GUIDELINES
This guideline should be read in conjunction with:

- The Alfred Health Clinical Pathway for Sternotomy
- The Alfred Analgesia Management for Sternotomy Patients guideline
- The Alfred Health Clinical Care Standards Policy.
- Mutual Obligation for Patient Safety and Quality of Services at Bayside Health

PURPOSE
This document is aimed at ICU Registrars, Residents and Critical Care trained ICU nurses. It is intended as a basic guide to managing patients in ICU after Cardiac Surgery.

ARRIVAL TO ICU
The Anaesthetist will transfer the patient from the Operating Suite (OR) to ICU. The most senior ICU doctor and receiving ICU nurse should be there to take the handover, this should include surgical, anaesthetic and nursing information, relevant patient issues and current management goals.

The patient should be connected to a ventilator with the following initial settings:

- SIMV Volume Control mode
- Tidal Volume @ 6 – 8ml/kg (set 500mls and adjust when patient arrives)
- Flow 50L/min
- FiO2 .7
- 5cm H2O PEEP
- Vol (Flow) Trigger @ 3l/min
- Pressure support 8-10cmH2O
- Rate of 12 BPM

Transfer portable monitoring to ICU monitor and admit patient into ICU. Ensure the following waveforms are present:

- ECG (lead II and V)
- Arterial blood pressure
- Oxygen Saturation
- End Tidal CO2 (ETCO2)
- Central Venous Pressure (CVP)
- Pulmonary Arterial Pressure (PAP)
ARRIVAL TO ICU (Cont)
Level pressure transducers to Phebostatic level (4th intercostal, mid axilla) utilizing spirit level and Manifold holder and zero all transducers. Baseline observations of vital signs, fluid levels and ventilation should be recorded immediately on ICU observation chart.

Mediastinal drains must be connected to suction at 20kpa.

Confirm and document what infusions are in progress and at what rate.

Ensure pacing wires are secure in hub at lead/wire interface. Secure pacing leads to chest with Tegaderm and gauze. Ascertain from Anaesthetist what the underlying rhythm was (if any).

Secure Swan Ganz catheter to patient with Hypofix dressing and tape. Ensure that wedging syringe is fully deflated and that the gate is left in open position.

Connect Cardiac Output monitoring to Swan Ganz catheter (ensure Injectate syringe connected to Blue Proximal Injectate port of Swan) and confirm both Injectate and core PA temperatures are present on Cardiac output screen with a minimal temperature difference of 10 degrees Celsius as well as computation constant of .595 and patient BSA.

Connect three way tap in line with Arterial line to allow ease of blood sampling. Obtain Arterial Blood Gas and send standard initial laboratory tests:

- U&E
- LFT’s
- FBE
- Coags
- Mg, Po4 & Ca
- Troponin

ICU Resident to order patient Chest X-ray (CXR)

IMMEDIATE ASSESSMENT
Confirm level of ETT at teeth and secure. Visually confirm bilateral chest inflation and auscultate for bilateral air entry. Assess adequate gas exchange via pulse oximetry and capnography. Assess for appropriate patient synchrony with initial ventilation settings.

Confirm adequate rate and rhythm on monitored ECG. If paced note mode and ensure that selected rate correlates with patient rate displayed on monitor. It is possible that intrinsic underlying rate will not be present this early in post operative recovery; this may render it unsafe to check pacing settings at this stage.

Confirm adequate blood pressure on arterial line. Initially aim for the following therapeutic goals: (guide only):

- MAP > 70mmHg
- CVP > 8 - 10mmHg (if normal ventricular function)
- PA Diastolic 10 – 15mmHg

A warming blanket should be applied if patient’s temperature below 35.5°C.
INITIAL EVALUATION
A thorough examination of the patient should occur and any immediate problems identified need to be addressed.

Obtain ABG results to clarify PaO2, PCO2 & PH. Adjust Ventilation as required.

Check and manage Blood Sugar Levels (BSL) between 6.1 and 9.0 mmol/L

Obtain Potassium concentration from ABG and maintain >4.5mmol/L. Maintain Magnesium level >0.95mmol/L.

Assess for blood loss from Mediastinal drains, ensure drainage site maintaining forward drainage. Report to medical staff if chest tube drainage greater than 100mls in the first hour.

Perform Cardiac outputs (CO) with the following initial hemodynamic aims as a guide only:

- Cardiac output > 3.5L/min
- Cardiac index >2.2L/min/m²
- Systemic Vascular Resistance (SVR) 800 – 1200 dynes/sec/cm⁵
- Pulmonary Vascular Resistance < 250 dynes/sec/cm⁵

If Cardiac Index (CI) is low then consider obtaining a mixed venous sample (SvO2) from the distal port of PAC which may be clinically relevant. A normal SvO2 is between 60-80%.

