# Procedural Guideline

## Continuous ST Monitoring in Intensive care Unit (ICU)

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| **Document No:** | CRG_PG2015_9094 |
| **Functional Sub-Group:** | Clinical Governance |
| **Summary:** | This procedural guideline describes how to establish and maintain ST segment ECG monitoring for all patients admitted to the Intensive Care Unit at CRGH |
| **Approved by:** | Clinical Policy Committee |
| **Consultation:** | Nursing Policy & Practice Committee<br>Intensive Care. |
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**Note:**
Sydney Local Health District (SLHD) was established on 1 July 2011 following amendments to the Health Services Act 1997 which included renaming the former Sydney Local Health Network (SLHN). The former SLHN was established 1 January 2011, with the dissolution of the former Sydney South West Area Health Service (SSWAHS).

**Content:**

# Continuous ST Monitoring in ICU

## 1. Introduction

Patients in the Intensive Care unit are particularly at risk of myocardial ischaemia as issues related to myocardial oxygen demand versus supply are seen in this group. The physiological stress of critical illness create increased metabolic demands, which in conjunction with haemodynamic instability and respiratory insufficiency may trigger myocardial ischaemia.

Up to 90%[4] of all episodes of myocardial ischaemia are clinically silent (SMI). If undetected and untreated, prolonged SMI may lead to myocardial infarction. Additionally in one prospective study of patients at elevated risk of cardiac ischaemia, 21% of patients were demonstrated to have changes consistent with ischaemia on 12 lead monitoring[9].

Reliance on routine continuous ECG monitoring, intermittent 12 lead ECGs, observation of the patient and patient self reporting collectively are only 3% effective in detecting SMI[4]. Continuous ST monitoring however facilitates early detection of ischaemia and can help in the institution of timely therapeutic intervention.

### The risks addressed by this Procedural Guideline:

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| Clinical Risks: Unrecognised silent myocardial ischaemia in critically ill patients. Consequential clinical deterioration the Intensive Care Unit. |

### The aims / expected outcome of this Procedural Guideline:

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| To provide uniformity and accuracy in how continuous ST monitoring is established and maintained for all patients in the Intensive Care Unit to facilitate early detection and treatment of silent myocardial ischaemia. |

## 2. Procedural Guideline Statement

In the cardiac cycle the ST segment represents the phase between the ventricular depolarisation and repolarisation and is usually isoelectric and slightly slanted upwards. When coronary blood flow is inadequate to support the oxygen needs of the myocardium, myocardial ischaemia occurs.

Even with relatively short periods of ischaemia, electrophysiological changes occur resulting in cellular depolarisation. The ischaemic tissue cannot maintain its membrane potential resulting in injury currents flowing from the depolarised ischaemic regions to normal myocardial tissue. This is seen by displacement of the ST segment: downwards in subendocardial injury and upwards in subepicardial or transmural injury. The larger the ischaemic area, the greater this deviation.

