulmonary embolus | Presumed right heart strain or hypoxia | |
| Coronary artery spasm | Small percentage of patients only | |
| Coronary artery embolisation | Clot | |
| | Air CABG | |
| Coronary artery inflammation with microvascular occlusion | Vasculitides | |
| | Connective tissue disease SLE | |
| End stage renal failure | More severe CAD but 50% have normal coronaries | |
| Rhythm disturbances | Prolonged tachyarrhythmia or bradyarrhythmia with IHD | |
| Acute heart failure | Only if caused by IHD | |
| Direct coronary artery trauma | | |
| Extreme endurance exercise | Extreme marathons | Wall motion abnormalities |
| | Extreme training | cTn +ve deaths presumed caused by extreme oxygen debt producing ischaemia |
| Non-ischaemic cardiac injury | | |
| Known causes of myocarditis | Infection | Bacterial Viral |
| | Inflammation | |
| | Auto-immune | Polymyositis Scleroderma Sarcoid |
| | Drugs | Alcohol Chemotherapy |
| | Inflammation | |
| Cardiac trauma | Direct | RTA Stabbing |
| | Cardiac surgery | |
| Metabolic/toxic | Renal failure | |
| | Multiple organ failure | |

AMI, acute myocardial infarction; CABG, coronary artery bypass graft; CAD, coronary artery disease; IHD, ischaemic heart disease; MI, myocardial infarction; PTCA, percutaneous transluminal coronary angioplasty; RTA, road traffic accident; SLE, systemic lupus erythematosus.