Obtain 12 lead ECG and ensure it is review by both medical and nursing staff.

Commence an IV maintenance infusion of Hartmanns containing 30mmol KCL utilizing the following equation: 750 x BSA / 24hrs = Mls/Hr

INITIAL MANAGEMENT aims to ensure:

- Therapeutic aims are charted
- All relevant drugs / infusions and IV fluids charted
- That adequate sedation and analgesia are prescribed
- All blood tests ordered
- That new drug chart is completed
- That the patient’s chest X Ray ordered electronically

COMMON EARLY POST OPERATIVE PROBLEMS

CARDIOVASCULAR

Hypotension:
This is a common problem in initial post operative period and is often defined as a map less than 65mmHg.

In the first instance ensure all monitoring equipment is working:

- Ensure all transducers have been confirmed levelled and zeroed correctly
- Make sure the attached pressure bag is inflated to correct pressure of 300mmHg
- Ensure arterial line flushes appropriately, assess for waveform ‘bounce’ on monitor immediately post flush
Hypotension (Cont)
- Observe that monitored arterial waveform is not underdamped
- Ensure that a non-invasive blood pressure is taken to correlate accuracy of monitored arterial blood pressure.

Once mechanical fault has been ruled out, efficient diagnosis of physiological causes of hypotension can be assessed. Variables derived from the pulmonary artery catheter may be helpful in determining the cause (see 1.2 initial evaluation for normal aims).

Swift interpretation and intervention requires a working clinical knowledge of the attained PAC variables in relation to the following cardiac concepts:
- \( CO = HR \times SV \)
- \( BP = CO \times SVR \)
- \( CO = Preload + Afterload + Contractility + Rate/Rhythm \)

Suspected diagnosis is often related to exposure of blood to bypass circuit and myocardial dysfunction and often involve the above concepts related to the following considerations:
- Hypovolemia – Excessive bleeding
- Fluid shifts
- Rhythm disturbances
- Inadequate level of sedation – valsalva (Ventilator Dyssynchrony)

Less common factors to be considered:
- Cardiac Tamponade
- Loss of pacing capture

In most cases hypotension should respond to simple interventions such as:
- fluid administration
- increasing cardiac pacing rate
- cessation of dilators
- adding or increasing inotropic support
- Adding sedation or paralysis to stop Valsalva

If the hypotension is refractory to the above simple interventions and the cause is unknown then an echocardiography may be indicated.

Catastrophic cardiovascular collapse may require ICU re-Sternotomy before investigation.

Bleeding:

The risk of bleeding in the immediate post operative phase is precipitated by several factors:
- Hypothermia
- Coagulopathy precipitated by CPB
- Incomplete reversal of Anticoagulation (Heparin)
- Underlying clotting deficiency
- Redo Sternotomy
- Leaking coronary graft or suture line
Bleeding (Cont)
Close monitoring of drainage from Mediastinal ICC’s is a priority and should not exceed 75mls in the first half hour post surgery and not exceed 100mls in the next hour thereafter.

The majority of patients will return to ICU with an anti-fibrinolytic agent (Tranexamic Acid) being infused to aid in prevention and cessation of any potential bleeding issues. In the case of significantly deranged coagulation, low platelets and active bleeding, blood products should be given to correct abnormalities. Protamine may be a consideration if incomplete heparinisation reversal is suspected.

New or continued bleeding should always be discussed with the cardiothoracic surgical team especially if bleeding measures above 100mls/hr for the first two hours despite administration of blood products.

Pacing:
It is common to have the ability to pace the atria if the patient has undergone uncomplicated CAGS if more complex surgery has been performed such as Valvular surgery.

Some common modes used at the Alfred Hospital:
- AOO
- DDD
- AAI
- VVI

VOO has the potential risk of causing ventricular arrhythmia’s and ideally should not be used unless clinical risk has been assessed.

Pacing checks can be commenced at any stage, in conjunction with ICU epicardial pacing guideline, however it is unlikely that an adequate intrinsic rhythm will exist in the initial post operative period that will allow this to be safely achieved. In which case limitations to safely check pacing settings will be incurred and should be attempted at a later time post operatively. [X:\ICUAppSubgroup\Guidelines\Single Chamber Threshold Testing.pdf](X:\ICUAppSubgroup\Guidelines\Single Chamber Threshold Testing.pdf)

ARRHYTMIA MANAGEMENT:

ATRIAL FIBRILLATION AND FLUTTER
Postoperative Atrial Fibrillation (AF) following cardiothoracic surgery occurs in approximately 33% of patients after coronary heart surgery and predisposes the patient to hemodynamic compromise, increased risk of stroke and thromboembolism.

