# Use and interpretation of cardiac troponin testing

## Introduction

Cardiac troponins are components of cardiac muscle which have a regulatory role in muscle contraction. Over the last 15 years, serum troponin assays have replaced older, less sensitive cardiac markers such as CK-MB (creatinine kinase myocardial band) for the diagnosis and risk stratification of patients with suspected myocardial infarction. The availability of troponin assays has undoubtedly reduced the number of patients with a missed diagnosis of cardiac ischaemia. However, a positive troponin test is not enough by itself to make a diagnosis of myocardial infarction. Although detection of circulating troponin specifically indicates myocardial cell injury, it does not provide any information about the causal mechanism. In fact a wide range of disorders can result in cardiac cell damage and consequently a rise in serum troponin levels.

While this is increasingly appreciated, it is not uncommon to come across patients treated for acute coronary syndrome on the basis of elevated troponin levels alone, in some cases resulting in delayed or missed diagnosis of other serious pathology. This article gives a practical guide to troponin testing and interpretation.

## What is troponin?

Troponin is a protein found in skeletal and myocardial cells, which was discovered by Ebashi in 1963. The protein forms part of the cytoskeleton that gives muscle cells their structure and facilitates muscle contraction (*Figure 1*) (*Table 1*).

Troponin is made up of three subunits: troponin I, troponin T and troponin C. Myocardial cells contain a unique form of all three subunits. When cardiac muscle cells are injured, regardless of the cause, cardiac troponin is released into the bloodstream. Its detection acts as a specific marker of myocardial cell injury (Adams et al, 1993), but gives no information about the mechanism of injury. There is no level of troponin which proves that ischaemia is the cause.

## How is troponin level measured?

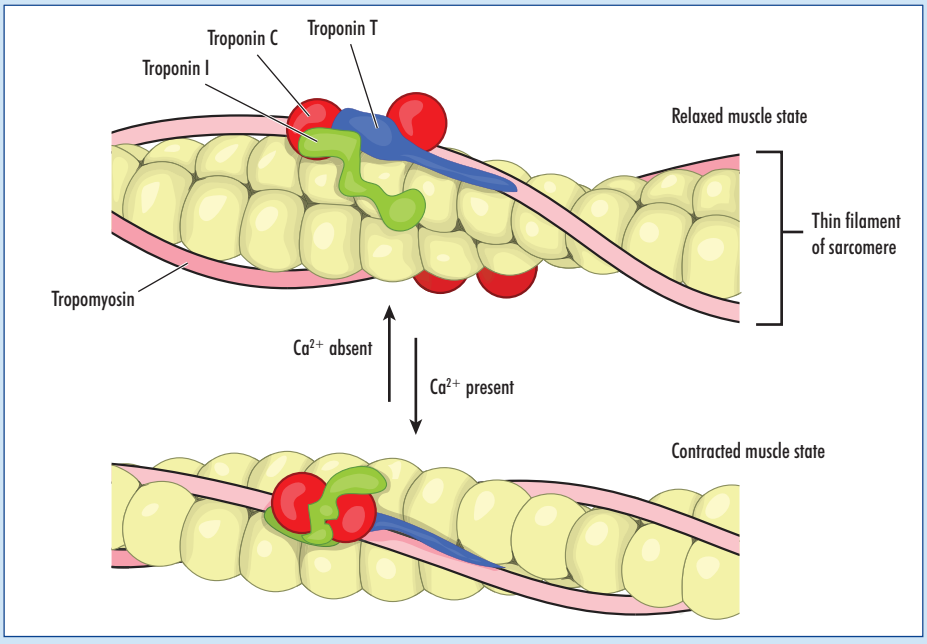
Cardiac troponin I and troponin T have a unique N-terminal amino acid sequences which can be detected using specific antibodies. Five assays are commercially available for cardiac troponin I and one for cardiac troponin T. In the bloodstream cardiac troponin I and cardiac troponin T circulate in different forms. Each assay has a different sensitivity for the different forms, which leads to variability in the precise level of troponin measured, so results from different assays are not directly comparable (*Table 2*).

