“In the wake of Harrison’s success with H-4, legions of watch makers took up the special calling of maritime time keeping. It became a boom industry in a maritime nation. Indeed, some modern horologists claim that Harrison’s work facilitated England’s mastery over the oceans, and thereby led to the creation of the British Empire, for it was by dint of the chronometer that Britannia ruled the waves.

…With his marine clocks, John Harrison tested the waters of space-time. He succeeded, against all odds, in using the fourth, temporal, dimension to link points on the three-dimensional globe. He wrested the world’s whereabouts from the stars, and locked the secret in a pocket watch.”

Dava Sobel, “Longitude”
One of the greatest scientific dilemmas of the 18th century was the “Longitude problem”, the ability to accurately determine the longitude whilst at sea. Thousands of lives and the increasing fortunes of a rapidly expanding British empire, hung on a resolution to this problem. In 1714 the English parliament offered the staggering sum of 20,000 pounds to anyone who could solve it. The scientific establishment from Galileo to Newton had mapped the heavens in both hemispheres in pursuit of a “celestial” answer without any real success.

John Harrison, a self taught Horological genius, approached the problem from a different angle, he saw it as a matter of “timing”. He developed a series of ever more accurate time pieces, H1, H2, H3 and finally H4 - the first accurate and portable maritime chronometer, essentially the world’s first modern watch, which would provide the precise time at sea and in so doing provided a means to accurately determine the longitude whilst at sea.

The key to the treatment of STEMs, like the Longitude problem is also one of timing. Rather than its accurate determination however, it is a matter of action within a prescribed time; the earlier the better, and like Harrison’s clock, lives will depend on this.
**ST SEGMENT ELEVATION MYOCARDIAL INFARCTION**

**Introduction**

These guidelines are based on the recommendations of the Acute Coronary Syndrome Guidelines Working Group ¹, ⁴

All patients who present with a suspected acute coronary syndrome must be assessed in the ED on an urgent (category 2) basis and have an ECG performed as soon as possible.

A “CODE STEMI” activation system (i.e. a system based approach to deliver timely intervention) should be in place in any hospital that has an acute percutaneous coronary intervention service.