## Pathophysiology of ST depression and elevation

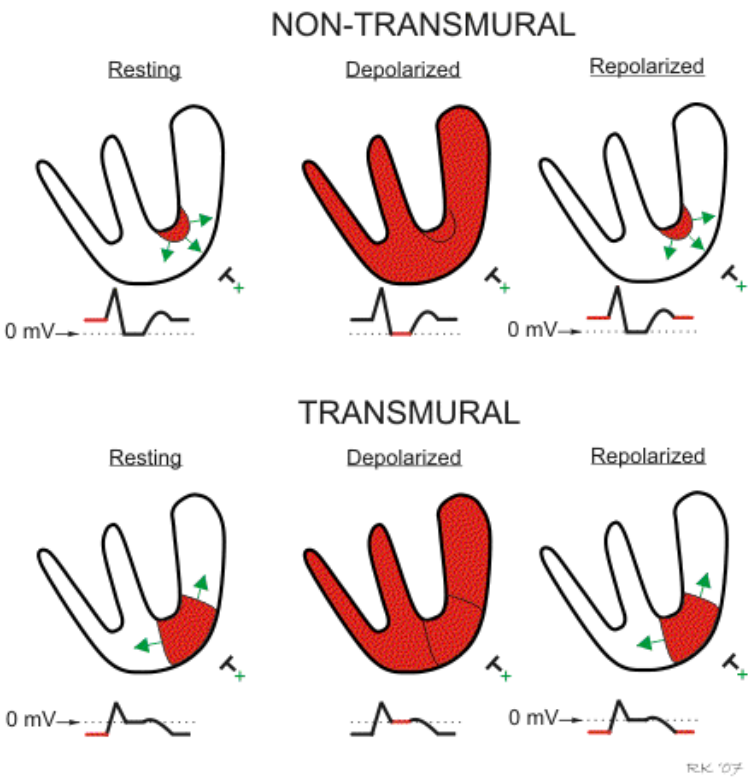



Figure 1

http://www.cvphysiology.com/CAD/CAD012.htm

For non-transmural or sub endocardial ischaemia, ST segment depression occurs because when the ventricle is at rest, the depolarised, ischaemic region generates electrical currents that are recorded by an overlying electrode. If the depolarising currents are traveling toward the positive electrode, the baseline voltage prior to the QRS complex (which is normally isoelectric - i.e., zero volts) will be elevated. In contrast, when the ventricle becomes depolarised, all the muscle is depolarised so that zero voltage is recorded by the electrode as usual. Therefore, the net effect of the elevated baseline voltage is that the ST segment appears to be depressed relative to the baseline.

For transmural or sub epicardial ischaemia, ST segment elevation occurs because when the ventricle is at rest, the depolarised, ischaemic region generates electrical currents that are traveling away from the positive electrode; therefore the baseline voltage prior to the QRS complex will be depressed. When the ventricle becomes depolarised, all the muscle is depolarised so that zero voltage is recorded by the electrode. Therefore, the net effect of the depressed baseline voltage is that the ST segment *appears* to be elevated relative to the baseline. ST depression may also occur as a reciprocal change in the leads opposite an area of ischaemia as a mirror image of the ischaemia.

## How the ST segment is analysed

The ST segment begins at the J Point where the QRS waveform ends. The ST segment is then analysed 60 or 80 milliseconds from the J point to assess for ST elevation or depression. This location is known as the ST point. A point on the isoelectric line, prior to the QRS complex, acts as the baseline reference point for ST segment deviation, this is known as the isoelectric point –the *ISO point*. For accurate ST monitoring it is important that these points are correctly placed. Once the patient is connected to the ECG monitor and ST analysis is activated, these reference points are automatically determined by the monitor. The reference points however should be checked at the beginning of each shift to ensure that they are correctly placed, manually adjusting if necessary.

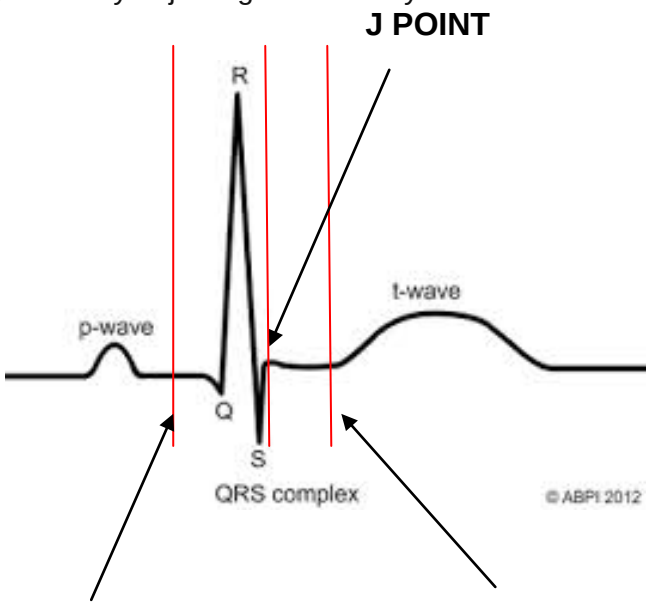



Figure 2

## 3. Procedure

### 3.1 Equipment required

- GE Carescape Patient Data Modular Monitor B850
- Monitor cable
- Standard 5 electrode trunk (limb electrodes plus one chest electrode)
- Additional 5 electrode trunk (remaining 5 chest electrodes V2-V6)

### 3.2 Indications

All patients admitted to CRGH ICU/HDU where it is possible to evaluate the ST segment of the ECG trace

### 3.3 Contraindications

The ST segment may be obscured or altered in the ECG of the following patient conditions rendering ST monitoring as futile.