With these standard troponin assays, the majority of people have undetectable or very low levels of circulating troponin. The level of troponin that is considered 'positive' is arbitrarily set at the 99th percentile of the level found in a reference healthy population (Newby et al, 2012). By definition this means that a small proportion of

**Table 1. Troponin**

| |
|---|
| Protein complex composed of three subunits I, T and C |
| Troponin has a regulatory role in muscle contraction |
| Troponin subunits have a unique structure in cardiac muscle |
| Troponin is released into the bloodstream in myocardial injury |
| Troponin I and troponin T have a unique N-terminal, which can be detected using assays |

***Figure 1. Function of troponin as a regulatory protein. In the cytoskeleton troponin binds another protein called tropomyosin in the groove between actin filaments. After electrical excitation of muscle cells, intracellular calcium levels rise. Calcium binds to troponin causing it to change shape and expose the active sites on actin filaments, allowing the formation of myosin crossbridges, leading to muscle contraction.***




**Dr Nadine Ali** *is Cardiology Specialist Registrar in the Trent Cardiac Centre, Nottingham City Hospital, Nottingham NG5 1PB,* **Dr Ivan Le Jeune** *is Consultant Acute Physician and* **Dr Mark Simmonds** *is Consultant in Acute and Critical Care Medicine, Queens Medical Centre, Nottingham,* **Mr Jeetesh Patel** *is Medical Student in the University of Nottingham Medical School, Queens Medical Centre, Nottingham and* **Dr Michael D Sosin** *is Consultant Cardiologist, Trent Cardiac Centre, Nottingham City Hospital, Nottingham*

*Correspondence to: Dr N Ali (nadineali@doctors.org.uk)*

healthy people will have troponin levels that would be considered 'positive'.

A new generation of high sensitivity troponin T assays has been developed and is currently in use in many UK centres. These newer assays are able to detect very low levels of circulating troponin with detection rates of up to 95% in a reference healthy population (Vafaie et al, 2013). In clinical practice this enables detection of myocardial cell injury earlier than with conventional assays. The National Institute for Health and Care Excellence (2014) has approved two high sensitivity troponin assays to exclude acute coronary syndrome in the emergency department. Centres throughout the UK may use different assays.

**Table 2. Troponin measurement**

| |
|---|
| Antibody assays are used to detect cardiac troponin in bloodstream |
| Antibody assays by different manufacturers have different sensitivity and specificity |
| A standard troponin test is considered positive if the level is above the 99th percentile of a sample healthy population |
| High sensitivity troponin assays can detect the protein in 95% of a healthy population sample |

## Troponin kinetics

Following a myocardial infarction, standard troponin tests become positive within 4–9 hours, the level peaks at 12–24 hours and remains elevated for up to 14 days. As noted above, high sensitivity troponin assays become positive more quickly. Three hours after the onset of symptoms, approximately 40% of patients with an acute coronary syndrome will have a positive standard troponin test, but close to 100% will have a positive high sensitivity troponin assay. Other mechanisms of myocardial injury are associated with different troponin release patterns as illustrated in *Figure 2*.

If multiple troponin tests are taken, then the area under the troponin curve can be used as a measurement of the magnitude of myocardial damage. Patients presenting with acute ST elevation myocardial infarction who are successfully reperfused show a smaller area under the troponin release curve than patients who are not reperfused, although their peak troponin level may actually be higher (*Figure 3*). A single troponin measurement cannot therefore reliably indicate the amount of cell damage.

## Timing of troponin testing

Protocols for troponin testing in patients with suspected acute coronary syndrome vary between hospitals and depend upon the assay available locally. With standard troponin assays, a baseline troponin level should be taken at the time of admission, and if this is negative or comorbidity is present (see below), a second test should be performed 10–12 hours after the onset of symptoms.

With high sensitivity troponin assays the repeat sample can be obtained earlier, at 3–6 hours from symptom onset. A positive result is considered present if the admission troponin level is below the upper reference limit of the assay, and the repeat level is both above the upper reference limit and there is a 50% or greater rise between the two. If the admission level is already above the upper reference limit, then a positive result is present if there is a 20% or greater rise in the level between the two samples.