Although post-op AF is generally self-limiting, treatment is indicated for those patients who become hemodynamically unstable, and develop cardiac ischemia or heart failure. Conventional treatment strategies may include:

- Obtain 12 lead ECG confirm diagnosis
- Elective DCR if sudden and severe hemodynamic compromise exists
- Replacement and optimisation of (Electrolytes) Potassium (>4.5mmol/L) and Magnesium (>0.95mmol/L)
- Pharmacological rate control (Bblocker, Amioderone, Ca Antagonist)
- Antithrombotic therapy.
- Atrial overdrive pacing using temporary epicardial pacing leads (if atrial flutter is the dominant rhythm)
RESPIRATORY
During CPB the lungs are not optimally ventilated. Nearly all patients that have experienced CPB will therefore suffer a degree of pulmonary atelectasis and dysfunction. Utilising PEEP during ventilation recruits collapsed alveoli and maintains adequate gas exchange.

Most patients will be extubated within 6-12 hours after surgery, however 5 – 10% will require extended ventilatory support for up to, and beyond 48 hours. SIMV Volume control is the most commonly initiated mode of ventilation post operatively. (See initial settings above)

The clinical objective in this post operative period is to maintain parameters of:
- SaO2 > 95%
- PaO2 > 80mmHg
- PCO2 35-50mmHg
- PH 7.32-7.48

VENTILATION WEANING CRITERIA
It is prudent to consider weaning the patient from mandatory mechanical ventilation to a spontaneous mode and then consider extubation as soon as they are clinically able. Consider the following as a guide to achieving this:

- Ensure minimal sedation and patient is awake with stimulation
- Ensure there is no residual neuromuscular blockade present and patient is able to move all limbs and head normally to command
- Assess for pain and provide adequate analgesia in form of IV Morphine infusion and PR Paracetamol.
- Ensure patient is able to maintain ventilation in Spontaneous mode on minimal support and is able to take large breaths with minimal pain.
- Confirm stable gas exchange:
  - FiO2 ≤ .5 with PaO2 > 75
  - PCO2 < 50
  - PH 7.3 – 7.5
- Patient should be normothermic, temp > 36 degrees
- Patient hemodynamic ally stable:
  - HR < 120BPM
  - MAP > 70
  - CI > 2.2
- Ensure no major abnormalities on CXR

If all of these clinical indicators are present it may be time to extubate the patient to a face mask and humidified air or nasal prongs dependent on oxygen saturation levels.
RENAL
Renal impairment is common postoperatively. It occurs more commonly in patients with previous renal impairment and diabetes.

Urine output in the initial post operative phase of the patient's recovery should be high if there is no existing renal impairment (>100mls/hr for 2/24) and is referred to as the post pump diuresis. This is not applicable if cardiac surgery was performed ‘off’ pump.

If there is a marked bypass time (>90min) time or existing renal impairment urine output may be low. A history of renal impairment and base line function should be noted in this instance.

If no other impairment known a urine output aim of .5ml per Kg of weight should be achieved.

GIT
Patients in whom early extubation is unlikely should be commenced on an enteral feeding regime as soon as nasogastric tube position can be confirmed. http://intrnet.baysidehealth.org.au/Assets/ContentFiles/1/ICUEnteralFeedingFlowChartRev1.pdf
Ranitidine should be given for stress ulcer prophylaxis in ventilated patients.

Hyperglycaemia is common post operatively and should be managed according to standard ICU protocols. W:\ICU\Apps\cuneet\Guidelines\Infusio\Infusions on ICU.pdf

- BSL maintained <9mmol/L

POST OPERATIVE ANALGESIA
Patients having undergone cardiac surgery experience severe pain that if managed incorrectly can have negative effects on a patients post operative recovery.

On return to ICU the patient should be rolled and PR Panadol suppositories administered, Intravenous administration of Panadol may be considered by managing Intensivist.

Once the patient is hemodynamically stable and ready to wake, an IV Morphine infusion can be commenced. W:\fcapps01\apps\CCDrug\Final流PDF\Standardised Drug Infusion Concentrations.doc

- Assess level of pain and bolus only as required to enable patient comfort and ability to deep breath prior to extubation.
- Once extubated, start Morphine infusion at 1-2 mg/hour or as prescribed by managing Intensivist or registrar.
- Ensure regular assessment of patient pain level carried out.
- If allergies to certain analgesia exist alternative analgesia to be considered as per managing Intensivist

Continuing analgesia requirements from ICU to Ward:

In order to ensure all patients are discharge from ICU to Cardiothoracic ward with an effective pain management plan, please review the following:

1. Aim is to have patients on Oral Analgesia, prior to discharge from ICU

2. Prior to discharge from ICU, if oral analgesia is inadequately controlling pain, ICU consultants to liaise with Acute Pain Services (APS) & early referral made.
Analgesia (Cont)

3. If a patient is discharged from ICU on a Morphone infusion, the use of PCA Pump is preferred (APS to supply).

4. If there are no PCA pumps available on discharge send with IMED at ward concentration dose 50mg Morphone in 50mls of Normal Saline 0.9%.

