

## **SECTION I : ANAESTHESIA**

# *Perioperative Respiratory Monitoring in Cardiac Surgery*

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### **INTRODUCTION**

Pulmonary dysfunction is a common complication after cardiac surgery. Arterial hypoxaemia in the early postoperative period can result from ventilation-perfusion mismatching caused by atelectasis pulmonary oedema, bronchospasm, or ARDS etc.

Monitoring and management of respiratory system is important in cardiac surgery patients in intensive care unit (ICU) because general anaesthesia, surgical procedure and cardiopulmonary bypass have profound effects on the respiratory system.

### **MONITORING DURING MECHANICAL VENTILATION**

Most of the cardiac surgery patients are placed on ventilatory support with PEEP of 5 cm H<sub>2</sub>O after arrival to ICU and usually remain on mechanical ventilator for 6-18 hours. During this time, arterial blood gases and blood oximetry are checked frequently

### **CHEST X-RAY**

A routine chest x-ray is necessary on arrival of patient to ICU to check position of endotracheal tube, gastric tube and CVP catheters. Lung parenchyma and pleural spaces are also checked.

### **PULSE OXIMETRY**

In haemodynamically stable patients, arterial oxygenation can be monitored adequately using non-invasive technique of pulse oximetry.

### **CAPNOGRAPHY**

Capnography is another non-invasive method which reflects the end point of carbon dioxide exchange in the lungs. Capnographic recordings are also useful in guiding respiratory management of postoperative cardiac patients needing prolonged ventilatory support. It can facilitate the weaning procedures as well.

### **CAPNOMETRY**

Another non-invasive approach to continuous CO<sub>2</sub> monitoring is provided by capnometry. A capnometer is CO<sub>2</sub> analyser which displays breath - by - breath numerical value of CO<sub>2</sub>.

### **APPLICATION OF PEEP**

Although PEEP is routinely used in postoperative cardiac surgery patients, but in a study it was assessed that the effect of no PEEP versus 5 or 10 cm H<sub>2</sub>O PEEP on postoperative gas exchange had no particular advantage in improving gas exchange<sup>4</sup>.

### **EARLY EXTUBATION**

A combination of appropriate anaesthesia and surgical techniques and management in ICU allows early extubation in selected coronary artery bypass graft patients, aiming at a reduction in respiratory complications, reducing ICU stay and total hospital costs. However, higher incidence of postoperative myocardial ischemia has been observed in patients managed in this way<sup>5</sup>.

### **WEANING**

Weaning from mechanical ventilation in these patients is easier when SIMV plus pressure support ventilation (PSV) is used initially, followed by PSV. The level of pressure support usually starts at 10 cmH<sub>2</sub>O and is gradually lowered to 5 cmH<sub>2</sub>O. Cardiac surgery patients are regarded as candidates for extubation if respiratory rate is less than 20 breaths per minute with normal PO<sub>2</sub>, and PCO<sub>2</sub>, and patient is haemodynamically stable. When the combination of SIMV and PSV is used, no change in overall V/Q matching is found compared to controlled mechanical ventilation, whereas dead space ventilation (V<sub>D</sub>) is increased.

## PROLONGED VENTILATORY SUPPORT

It is estimated that 6-8 percent of cardiac surgery patients need prolonged (more than 2 days) ventilatory support, mainly because of haemodynamic instability rather than respiratory complication. In the patients with increased peak airway pressure, the pressure-regulated volume-controlled mode of ventilation is usually used in order to minimize barotrauma.

## PRESSURE-SUPPORT VENTILATION

In cardiac surgery patients ventilated with pressure support mode, tidal volume ( $V_T$ ), respiratory rate (RR), minute ventilation (VE) and vital capacity (VC) are the most common routine measurements. These parameters are indices of successful weaning. A  $V_T$  less than 4 ml per kg and/or respiratory rate above 25 breaths per minute does not encourage extubation.<sup>7</sup>

## VITAL CAPACITY

Normal vital capacity is 65-75 ml per kg. It can also be used as an index of successful weaning but it has a poor predictive value because it depends upon cooperation of the patient.