***Figure 2. Troponin release kinetics. a. Major myocardial injury. b. Minor myocardial injury. c. Myocarditis.***

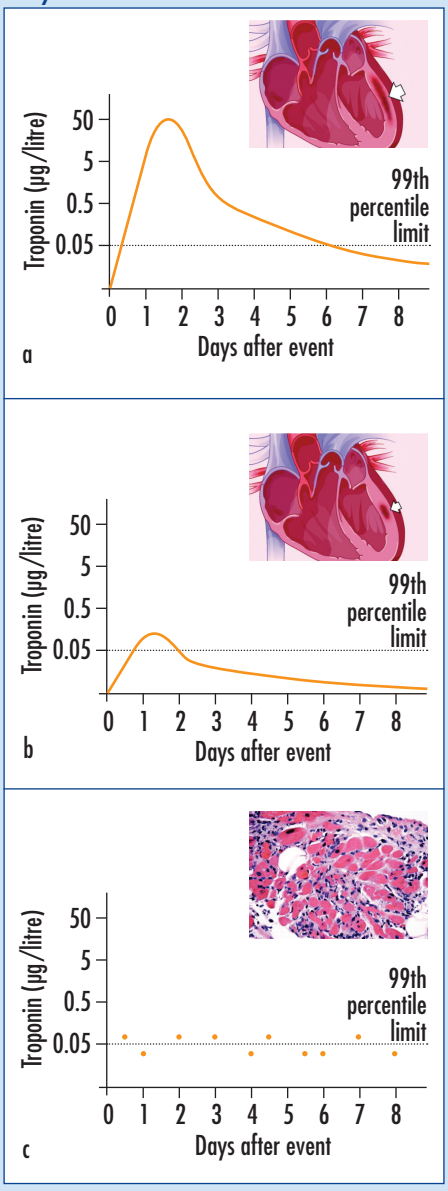
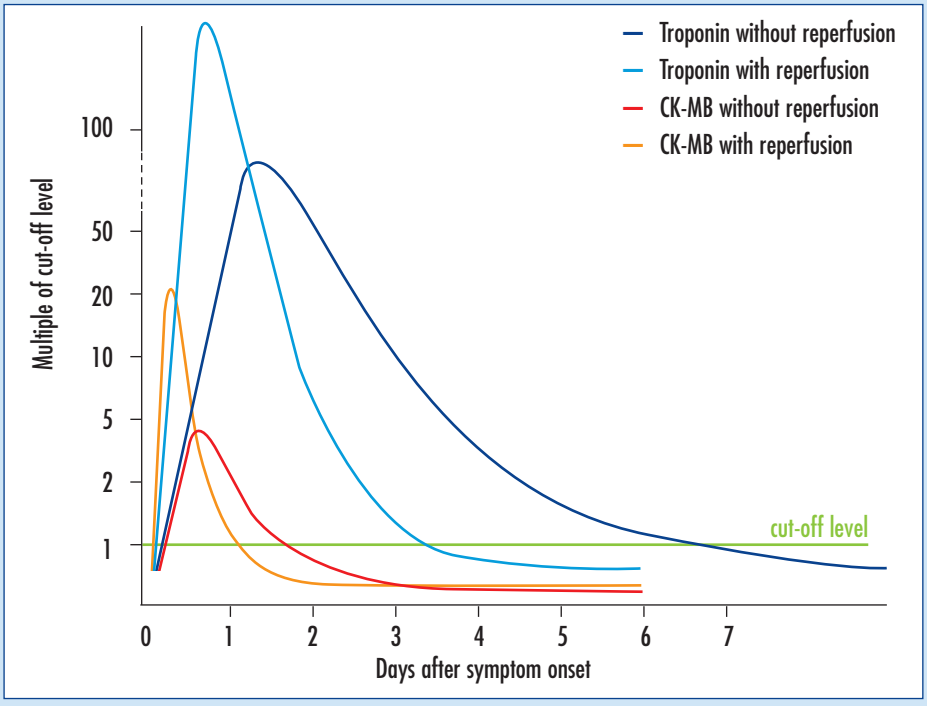



***Figure 3. Troponin release in ST elevation myocardial infarction, with and without reperfusion.***



## Use of troponin test results in patients with chest pain

It is important to note that the vast majority of patients presenting with chest pain do not have an acute coronary syndrome. A retrospective cohort study (Christenson et al, 2004) examined over 8000 patients presenting with non-traumatic chest pain. Only 10% of these patients were found to have a myocardial infarction and only 22% had unstable or stable angina. No cardiac ischaemia or serious cause of chest pain was found in 30% of patients.

Acute coronary syndrome is an umbrella term describing a spectrum of clinical presentations that share the same underlying cause – an unstable coronary plaque. Clinical presentation depends upon the duration and degree of occlusion of the affected vessel, and includes unstable angina, non-ST elevation and ST elevation myocardial infarction. Diagnosis of acute coronary syndrome is based on a suggestive history plus or minus appropriate electrocardiogram changes or imaging evidence of ischaemia. The troponin result separately determines whether myocardial infarction has or has not occurred – a negative troponin does not exclude acute coronary syndrome.

A positive troponin, as noted above, is a specific marker of myocardial cell damage, i.e. myocardial infarction. However, not all myocardial infarction is caused by the same mechanism (*Figure 4*). *Table 3* lists the five types of myocardial infarction (Thygesen et al, 2007). Clinical trials showing the benefit of medications such as low molecular weight heparin (Anon, 1996) and dual antiplatelet agents (Steinhubl et al, 2002) only recruited patients with myocardial infarction caused by coronary artery plaque rupture (type 1 myocardial infarction). In patients with other types of myocardial infarction, these treatments may be harmful. For example in type 2 myocardial infarction caused by severe anaemia the management will be quite different. In addition, patients with unstable angina will benefit from acute coronary syndrome treatment and may be at high risk of mortality, and yet whose troponin is by definition negative. From this it is clear that relying on troponin results alone to decide who to treat – or not treat – for acute coronary syndrome is incorrect.