- Atrial Flutter
- Ventricular Pacing
- Left or Right Bundle Branch Block

Non ischaemic causes of ST deviation may include

- Metabolic Abnormalities
  - Hypokalaemia - ST depression
  - Hyperkalaemia – Peaked T waves
  - Hypomagnesaemia – ST depression
  - Hyperthyroidism – ST elevation
- Medications
  - Digitalis – ST depression
- Other causes
  - Pericarditis – ST elevation
  - Hypothermia – ST depression
  - Raised Intra Cranial Pressure- ST elevation or depression

### 3.4 Lead Selection

Optimally, patients should be monitored across all 12 leads to maximize the area of myocardium that is analysed. **Therefore where possible all ICU and HDU patients should have continuous 12 lead monitoring.** (This may not be possible with Burns patients with chest wounds for example) Electrodes are to be replaced daily and PRN. Inspect skin for signs of inflammation or breakdown of integrity.

Lead selection depends on the patient's history. Studies have determined which leads are most sensitive to myocardial ischaemia in both patients with and without a cardiac history. Leads III and V3 have been shown to best reflect primary coronary artery perfusion. Whilst Lead V5 has been shown to best reflect demand ischaemia.

When utilising the standard 5 electrode trunk leads I,II,III,AVL,AVR,AVF and one chest lead only are ST monitored. In patients with a history of cardiac disease this chest lead (brown lead) should be placed on V3 and patients with no cardiac history should have this electrode placed on V5. Refer to image below.

### 3.5 Patient lead placement

1. All patients where possible should have continuous 12 lead ECG monitoring. If continuous chest lead placement is not possible place the brown chest lead as follows:

| History of cardiac disease | NO history of cardiac disease |
|---|---|
| V3 | V5 |

Figure 3

2. Properly prepare the patient's skin before attaching the ECG electrodes
   - Clip excessive hair
   - Remove skin oils with soap and water
     (Avoid alcohol wipes as this dries the skin and impedes electrical conduction)
     Mildly abrade the area with a dry cloth.

3. Once lead placement has been determined, endeavour to keep the same lead placement when changing ECG dots. Altering the location of the skin electrodes during monitoring can create false positive ST-segment change. The use of indelible ink to mark electrode placement could be considered with consent.

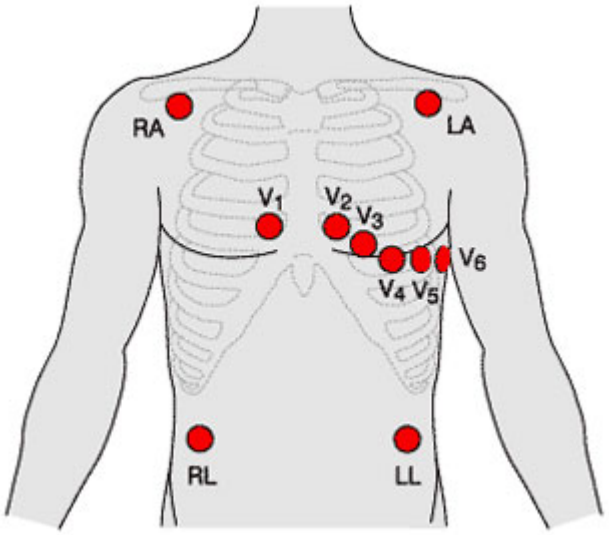



Figure 4

RA (White) – below the clavicle near the right shoulder

LA (Black) – below the clavicle near the left shoulder

RL (Green) – Lower right abdomen

LL (Red) – Lower left abdomen

V1 (Brown) – 4th Right intercostal space at the sternal border

V2 (Yellow) – 4th Left intercostal space at the sternal border

V3 (Green) – Halfway between V2 and V4

V4 (Blue) – Left Mid Clavicular line in the 5th intercostal space

V5 (Orange) - Left anterior axillary line at same horizontal level as V4

V6 (Purple) - Left mid-axillary line at same horizontal level as V4 and V5

### 3.6 Monitor Configuration

1. Access the ST menu by either
    - Choosing the ST tab under the ECG menu OR
    - Choosing the ST parameter window directly from the screen if it is displayed as its own parameter window.

