Cardiac Surgery Department ICU Protocol

2010 - 2011

Receiving the patient in the ICU

30 minutes before arrival of the patient from the OR

Adjust the ventilator to SIMV mode and keep the initial ventilator settings as in the table:

Tidal volume	8 ml/kg
Respiratory rate	18/min
Fio2	1.0
PEEP	5 cm H20
Pressure support	8 cm H20
plateau	0.4-0.6 sec

On arrival from OR

- The ventilator is connected to the patient and chest is auscultated for bilateral equal satisfactory air entry.
- The patient is connected to ECG of the main monitor first, followed by the saturation probe and lastly the invasive arterial blood pressure.
- Chest tubes are connected to the underwater seal, in a level lower than bed and connected to wall suction at a pressure of -20 cm H2O and checked for patency and drainage.
- Urinary catheter to gravity drainage
- Connect the temperature probe and warm the patient if hypothermic
- Elevate the head of the bed to 30 degrees
- ABG with the initial ventilator setup and then after 30 minutes to reach a target of respiratory rate of 12/ min and Fio_2 of 0.5.
- Check that all IV infusion pumps are running without occlusion or not accidentally disconnected during transferal.

Vital data

- Vital signs should be recorded every 15 minutes during the first hour and every hour if the patient condition is stable

- Urinary output should be monitored and recorded hourly as regard volume and any significant color change
- Chest tubes output is hourly monitored and specified [mediastinal or pleural drainage], color and consistency of output should be considered.

Respiratory management

- Endotracheal tube suction every 4 hours then when needed
- Weaning from ventilator according to protocol [see later]

GI management

- Nasogastric tube to gravity drainage

Medications

Routine IV drips:

- Dextrose 5% at a rate of 1ml/kg/hour for Pump cases and 2ml/kg/hour for Non – pump cases
- Arterial line is flushed regularly with every ABG. The flushing fluid is prepared using 500 units of heparin on 500 ml normal saline.
- Magnesium sulphate 2 g IV on 100 ml dextrose 5% over 1 hour.

IV antibiotics

- Ceftazidime 1 gm /8h for 3 days [adjust for renal impairment and allergy]

Sedatives

- Initial 2 mg IV of midazolam [Dormicum] if patient is awake.
- Midazolam [Dormicum] 2 mg IV every 2 hours when needed for agitation.
- Meperidine [Pethidine] 25 mg IV when needed for shivering.

Other medications

- Aspirin 150 mg once daily starting 6 hours after arrival For CABG patients. Hold for platelets count less than 75,000 or chest tube drainage > 50 ml/hr.

Standard Labs and Imaging

- Stat ABG, CBC, Electrolytes.
- Check Glucometer on arrival and after 8 Hours
- Stat INR, PT, PTT
- Stat chest X-ray
- ECG after the patient is fully stabilized [15 minutes].

Initial management of standard labs and imaging

Chest X-ray: It should be evaluated by both the cardiac surgery resident and the ICU resident and if there is suspicion of any abnormality, you should notify the consultant. Pay attention to the following while reviewing the CXR:

a. Position of the endotracheal tube
b. Position of the central line
c. Width of the mediastinum
d. Presence of pneumothorax
e. Presence of pleural effusion
f. The lung fields for volume overload or atelectasis
g. The position of intercostal and mediastinal drains

CBC:

Hct: is evaluated with every ABG, maintained at a value of 28% and if drops below this value, packed RBCs are transfused.

Platelets count: if below 60,000, platelets transfusion is needed, ideally 1 unit/10 kg body weight even if there is no bleeding.

Electrolytes management:

Potassium: It is one of the most important electrolytes for the myocardium; it should be checked regularly **[every 4 hours and more frequently when needed]** in order to avoid abnormal variations of its blood level**.**

Abnormalities of serum k^+ level:

Hypokalemia is corrected with caution according to levels shown in table below. KCL is diluted in Dextrose 5% and given slowly via central line over a period of time

K level	KCL in mEq	Amount of D5%	Period of time
4.0 – 4.5	10 mEq	50 cc	30 min
3.5 – 3.9	20 mEq	100cc	60 min
<3.5	40 mEq	250cc	90 min

Hyperkalemia: is lethal and must be dealt with promptly. **It is defined as** serum k^+ level > 5.5 mEq/L