Instead, the value of troponin results lies in risk stratification. Several scoring systems (such as the GRACE score) can be used to predict the risk of death and morbidity following an acute coronary syndrome (Henderson, 2013). Scoring incorporates several variables including troponin, age, renal function, left ventricular failure and electrocardiogram changes. High and medium risk patients are likely to benefit from an early invasive strategy with a view to percutaneous or surgical revascularization, whereas low risk patients (which will include some patients with positive troponin results) can be managed with an initial conservative strategy.

In patients who present with chest pain less than 14 days after a myocardial infarction or revascularization procedure the baseline troponin level may remain elevated from the original myocardial infarction, and so paired samples are required and again a rise of >20% is considered positive.

## What other conditions can cause a positive troponin?

Any condition that results in myocardial damage will cause a rise in serum troponin levels, not just ischaemia (Newby et al, 2012) (*Table 4*). A single elevated troponin level, no matter how high, can be caused by any of the conditions listed in *Table 4*. This highlights the danger in using troponin as a screening test for acute coronary syndrome, as a positive level may broaden rather than narrow down the differential diagnosis. In patients with one or more of these conditions, a raised troponin level (or even a rise between paired samples) does not necessarily indicate that acute coronary syndrome treatment is beneficial. Trials interventions such as low molecular weight

***Figure 4. The mechanism of type 1 and type 2 myocardial infarction.***

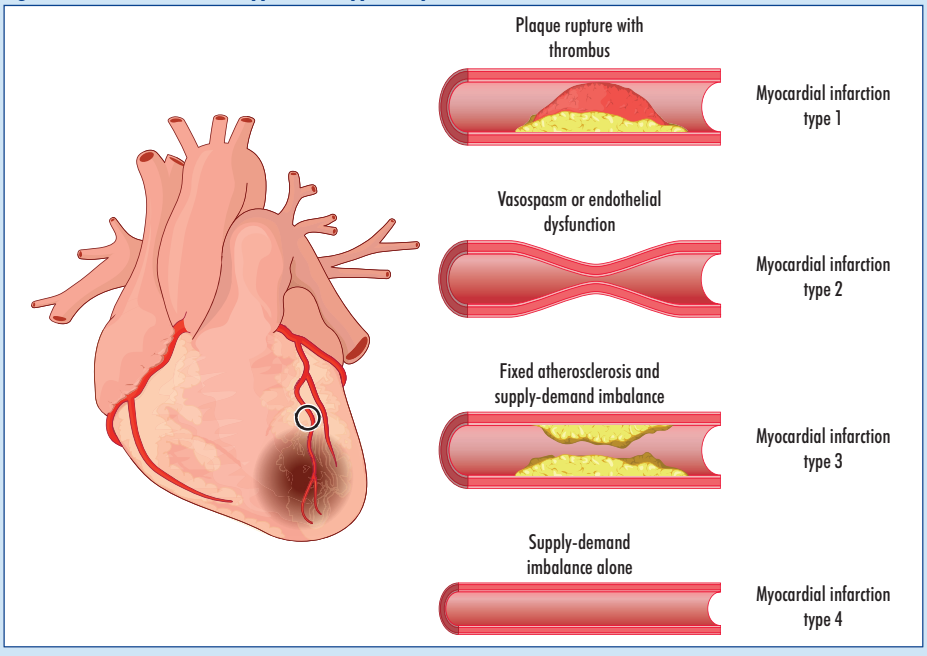



**Table 3. The five types of myocardial infarction and their mechanism**

| Type | Mechanism |
|---|---|
| 1 | Spontaneous myocardial infarction caused by coronary artery disease such as atherosclerotic plaque rupture |
| 2 | Infarction caused by myocardial ischaemia as a result of an imbalance between oxygen supply/demand to the cardiac muscle. Examples include coronary spasm, arrhythmia, anaemia and hypotension. Treatment should address the underlying cause |
| 3 | Myocardial infarction suspected to be the cause of sudden death |
| 4 | Myocardial infarction associated with percutaneous coronary intervention or stent thrombosis |
| 5 | Myocardial infarction associated with coronary artery bypass grafting |

heparin, fondaparinux, antiplatelet agents and revascularization routinely excluded patients with any significant comorbidity, so even if acute coronary syndrome is present it is far from clear that these treatments will be beneficial.

## How should a raised troponin level be interpreted in patients with heart failure?

Patients with acute and chronic heart failure may have raised troponin levels whether or not they have underlying coronary disease (Kociol et al, 2010). The mechanism of troponin release in heart failure is not fully understood. Current thinking is that troponin release in heart failure results from a combination of myocardial cell injury and increased permeability of myocardial cells (Newby et al, 2012).