2. Start ST detection
    - Select *Setup*
    - Select *On* from the *ST analysis* list

3. Select leads to the ST window

    - These are the primary leads to be ST monitored and the leads you will set the reference points with.
    - For patients with a known cardiac history they should be leads III, V3, and AVL
    - For patients with no cardiac history they should be leads II, III and V5

**.This will differ from the displayed ECG lead trace on the ECG monitor as lead II and the selected V lead will be displayed

4. Select leads for display in the ST window
   - Select *ST window*
   - Select *All Leads*
   - The current ST deviation of the leads will be displayed in numeric form

5. Assess the accuracy of the automatic ST monitoring reference points.

In the *Setup* screen assess the ECG trace and adjust the reference points manually if required using the side tabs

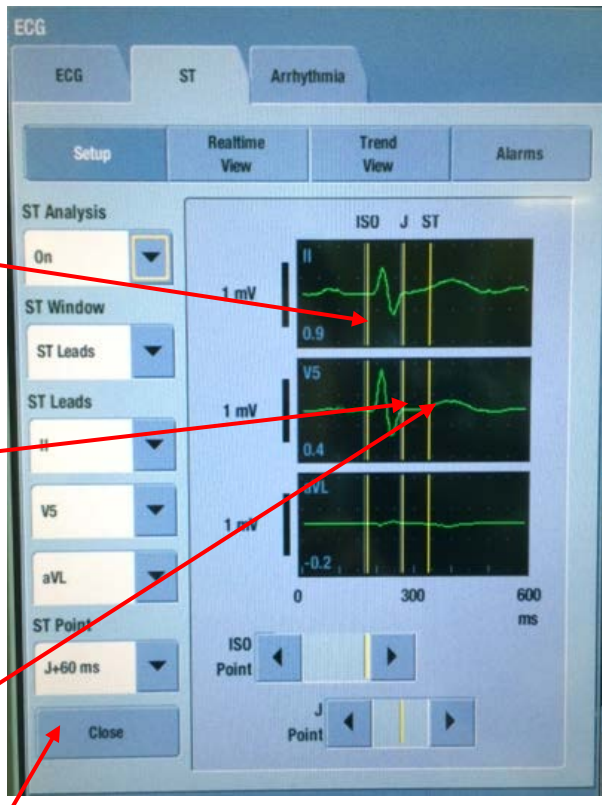
- **ISO Point:** this is the reference point for the measurement of ST deviation.

  Ensure the reference point (point where yellow line intersects with the ECG beat) lies on the flat aspect of the ECG. If adjustment is required, select the Left or Right arrows to reposition.

- **J Point** is the junction between the termination of the QRS complex, it represents the beginning of the ST segment. Adjust the J Point if required using the left and right arrows

- **ST point** this is the actual point on the ECG trace where ST deviation will be analysed.

  The monitor automatically sets 60ms after the J point if the heart rate is greater than or equal to 120bpm and to 80ms after the J point if the heart rate is less than 120bpm




- In the *Setup* menu Select *J +60ms* or J + 80ms from the ST point list

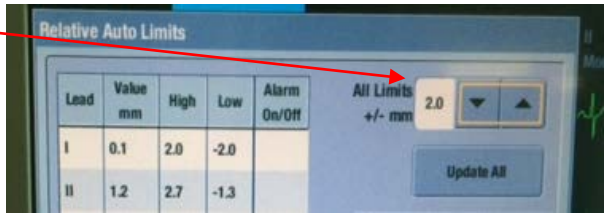
6. Select *Save a reference QRS manually* if the reference points have been manually adjusted.