Aim of correction: to stabilize the cell membrane, shift potassium into cells and increase its excretion from the body

1. Optimize cardiac functions
2. Identify and remove any potential source of k^+ intake or medications that may increase serum k level
3. Regular insulin 10 units/25g of dextrose 50% IV drip
4. $NaHCO_3$ (25-50 mEq/L) to correct acidosis and raise the pH to 7.40 – 7.50
5. Furosemide 10 – 200 mg IV
6. **If serum K > 6mEq/L: In addition to above , do the following:**

a) administer calcium glaciate 5 – 10 ml of a 10% solution IV over 15 minutes to stabilize the cell membrane
b) Aerosolized β-agonists by nebulizer
c) Kayexalate enema 50g in 50 ml sorbitol as retention enema or 50g PO with 50 ml of sorbitol every 6 hours
d) Urgent nephrological consultation to initiate hemodialysis or peritoneal dialysis

PT, PTT, INR: watch the patient closely for mediastinal bleeding. If bleeding develops, proceed to the protocol of bleeding management.

Blood Glucose: **maintain blood sugar between 110 and 180 mg/dl after surgery**

Protocol for management for hyperglycemia:

1. **Check** glucometer upon arrival to ICU and if <180 check it again after 8 hours.

2. if > 180 measure every 2 hours; increase to every hour during rapidly changing conditions and decrease to every 4 hours if no changes in insulin drip rate for 6 hours and serum blood sugar <180 on 3 consecutive measurements.
3. **Correlate** glucometer blood sugar to serum blood sugar daily
4. **Maintain** serum potassium level > 4mEq/L
5. **Initiate** protocol for blood sugar > 240 on admission to ICU or blood sugar > 180 at 8h

Blood sugar	Regular insulin IV bolus	Initial infusion rate
181-200	No bolus	0.5 unit/h
201-240	3 units	1 unit/h
241-280	5 units	1 unit/h
281-320	10 units	2 units/h
Insulin drip preparation: Regular insulin 50 units in 50 ml normal saline		

Adjust insulin infusion rate according to the following protocol:

<95	Iv bolus with 25 ml dextrose 50%	Lower infusion by 1 unit/h
96 -	----------	Lower infusion by 0.5 unit/h

110	----------	
111 - 180	----------	No change in infusion rate
181 - 225	----------	Increase infusion rate by 0.5 unit/h
226 - 250	IV bolus with 5 units	Increase infusion rate by 0.5 unit/h
251 - 320	IV bolus with 10 units	Increase infusion rate by 1 unit/h
> 320	Check for acetone in urine	

Transitioning from infusion to SC insulin

24 h requirement in units is divided by 8 = X units = ---- units

Give first SC dose 30 min before stopping insulin infusion

Blood sugar adjustment to insulin regimen (checked by glucometer every 6h)

≤ 80	Inform the resident
81 - 120	Give ---- units SC (X - 4 units)
121 - 160	Give ---- units SC (X - 2 units)
161 - 200	Give ---- units SC (X units)
201 - 240	Give ---- units SC (X + 2 units)
> 240	Inform the resident

NB: the SC insulin protocol is adjusted individually for each patient and reported to the nurse in charge.

Weaning the patient from the ventilator

When do you start weaning (criteria for weaning)?

The patient must fulfill the following to allow proceeding into weaning off the ventilator:

1. The patient is awake with stimulation
2. Adequate reversal of neuromuscular blockade
3. Chest tube drainage <50 ml/h
4. Core temperature >35.5 ^{o}C
5. Haemodynamic stability
    - Good cardiac output
    - Blood pressure stable at 100 – 120 systolic on/off medications
    - Heart rate < 120/min
    - No arrhythmia

6. Satisfactory ABGs on full ventilation
    - PaO_2/FIO_2 > 150 (PO_2 > 75 torr on FIO_2 0.5)
    - $PaCO_2$ < 50 torr
    - pH 7.30 – 7.50

How do you proceed with weaning?