**Table 4. Conditions other than acute coronary syndrome that lead to troponin elevations**

| | |
|---|---|
| Cardiac | Heart failure |
| | Cardiomyopathies |
| | Arrhythmia |
| | Endocarditis |
| | Cardiac tumours |
| | Aortic dissection |
| | Post cardiac transplantation |
| | Post cardiac surgery |
| Pulmonary | Pulmonary embolism |
| | Chronic obstructive pulmonary disease exacerbation |
| Haematological | Primary amyloid |
| | Primary haematological conditions |
| Other | Sepsis |
| | Severe metabolic conditions, e.g. diabetic ketoacidosis |
| | Chronic kidney disease |
| | Rhabdomyolysis |
| | Autoimmune and connective tissue disease |
| | Subarachnoid haemorrhage |
| | Post non-cardiac surgery |
| | Thermal injury |
| | Toxin induced |
| | Strenuous exertion, e.g. marathon runners |

An elevated troponin level in the context of heart failure indicates a worse prognosis as demonstrated in the ADHERE study where heart failure patients with an elevated troponin level had a higher in-hospital mortality rate (Peacock et al, 2008). Routine measurement of troponin in these patients offers no diagnostic benefit or management guidance. Troponin should only be measured if acute coronary syndrome is suspected to be the underlying cause of heart failure. A careful history of symptoms onset, preceding chest pain, serial electrocardiogram and comparison with old electrocardiograms may help to unveil a diagnosis of acute coronary syndrome.

In patients presenting with acute decompensation of heart failure, acute coronary syndrome is only one of a number of possible causes. If the patient is known to have heart failure as a result of non-ischaemic causes, an acute coronary syndrome is very unlikely to be the cause of an episode of decompensation.

## How should a raised troponin level be interpreted in patients with renal impairment?

Chronic kidney disease and dialysis patients present a diagnostic and therapeutic challenge with regards to acute coronary syndrome. These patients are at risk of coronary disease and carry a worse prognosis from myocardial infarction (Sarnak et al, 2003). They often present with atypical symptoms, interpretation of troponin levels is complicated and therapeutic options must be carefully considered.

With regards to troponin, chronically raised levels are commonly found in patients with moderate–severe renal impairment and those on dialysis. Although the evidence is not conclusive a baseline elevation of cardiac troponin in these patients is thought to be caused by reduced renal clearance. The pathophysiology is unclear as troponin molecules are too large to be filtered by the kidneys. Troponin T is broken down into smaller fragments that may be filtered by the kidneys (Diris et al, 2004).

Focusing on history, clinical and electrocardiography findings suggestive of acute coronary syndrome is reiterated. Troponin should only be requested when acute coronary syndrome is suspected, and serial measurements are likely to be needed.

## How should a raised troponin level be interpreted in critical care patients?

Diagnosis of myocardial infarction in patients in a critical care setting is especially challenging. Sedation makes it difficult to gain a history, subtle electrocardiography changes may be missed and inotropic support among other things makes it difficult to use imaging techniques to assess ischaemia. Elevated cardiac troponin levels are commonly found in patients on the intensive care unit irrespective of their diagnosis. Studies in unselected patients in a critical care setting have shown that as many as 43% have a positive troponin test (Lim et al, 2006). A large proportion of such elevations are caused by sepsis, pulmonary embolism, atrial fibrillation and renal failure, whereas myocardial infarction accounts for only around 30% (Hamilton et al, 2012). As a result, a single elevated troponin level is of little diagnostic utility in this patient group, and even a rise in troponin on serial testing can be difficult to interpret in the context of severe coexisting illness. Additional tests such as serial electrocardiography and in some cases echocardiography may be helpful.

The presence of an elevated troponin level in a critical care patient indicates an adverse prognosis. A meta-analysis by Lim et al (2006) showed increased risk of death, longer stay in the intensive care unit and increased length of hospital stay in patients with elevated troponin levels. However, troponin measurement in critical care patients to assess prognosis is not routine practice at the present time.

## How should a troponin elevation be interpreted in patients post-surgery?

Surgical procedures can lead to myocardial injury through a variety of mechanisms; haemodynamic changes, coronary plaque rupture or arrhythmia to name but a few. Troponin rise can result from any of these mechanisms and is associated with a worse prognosis (Vascular Events In Noncardiac Surgery Patients Cohort Evaluation (VISION) Study Investigators et al, 2012).

This group of patients is often asymptomatic and electrocardiography changes may be non-specific, making it very difficult to identify the cause of troponin release. When troponin rise is thought to

be caused by coronary plaque rupture (type 1 myocardial infarction), the risk of postoperative bleeding on dual antiplatelet therapy must be carefully considered.