Always ensure adequate time is allocated to assessing appropriate level of analgesia requirement when change in route of administration occurs – prior to discharge to ward.

Appendix 1:

Therapeutic goals and timelines for care of Cardiothoracic patient in ICU (Guide only):

Same day of Surgery:

- Admission to ICU
- Establish monitoring, maintain CVS therapeutic aims, mechanical ventilation, pacing, pharmacological supports, carry out routine investigations, and control bleeding.
- establish adequate pain relief
- wean sedation and extubate patient within 12hours of return to ICU

Post operative day 1:

- CVS therapeutic aims maintained
- Routine investigations performed and reviewed
  - CXR
  - Bloods/ABG
  - ECG
- PAC removed \footnote{PAC Guidelines.pdf}
- If able consider removing arterial line
- adequate pain relief maintained
- consider DVT prophylaxis and Aspirin
- consider commencing other pharmacological supports:
  - Antilipid
  - Antihypertensives
  - Antifailure
  - Antiarrythmia (Beta Blockade)

- BSL controlled and oral intake as tolerated
- Consider discharge to ward

Post operative day 2: (if not discharged to ward)

- Isolate Pacing wires
- adequate pain relief maintained
- Mediastinal drains removed (Re: Cardiology)
- IDC removed
Appendix 2: Post Operative Cardiac Patient: Cubicle set up

BED: (To be sent to theatre)
- Monitoring Brick
- ECG monitoring
- Transducer Pressure cables x 3
- SaO2 probe
- CO2 cable

CO2 window
Syringe driver x 3
Pacing box + battery
Drain clamps x 2
Bed pole
Manifold
Bagging circuit and mask
Full O2 cylinder under bed

CUBICLE:
Admission pack
Hartmann’s + KCL 30mmol IVT
5% Glucose 500ml (injectate)
PAC injectate line
Blood tubes (blue, pale green, purple)/ABG + 3-way tap + artery forcep
Cardiac Output Cable and module
Spirit level
Hypofix and Tape to secure SWANN catheter
3 suction ports (2 cannisters/1 drain) plus suction tubing
O2 Flow meter + green nipple
Bagging circuit (sealed)
Drip stand + double pump
Manifold holder
Bair hugger + Blanket

VENTILATOR: (Recommended settings)
- Ventilator attached to blue plug, O2 and Air connected
- 1L H2O: Humidifier on
- 1 Inline suction: Connected
- Mode: SIMV Volume Control
- Set rate 12 breaths/min
- Tidal volume 6-8 ml/kg
Appendix 3  Normal Pulmonary Artery Catheter Values
Right Atrial Pressure / Central Venous Pressure 0 – 8 mmHg
Pulmonary Artery Systolic 15 – 30 mmHg
Pulmonary Artery Diastolic 6 – 12 mmHg
Pulmonary Artery Mean 10 – 20 mm Hg
Pulmonary Capillary Wedge Pressure 5 – 15 mmHg
Cardiac Output = Stroke Volume x Heart Rate
Cardiac Output 4 – 8 L/min
Cardiac Index 2.5 – 4 L/min/m2
Systemic Vascular Resistance (SVR) 800 – 1200 dyne/sec/cm-5
Pulmonary Vascular Resistance < 250 dyne/sec/cm-5
Right Ventricular Ejection Fraction 40 – 60 %
Left Ventricular Ejection Fraction 60 – 70 %
Stroke Volume (SV) CO/HR x 1000 60 – 100 ml
Coronary Artery Perfusion Pressure MAP – PCWP 60 – 80 mm Hg

Related Documentation:
The Alfred Health Clinical Pathway for Sternotomy Intranet
The Analgesia management for Sternotomy Patients guideline Intranet
The Alfred Health Clinical Care Standards Policy Intranet

References:
Charter of Human Rights and Responsibilities Act 2006 (Vic)¹

¹ REMINDER: Charter of Human Rights and Responsibilities Act 2006 – All those involved in decisions based on this guideline have an obligation to ensure that all decisions and actions are compatible with relevant human rights.