**Terminology**

```
   ACS
     \   /  \\
   STEMI  NSTEACS
         /  |
        NON-STEMI UNSTABLE ANGINA
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**ACS (Acute Coronary Syndrome)**

- Acute coronary syndrome is an all encompassing term that refers to ischemic chest pain.

**STEMI (S-T Segment Elevation Myocardial Infarction)**

- STEMI is defined as presentation with clinical symptoms consistent with an acute coronary syndrome together with S-T segment elevation on ECG
- New LBBB may be included in this sub-heading as the treatment approach is similar to STEMI.

**NSTEACS (non S-T Segment elevation acute coronary syndrome)**

- NSTEACS refers to any acute coronary syndrome which does not show S-T segment elevation.
- The ECG may show S-T segment depression or *transient* S-T segment elevation, but often will be normal

**Non-STEMI (Non S-T Segment Elevation Myocardial Infarction)**

- By definition this will be shown by an elevation of serum troponin levels in the absence of S-T segment elevation.
- Note that minor elevations of troponin may occur without a concomitant elevation of CK (or CKMB) levels. About a third of patients with elevated troponin, but normal CK and CK-MB
levels, will develop an adverse outcome. This scenario is sometimes referred to as “minor myocardial damage” in distinction to a “true” non-STEMI which shows elevation of both markers.

Unstable Angina

- Unstable angina is ischemic chest pain over and above the patient’s usual pattern and where the ECG remains normal, (apart from transient changes which then return to normal) and cardiac markers (CK and troponin) are not elevated. It is diagnosed on clinical therefore on grounds

The rest of these guidelines refer specifically to STEMI, (for patients with NSTEMI, see separate guidelines).

Clinical Assessment

After the diagnosis of STEMI is made on ECG a brief and directed history and examination needs to be done to then determine the best reperfusion strategy.

**Important points of history:**

1. History of the event:
   - When did the pain commence?
   - Establish the nature of pain (cardiac versus pleuritic) and its duration.

2. Allergies.
   - Ask specifically about aspirin.

3. Current medications, including:
   - Warfarin therapy or NOAC
   - Has aspirin or other anti-platelet agent been taken?

4. Past history:
   - This is vital for establishing any contra-indications to thrombolysis. The most important include history of stroke or active recent internal bleeding.
   - Have there been any previous coronary interventions or investigations?

**Important points of examination:**

This will not generally be helpful in establishing the diagnosis of STEMI

1. Assess any immediate ABC issues.

2. Vital signs
• Blood pressure is especially important with respect to the decision to thrombolyse.

3. Degree of patient anxiety/distress.


**Investigations**

**Blood tests**

1. FBE

2. U&Es/glucose

   • In particular check the potassium level.

3. CK (or CKMB):

   • This should be done as an initial baseline. It may then be used as a marker for possible subsequent re-infarction. Troponins are not useful for the diagnosis of early re-infarction as they may remain elevated for 5-14 days.

4. Cardiac troponin I:

   • Normal levels are considered to be < 0.04 micrograms/L, *(for conventional assays)*

   • Troponin I may persist for 5-14 days post infarction.

   • An initial troponin level should be done on all cases of suspected ACS with a second level done at 8-12 hours from the onset of the chest pain, when conventional troponin assays are being used.

   • Note that all troponin assays, regardless of their detection sensitivity do not rule out other ACS or stable coronary ischemia. Clinical management decisions should not be bases solely on troponin levels, but on thorough investigation and risk assessment that includes detailed clinical assessment, observation, repeated ECG tests, and where available functional testing.

**ECG**

All patients who present with a suspected acute coronary syndrome must have an ECG as soon as possible.

All ECGs must then be shown to an ED consultant or the ED registrar after hours.

The immediate decision pathway will then involve the ECG stratification of STEMI, from NSTEACS, (S-T segment depression or T wave changes or transient S-T segment elevation or no new changes).
**STEMI minimum criteria are as follows:**

**STEMI** is defined as presentation with clinical symptoms consistent with ACS with ECG features including any of:

- Persistent S-T elevation of > 2 small squares (2 mm) in 2 or more contiguous precordial leads.
- Persistent S-T elevation of > 1 small square (1 mm) in 2 or more contiguous limb leads.
- New LBBB, *(LBBB should be considered new unless there is evidence otherwise).*

Note that the minimal S-T changes can be difficult to interpret, especially in those with pre-existing CAD or other significant CVS disease. In such cases:

- Comparison with old ECGs will be useful.