It is very important to be clear why the test is being requested and how the result will change management. Troponin should not be used to screen postoperative patients for acute coronary syndrome in the absence of symptoms or electrocardiography changes.

## Syncope

Syncope forms 3% of presentations to the emergency department and 6% of medical admissions. Most cases are caused by benign pathology. Sinister cardiac causes such as arrhythmia, severe aortic stenosis and acute coronary syndrome are rare (Lindner et al, 2013). Indeed it is very unusual for patients with acute coronary syndrome to present with syncope.

A retrospective study looked at 121 patients who presented to the emergency department with syncope and had a cardiac troponin measurement requested on presentation (Lindner et al, 2013). Around 42% had a raised troponin level with seven patients showing a dynamic change. Three patients underwent diagnostic coronary angiography, all three were normal. After investigation, none of the 121 patients were found to have any evidence of coronary disease.

The use of troponin as a screening tool for acute coronary syndrome in patients presenting with syncope is not uncommon but yields no diagnostic benefit (since several other conditions which may present with syncope, such as pulmonary embolism, are also associated with elevated troponin levels) and may delay the real diagnosis. Without a history suggestive of acute coronary syndrome treating such patients with antiplatelet therapy may cause harm by unnecessarily increasing bleeding risk.

## Arrhythmia

Tachyarrhythmias commonly encountered in clinical practice such as atrial fibrillation and ventricular tachycardia can cause a troponin rise in the absence of underlying coronary disease or haemodynamic compromise (type 2 myocardial infarction) (Kanjwal et al, 2008), particularly if prolonged. In this group of patients, a positive troponin alone should not be considered sufficient evidence to treat the patient for acute coronary syndrome, and if the history and electrocardiogram do not support a diagnosis of acute coronary syndrome troponin testing is unlikely to be helpful.

## Other novel cardiac markers

There are other biomarkers that may be helpful in assessing patients with acute coronary syndrome. At present, they are not used in routine clinical practice in the UK.

A detailed description of these biomarkers is beyond the scope of this article, but three examples are mentioned. Myeloperoxidase is a protein secreted by neutrophils after their activation. Elevations in myeloperoxidase have been associated with worse prognosis in patients with acute coronary syndrome (Baldus et al, 2003). Elevated myeloperoxidase levels have also been associated with elevated cardiac risk.

The second example is heart type fatty acid binding protein. This protein is found in myocardial cells, and it is involved in the uptake and buffering of free fatty acids. Elevations in this biomarker are associated with higher rates of re-infarction and death in patients with acute coronary syndrome (Viswanathan et al, 2010).

The third biomarker, called ischaemia modified albumin, is a biomarker specific for ischaemia. In patients with acute coronary syndrome elevated levels are associated with higher mortality (Van Belle et al, 2010).

In the future these novel biomarkers may be used in combination with cardiac troponin to assess prognosis in patients with acute coronary syndrome.

## Conclusions

The availability of troponin assays has undoubtedly reduced the number of patients with a missed diagnosis of cardiac ischaemia. Troponin levels can provide important prognostic information in patients with myocardial infarction, but should be used as part of a risk score, such as the GRACE score. While a positive troponin test reflects myocardial injury, it gives no clue to the underlying mechanism, and is not enough alone to diagnose an acute coronary syndrome. The majority of patients presenting to hospital with chest pain do not turn out to have an acute coronary syndrome. A wide variety of conditions can cause myocardial injury and troponin release, and while some of these conditions present with clinical features which make confusion with myocardial infarction unlikely, others such as pulmonary embolus or aortic dissection can have similar symptoms.

With the advent of high sensitivity assays, damage to just a few myocardial cells is enough to result in a positive test. While this reduces the chance of missing a small myocardial infarction, it also increases the chance of finding a positive result in a patient who does not have myocardial infarction.

Relying on troponin alone to determine when to treat for acute coronary syndrome is incorrect and may result in other important diagnoses being missed. This is particularly true in patients with conditions associated with baseline troponin elevation, such as heart failure and renal failure. Troponin results must always be interpreted in light of the patient's symptoms, electrocardiogram and past medical history, never alone (*Figure 5*). BJHM

### KEY POINTS

- Elevated levels of cardiac troponin are caused by a wide range of cardiac and non-cardiac conditions, not just ischaemia.
- Only a minority of patients presenting with chest pain will have a final diagnosis of acute coronary syndrome. Approximately a third will have no evidence of any serious underlying cause of pain. Troponin should only be requested when acute coronary syndrome is suspected.
- Acute coronary syndrome should never be diagnosed on the basis of an elevated troponin level alone.
- Conversely, do not exclude a cardiac cause just because of a negative troponin result.
- Novel biomarkers may be used in future to assess prognosis after acute coronary syndrome.