   Reference points are automatically saved on commencement of ECG monitoring, however if the reference points have been changed a second reference trace should be saved. To save manual changes:

   - Once you have established the new reference points
   - Select *Realtime View → Save Reference*

7. Set ST Alarms
   - Select *Alarms*
   - Select *Relative Auto Limits*

- Select *Update All*




This automatically sets the upper and lower limits of +2/ -2 around the patients current ST value in all the leads monitored (different ranges may be verbally requested by the ICU medical team)

8. ST trends can be evaluated by selecting the *Trend View* tab.

   - The displayed green trace depicts the current ECG for each lead overlaying a white reference trace allowing ST deviation to be easily seen along with the current numeric ST value.
   - A window on the right displays the ST trend for each displayed lead. The yellow cursor can be moved along the horizontal time scale, a numeric value of the corresponding time is displayed.
   - The displayed leads can be changed by selecting *Leads*, then selecting the group of leads you wish to have displayed.
   - Ischaemic Burden should be turned on and set at +/- 1mm
     This is a visualisation of ischaemia and is displayed as a shaded area in yellow on the ST trend between ischaemic burden limit and the ST trend.

9. A 12 lead ECG report can be generated automatically when a ST alarm is activated. This is the default setting.
   (Both limb and chest leads need to be attached already for this to occur)

   - Select the ECG parameter window
   - Select *12 lead analysis*
   - Select *Settings*
   - Select *On* from the *12 lead on ST* Alarm list
   - Select *Confirm.*
   - Generated reports are viewed by
     i. Select *12 lead Analysis*
     ii. Select *Saved Reports*
     iii. Select : *Select Report*
     iv. On the touchscreen choose the report you wish to view
     v. Press: *View* and then *print.*

When changing from just a single 5 lead trunk to both trunks for 12 lead analysis and vice versa remember to push *update lead set.*

### 3.7 Responding to alarms

1. ST depression or elevation of 2 mm that lasts for ***at least 1 minute can be clinically significant*** and warrants further patient assessment. It is important to note that the ST Alarm sounds after one minute of ST elevation or depression.

2. A 12 lead ECG will automatically be generated if a ST alarm is generated. For this to occur however all of the ECG leads must be attached to the patient.

3. Check the ECG lead position, the ECG dots and their contact to the patient's chest wall.

4. Check the patient's body position. Right or left-side lying can alter the ST segment mimicking ischaemia. If the patient is in a side-lying position, they should be returned to the supine position, for ongoing ST segment monitoring.

   If the ST segment deviation persists in the supine state, it should be considered indicative of myocardial ischaemia.

5. Rule out non ischaemic causes of the ST deviation (Metabolic, medications, arrhythmias / pacing)-See section 3.3.

6. The patient should be assessed for indications of pain or any possible contributing factors for ischemia. Treatment should be initiated as required.