- ECGs can be faxed to the cardiologist on call for interpretation and further discussion.
- In cases of LBBB urgent echocardiography may be useful, if readily available, to detect wall motion abnormalities (suggesting myocardial ischaemia) and hence assist in decision making.

**CXR**

- This should be done in all cases
- **It should not however be allowed to delay any treatment measures, especially reperfusion therapies.**
- Patients should be x-rayed in Resus cubes and not leave the department.
- Look for cardiomegaly, cardiac failure or other associated pathology.

**Echocardiography**

This is not a routine test in STEMI patients, but may be considered on an urgent basis in selected cases including:

- Confirmation of wall motion abnormalities when the diagnosis of ACS is unclear (pericarditis or myocarditis is being considered for example or in cases of LBBB)
- Patients who develop cardiogenic shock.
- Some cases of inferior infarction where evidence of right ventricular infarction is being sought.
- Some cases of ACS where secondary complications are suspected, such as cardiac tamponade or valvular disruption

**Coronary Angiography**

- This is the definitive investigation for any patient with a STEMI who is to undergo a PCI.
Management

**Initial management:**

1. **All patients must be triaged to a monitored resuscitation cube.**
2. IV access, and blood tests taken
3. Oxygen therapy:
   - This is not routinely required in ACS, unless there is evidence of hypoxia (SaO$_2$ < 93%) and/or shock.  
4. Pain relief:

**Morphine**

- Opioid analgesia is preferred to nitrates for the initial control of pain in the setting of STEMI.

- **IV morphine** boluses titrated to clinical effect: $^5$
  
  ♥ 2.5 to 5mg IV as an initial dose, then titrated to effect every 5 to 10 minutes with further incremental doses of 2.5 to 5mg IV.

  *In elderly patients or those with cardiorespiratory compromise, an initial morphine dose of less than 2.5mg IV and incremental doses of 0.5 to 1mg should be considered.*

  *If morphine is contraindicated, consider fentanyl at 25 to 50 micrograms IV as initial equivalent dose.*

- Anti-emetic as required:

  ♥ IV 10 mg metoclopramide
  
  *Or*
  
  ♥ IV 12.5 mg prochlorperazine

**GTN**

If required in the setting of a STEMI this should be given as an **IV infusion**, rather than topically or sublingually.

It will be indicated for

- Pain, not controlled by adequate doses of opioid analgesia.
• Acute severe hypertension
• Acute cardiogenic pulmonary edema associated with hypertension.

5. Anti-Platelet Therapy

This should be given as for high risk, NSTEACS patients.

• **Aspirin 300 mg.**
  
  ♥ Unless there is a genuine contra-indication such as allergy this should be given in all cases.

• **Ticagrelor,** loading dose, **180 mg.**
  
  ♥ Careful assessment of bleeding risk should be undertaken before using these agents.

  ♥ Avoid if emergency coronary artery bypass grafting is likely

6. Heparin and Clexane:

**With PCI:**

• **Heparin** (i.e. “unfractionated”) bolus dose of 5000 units should be given in cases of patients who are to receive PCI for their STEMI.

• The role of clexane in STEMI patients who are to receive PCI is less clear, but current guidelines suggest that this is safe at a reduced dose (0.75mg/kg SC)

**With fibrin-specific fibrinolysis:**

• **Heparin** bolus loading dose with the first fibrinolytic dose and then commence heparin infusion.

*Alternatively:*

• **Enoxaparin,** 30 mg IV bolus dose, followed by 1 mg/kg SC (or a reduced dose, 0.75mg/kg SC in the elderly or those with renal impairment) 12 hourly.

7. Glycoprotein IIb/IIIa Inhibitors

Agents available include:

• **Reopro,** *(abciximab)*

• **Integristin,** *(eptifibatide)*

• **Tirofiban,** *(aggrastat).*
The need for, and the specific agent to be used, will be determined by the treating cardiologist.

With PCI:

- A glycoprotein IIb/IIIa inhibitor may be ordered for patients who are to undergo primary PCI.

The known benefits of using these agents in the setting of an acute PCI, must be balanced against the risk of bleeding in each individual case.

With fibrin-specific fibrinolysis, (i.e tenecteplase or reteplase):

- A glycoprotein IIb/IIIa inhibitor should not be used in patients who undergo fibrinolysis therapy.

8. Bivalirudin:

**Bivalirudin** is a direct thrombin inhibitor.

Amongst patients with STEMI undergoing primary PCI, the use of bivalirudin can be considered as an alternative to heparin and GP IIb/IIIa inhibitors. 

**Reperfusion Strategy**

**Indications**

All patients who present within 12 hours of symptom onset of STEMI should be considered for a reperfusion strategy, unless they have severe co-morbidities.

Reperfusion is not routinely recommended in patients who present more than 12 hours after symptom onset. It may be considered however in selected cases:

- There are ongoing symptoms
- There is ongoing electrical and or hemodynamic (cardiogenic shock) instability.

*These cases should be discussed with the interventionist cardiologist.*