*Conflict of interest: none.*


Adams JE, Bodor GS, Dávila-Román VG, Delmez JA, Apple FS, Ladenson JH, Jaffe AS (1993) Cardiac troponin I. A marker with high specificity for cardiac injury. *Circulation* **88**(1): 101–6

Anon (1996) Low-molecular-weight heparin during instability in coronary artery disease, Fragmin during Instability in Coronary Artery Disease (FRISC) study group. *Lancet* **347**(9001): 561–8

Baldus S, Heeschen C, Meinertz T et al (2003) Myeloperoxidase serum levels predict risk in patients with acute coronary syndromes. *Circulation* **108**(12): 1440–5 (doi: 10.1161/01.CIR.0000090690.67322.51)

Christenson J, Innes G, McKnight D et al (2004) Safety and efficiency of emergency department assessment of chest discomfort. *CMAJ* **170**(12): 1803–7

Diris JHC, Hackeng CM, Kooman JP, Pinto YM, Hermens WT, van Dieijen-Visser MP (2004) Impaired renal clearance explains elevated troponin T fragments in hemodialysis patients. *Circulation* **109**(1): 23–5 (doi: 10.1161/01.CIR.0000109483.45211.8F)

Ebashi S (1963) Third Component Participating in the Super precipitation of "Natural Actomyosin." *Nature* **200**(4910): 1010 (doi: 10.1038/2001010a0)

Hamilton MA, Toner, A, Cecconi M (2012) Troponin in critically ill patients. *Minerva Anestesiologica* **78**(9): 1039–45

Henderson RA (2013) Acute coronary syndrome: optimising management through risk assessment. *Clin Med* **13**(6): 602–6 (doi: 10.7861/clinmedicine.13-6-602)

Kanjwal K, Imran N, Grubb B, Kanjwal Y (2008) Troponin elevation in patients with various tachycardias and normal epicardial coronaries. *Indian Pacing Electrophysiol J* **8**(3): 172–4

Kociol RD, Pang PS, Gheorghiade M, Fonarow GC, O'Connor CM, Felker GM (2010) Troponin elevation in heart failure prevalence, mechanisms, and clinical implications. *J Am Coll Cardiol* **56**(14): 1071–8 (doi: 10.1016/j.jacc.2010.06.016)

Lim W, Qushmaq I, Devereaux PJ et al (2006) Elevated cardiac troponin measurements in critically ill patients. *Arch Intern Med* **166**(22): 2446–54 (doi: 10.1001/archinte.166.22.2446)

Lindner G, Pfortmueller CA, Funk G-C, Leichtle AB, Fiedler GM, Exadaktylos AK (2013) High-sensitive troponin measurement in emergency department patients presenting with syncope: a retrospective analysis. *PloS One* **8**(6): e66470 (doi: 10.1371/journal.pone.0066470)

National Institute for Health and Care Excellence (2014) Myocardial infarction (acute): Early rule out using high-sensitivity troponin tests (Elecsys Troponin T high-sensitive, ARCHITECT STAT High Sensitive Troponin-I and AccuTnI+3 assays). www.nice.org.uk/guidance/dg15 (accessed 8 December 2014)

Newby LK, Jesse RL, Babb JD et al (2012) ACCF 2012 Expert Consensus Document on Practical Clinical Considerations in the Interpretation of Troponin Elevations. A Report of the American College of Cardiology Foundation Task Force on Clinical Expert Consensus Documents. *J Am Coll Cardiol* **60**(23): 2427–63 (doi: 10.1016/j.jacc.2012.08.969)

Peacock WF, De Marco T, Fonarow GC et al, ADHERE Investigators (2008) Cardiac troponin and outcome in acute heart failure. *N Engl J Med* **358**(20): 2117–26 (doi: 10.1056/NEJMoa0706824)

Sarnak MJ, Levey AS, Schoolwerth AC et al (2003) Kidney disease as a risk factor for development of cardiovascular disease. A Statement from the American Heart Association Councils on Kidney in Cardiovascular Disease, High Blood Pressure Research, Clinical Cardiology, and Epidemiology and Prevention. *Circulation* **108**(17): 2154–69 (doi: 10.1161/01.CIR.0000095676.90936.80)

Steinhubl SR, Berger PB, Mann JT et al, CREDO Investigators (2002) Early and sustained dual oral antiplatelet therapy following percutaneous coronary intervention: a randomized controlled trial. *JAMA* **288**(19): 2411–20

Thygesen K, Alpert JS, White HD; Joint ESC/ACCF/AHA/WHF Task Force for the Redefinition of Myocardial Infarction (2007) Universal definition of myocardial infarction. *Eur Heart J* **28**(20): 2525–38 (doi: 10.1093/eurheartj/ehm355)