7. A 12 lead ECG should be obtained if not automatically generated by the ST alarm.

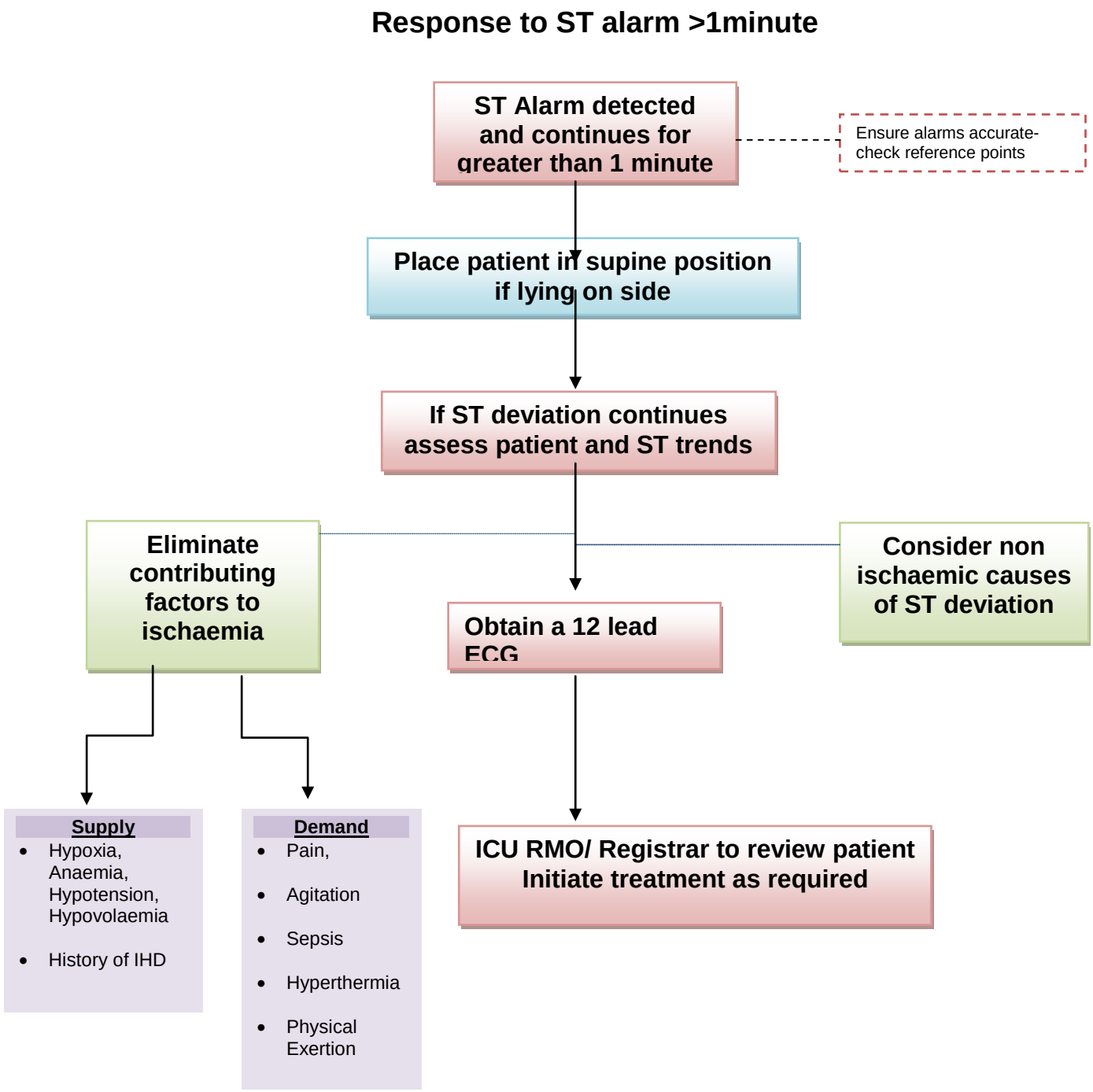
8. The patient should be reviewed by the ICU RMO or ICU Registrar

9. The goal of monitoring must be considered for each patient.

   For instance:

   - Patients with ST elevated Myocardial Infarction (STEMI), the goal of ST monitoring is to observe rapid ST segment recovery (back to isoelectric) within the one hour of treatment.
   - Patients with Acute Coronary Syndrome (ACS), the goal is to detect transient or recurrent ST segment changes.
   - ST changes that occur during ventilation weaning would indicate that the weaning process needs to be reviewed

### 3.8 Flow diagram of ST alarm response



## 4. Use of this Guide

This procedural guideline describes how to establish and maintain ST monitoring in CRGH ICU/HDU to assist with early diagnosis and treatment of silent myocardial ischaemia. It is intended for use by nursing and medical staff within the unit.

## 5. Definitions

**Depolarisation -** the reduction of a membrane potential to a less negative value. It is caused by the influx of cations, such as sodium and calcium, through ion channels in the membrane. In many neurons and muscle cells, depolarization may lead to an electric impulse called an action potential.

**Isoelectric** - Of equal electrical potential, pertaining to the electric baseline of an electrocardiogram
**Myocardial Infarction** – necrosis of myocardial tissue caused by prolonged ischaemia.

**Repolarisation -** the reestablishment of polarity, especially the return of cell membrane potential to resting potential after depolarization.

**Silent myocardial ischaemia** – an asymptomatic form of myocardial ischaemia where the blood flow to the heart muscle is insufficient to meet the muscles oxygen requirements

**Transmural** - extending through or affecting the entire thickness of the wall of an organ or cavity.

Guideline written by Lawrence Mead ICU CNS July 2014
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## 6. References

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