**Choice of Reperfusion Strategy**

The ideal treatment for all STEMIs is acute PCI or in some cases emergency CABGs

When this interventional treatment is not available or not feasible within an appropriate time frame, **thrombolysis** is the next best option, providing there are no absolute contra-indications to this therapy.

“Ideal” time frames have been described to guide decision making between these two options, as described in the table below:
PCI / CABGs

Any patient identified as having a STEMI should prompt activation of a “CODE STEMI” response

Note that “on site” cardiac surgical backup is not considered essential for a PCI intervention.

Whilst on site cardiac surgical backup is not essential, networks of urgent referral nonetheless need to be in place.

CAGS is considered in cases of:

- Failed PCI, (ongoing symptoms/ instability)
- Some complications following PCI.
- Suitable coronary vessel anatomy discovered on angiography, not readily amenable to PCI

Thrombolysis

There are 4 fibrinolytic agents currently available in Australia. The older streptokinase (SK, as an infusion) and the three newer fibrin-specific agents, reteplase (single dose), alteplase (tPA, as an infusion) and tenecteplase, (single dose)

SK has a number of serious disadvantages:

- Anaphylaxis, as it is a protein derivative derived from bacterial sources. Aboriginal and Torres Straight Islanders are more prone to this, possibly as a result of a relatively high incidence of previous sensitizing streptococcal infection.
• Previous use of SK precludes further use in the future, not only because of the risk of allergic reaction but also due to the development of neutralizing antibody decreasing subsequent effectiveness.

• It must be given as an infusion, (as opposed to bolus dosing for reteplase and tenecteplase)

The fibrin-specific agents reduce mortality to a greater degree than SK when used within 6 hours. Note that whilst SK may be associated with a lower incidence of intra-cranial hemorrhage, especially in older people, the overall mortality is still lower with the use of the fibrin-specific agents.

**The fibrin specific agents are therefore the preferred agents.**

**Further considerations:**

• If there are *absolute* contra-indications to thrombolysis, then the case needs to be discussed urgently with the cardiologist on call. and arrangements made for a possible PCI.

• If there are *relative* contra-indications to thrombolysis, treatment is more problematic and the potential risks must be weighed against the potential benefit on an individual basis. If there is any doubt about this, the on call cardiologist should be contacted.

• If the patient is hypertensive (>180/110), then a GTN infusion may be commenced to bring the blood pressure below this level, before giving thrombolysis.

• Patients with *minor* infarctions (especially inferior) and *severe co-morbidities*, especially if they also have risk factors for intra-cranial haemorrhage, (age over 75 years, female, smaller sized patients, prior stroke of any type, SP > 160 mmHg) should not be thrombolysed. These patients are best treated with either PCI or conservatively with aspirin and clexane.

**Failed Thrombolysis**

This can only be judged definitively by coronary angiography.

Clinical indications that that reperfusion has been unsuccessful include:

• Failure of the relief of ischemic chest pain.

• Failure of the restoration of hemodynamic / electrical stability.

• Failure of resolution of S-T segment elevation.

In the “REACT” trial this was defined as:

At 90 minutes after the initiation of thrombolytic therapy, the electrocardiogram shows less than 50% resolution of the ST segment in the lead that showed the greatest ST-segment elevation measured from the baseline, (ie the isoelectric line) at the initiation of thrombolysis.
Rescue PCI

If thrombolysis is not successful, then “rescue PCI” is a better option than second doses of thrombolysis or conservative management. 3

PCI should be considered in:

1. Patients who have had thrombolysis, regardless of the success or otherwise of pharmacologic reperfusion. 4
2. Patients who have evidence of re-infarction.
3. Patients who develop cardiogenic shock.
   - Whilst thrombolysis is not contra-indicated in cardiogenic shock it has not been shown to ultimately improve outcomes. PCI/ emergency CABGs is the best option in cases of cardiogenic shock.

Disposition

All STEMIs should be identified in a timely manner, and CODE STEMI procedures immediately activated according to local hospital practice. Patients are admitted to CCU following percutaneous intervention.

Occasionally some patients will be identified following coronary angiography, that will require transfer to a centre for Cardiac Bypass Graft Surgery.

Once the decision has been made to thrombolyse, this should be done in the ED as soon as possible. Once the patient has been thrombolysed and is stable they should be admitted to CCU.
References


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