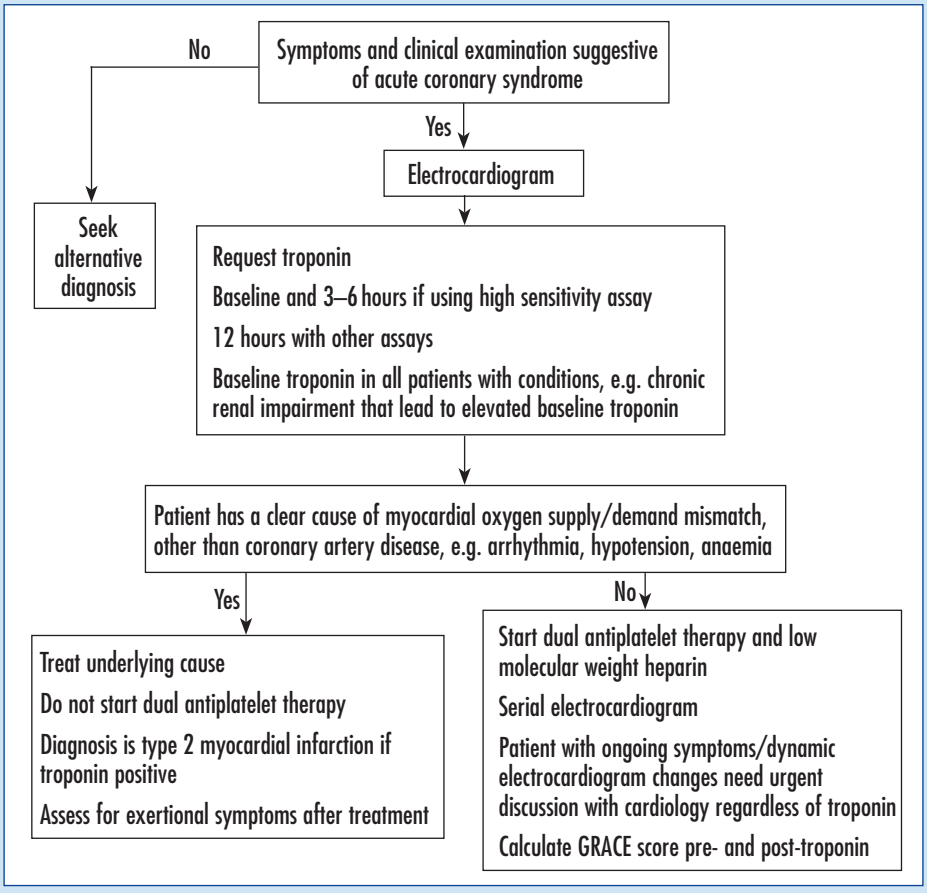
Vafaie M, Biener M, Mueller M et al (2013) Analytically false or true positive elevations of high sensitivity cardiac troponin: a systematic approach. *Heart* **100**(6): 508–14 (doi: 10.1136/heartjnl-2012-303202)

Van Belle E, Dallongeville J, Vicaut E, Degrandsart A, Baulac C, Montalescot G (2010) Ischemia-modified albumin levels predict long-term outcome in patients with acute myocardial infarction. The French Nationwide OPERA study. *Am Heart J* **159**(4): 570–6 (doi: 10.1016/j.ahj.2009.12.026)

Vascular Events In Noncardiac Surgery Patients Cohort Evaluation (VISION) Study Investigators, Devereaux PJ, Chan MTV, Alonso-Coello P et al (2012) Association between postoperative troponin levels and 30-day mortality among patients undergoing noncardiac surgery. *JAMA* **307**(21): 2295–304 (doi: 10.1001/jama.2012.5502)

Viswanathan K, Kilcullen N, Morrel C et al (2010) Heart-type fatty acid-binding protein predicts long-term mortality and re-infarction in consecutive patients with suspected acute coronary syndrome who are troponin-negative. *J Am Coll Cardiol* **55**(23): 2590–8 (doi: 10.1016/j.jacc.2009.12.062)


***Figure 5. Suggested flowchart for requesting and interpreting results.***




## TOP TIPS

- Establish the onset of symptoms and any exertional element.
- Gain a clear history of the patient's usual exercise tolerance.
- Symptoms of acute coronary syndrome can be typical (cardiac sounding chest pain) or atypical (shortness of breath, epigastric or back pain, uncontrolled blood glucose in patients with diabetes).
- Ask about any past history of angina or acute coronary syndromes.
- Establish and clearly document risk factors of atherosclerosis (smoking, diabetes, cholesterol, family history and hypertension).