## PERSISTENT HYPOXAEMIA : MONITORING

The gas exchange efficiency in cardiac-surgery patients with severe persistent hypoxaemia is monitored by  $PaO_2/FiO_2$  ratio, alveolar to arterial oxygen tension difference  $P(A-a) O_2$ , venous admixture (Shunt) and  $V_D/V_T$  ratio.<sup>8</sup>

- i. The alveolar to arterial oxygen tension difference is calculated using the equation:-

$$P(A-a)O_2 = 713 \times FiO_2 - 1.25 \times PaCO_2 - PaO_2 \text{ mm Hg}$$

- ii. These patients usually have a pulmonary (Swan-Ganz) catheter through which blood can be taken for  $SVO_2$  measurement. Venous admixture ( $Q_{va}$ ) can then be calculated from equation:

$$Q_{va}/Q_t = 1 - SaO_2 / (1 - SvO_2), \text{ with } FiO_2 = 1$$

the normal  $Q_{va}/Q_t$  is less than 10%

- iii. The dead space fraction to tidal volume ratio ( $VD/VT$ ) is calculated from modified Bohr equation:

$$VD/VT = PaCO_2 - PECO_2 / PaCO_2$$

$PECO_2$  is the mixed expired  $CO_2$  partial pressure and is determined by collecting expired gas in an air bag for several minutes.

## RESPIRATORY SYSTEM MECHANICS

Daily measurements of respiratory system mechanics are necessary for certain cardiac surgery patients needing prolonged ventilatory support and when there is difficulty in weaning patients from the ventilator. These measurements include primary variables such as airway pressure, the peak inspiratory airway pressure ( $P_{imax}$ ) and calculated variables such as lung compliance, chest wall compliance, airway resistance and work of spontaneous breathing.<sup>9</sup>

## $P_{imax}$

Peak inspiratory airway pressure ( $P_{imax}$ ) is useful for estimating patients ability to sustain spontaneous breathing following extubation.  $P_{imax}$  assesses respiratory muscle strength and it is measured after deep expiration to residual volume followed by inspiration to total capacity (TLC) by a manometer connected to tubing that can fit on to endotracheal tube. For successful tracheal extubation a  $P_{imax}$  value less than minus 30 cm  $H_2O$  is necessary (Normal value is minus 120 cm $H_2O$ )

## PEAK AIRWAY PRESSURE

An sudden increase in peak airway pressure is an early indicator of an acute clinical problem such as bronchospasm, pneumothorax, accumulated secretions, sliding of endotracheal tube into right bronchus or obstruction. High peak airway pressure ( $>45$  cm $H_2O$ ) is a great risk factor for barotrauma during mechanical ventilation.

## MONITORING DURING SPONTANEOUS BREATHING

After extubation, peak expiratory flow is decreased. Internal mammary artery dissection affects this change. During first three days after surgery all cardiac patients have hypoxaemia because of atelectasis or pulmonary oedema. Routine arterial blood gases monitoring is necessary during this period. In many cases pulse oximeter permits measurements of oxygen saturation.

## DIAPHRAGMATIC DYSFUNCTION

The left hemidiaphragm is often elevated after open heart surgery, because of atelectasis or phrenic nerve paresis. Topical iced slush used for myocardial preservation during bypass applied to phrenic nerve, direct nerve damage during IMA mobilization or

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## Quick Action Plans

### UNINTENTIONAL HYPOTENSION

The most likely cause may be suggested by the clinical situation. Unfortunately, the cause may not be obvious and a therapeutic trial may be necessary.

#### Immediate Steps

1. Increase the rate of IV infusion.
2. Reduce inhalational agent concentration/epidural infusion.
3. Increase FiO<sub>2</sub> to at least to at least 50%.
4. Monitor ECG.
5. Intubate, if necessary, and ventilate (avoid hyperventilation).
6. Elevate legs if feasible.
7. Insert CVP and consider arterial monitor if prolonged.

#### Specific steps-according to cause

1. Decreased venous return;
  - a) if there is surgical pressure on great veins-reduce it.
  - b) Give 200-300ml fluid quickly IVRepeat if:
  - BP improved.
  - BP unchanged.
  - CVP unchanged.

- c) Check:
  - blood loss (visible and occult).
  - (the IV giving set is connected to the cannula).
  - the IV cannula is properly in place.
2. Pump Failure:
  - a) Dysrhythmia-treat according to cause.
  - b) Decreased contractility.-usually CVP will be raised, show a rising trend, or will rise sharply with fluid challenge.
  - i) Dobutamine or dopamine by infusion.
  - ii) If overt pulmonary oedema-frusemide 40 mg IVx2.
- Left ventricular failure may occur with a normal or low CVP. Consider use of a pulmonary artery flotation catheter.**
3. Obstruction:
  - a) Tension Pneumothorax.
  - b) Cardiac tamponade.-raised CVP, muffled heart sounds-insert 14G cannula under xiphisternum toward left nipple.
4. Miscellaneous:
  - a) Pulmonary embolus.
  - b) Air embolus.
  - c) Septicemia.

(Brig M. Salim)