1. Minimize sedation
2. Maintain the FIO_2 at 0.5 with a PEEP of no more than 5 cm H_2O
   NB: if patient still requires a higher level of PEEP, weaning is usually not indicated
3. If oxygenation is satisfactory , lower the PEEP to 2.5 cm H_2O and initiate weaning
4. Weaning is usually accomplished in the SIMV mode. The IMV rate is reduced by two breaths every 30 minutes with observation of the SaO_2
5. If the ABGs and respiratory mechanics are acceptable after 30 – 60 minutes spontaneous breathing trial on T-piece or CPAP mode of 5 cm H_2O is done, and if the patient fulfills the **extubation criteria**, the endotracheal tube is then removed.

Extubation criteria:

1. The patient is awake without stimulation
2. Acceptable respiratory mechanics
    - Negative inspiratory force > 25 cm H_2O
    - Tidal volume >5ml/kg
    - Spontaneous respiratory rate <24 /min
3. Acceptable ABGs on 5 cm or less of CPAP:
    - PaO_2 > 70 torr on FIO_2 of 0.5 or less
    - $PaCO_2$ < 48 torr
    - pH 7.32 – 7.45

When do you stop weaning?

Weaning should be stopped and ventilation resumed at a higher rate when there are clinical signs that are not tolerated. These signs are considered as **failure criteria during weaning from the ventilator**

1. Somnolence, agitation, or diaphoresis
2. Systolic blood pressure increases by more than 20/min or to over 160/min
3. Heart rate changes by more than 20% in either direction or to over 140
4. Acute need of vasoactive medications
5. Arrhythmias develop or become more frequent
6. Respiratory rate increases more than 10 breaths / min or to over 35/min for 5 minutes
7. PaO_2 falls to less than 60 torr on FIO_2 0.5 or SaO_2 falls to less than 90%
8. Pco_2 rises above 50 torr with respiratory acidosis (pH < 7.30)

Post extubation respiratory care:

1. Pulse oximetry
2. Face mask or nasal cannula to achieve SaO_2>90%
3. Adequate analgesia.
4. Incentive spirometer and deep breaths every 1-2h, Use pillow for coughing.
5. Mobilization and chest physiotherapy as soon as possible

Important points to be put into consideration:

- Tachypnea is the first clinical sign of ineffective weaning

- Some patients get very agitated when sedatives are weaned. Even though adequate ABGs can be maintained, those patients should be given more sedation throughout the night with another attempt at weaning in the morning
- If the patient was very difficult to intubate in the OR. It's essential to ensure all ABGs and respiratory mechanics are satisfactory before extubation, and extubation itself should be delayed till morning or at least in the presence of an experienced individual.

Management of mediastinal bleeding

- **Consider the patient to have mediastinal bleeding if the drainage of the chest tubes is ≥100 ml/h**
- **Consider early exploration for significant ongoing bleeding or tamponade**

1. **Ensure** that chest tubes are patent and connected to -20 cm H_2O suction (this can be helped by gentle milking or tapping under complete aseptic conditions)

2. **Sedate** the patient if awake and control agitation (or shivering) if present
   - Short acting sedatives
     - Propofol 25 – 50 µg/kg/min
     - Midazolam 2.5 – 5 mg IV /1-2 h
     - Morphine sulfate 2.5 – 5 mg IV /1-2 h
   - For shivering
     - Meperidine 25 – 50 mg IV
     - Pancuronium 0.1 mg/kg IV over 5-10 minutes then 0.01 mg/kg every 1h or a continuous infusion of 2-4 mg/h (always with sedation).

3. **Warm** the patient to 37 ^{o}C with blankets, a radiant heat and/or heated humidifier in the ventilator circuit. All blood components should be delivered through blood warming devices if available.

4. **Control** hypertension (Nitroprusside)

5. **Increase** PEEP to 10 cm H_2O if homodynamics permit (if patient still ventilated)
6. **Give** 4 ampoules of cyclokapron (Tranexamic Acid)

7. Manage Abnormal Lab studies

For INR > 1.5	Give FFP (1 unit/10 kg BW)
For prolonged PTT, or prolonged ACT	Give Protamine sulfate 25 mg IV for two doses

For Platelets < 100,000	Give platelets transfusion (1 unit/10 kg BW)
For Hct level < 28	Give packed RBCs transfusion
▪ Consider giving Calcium Chloride 1 g IV for repeated blood transfusions	
▪ Consider use of Fibrinogen	
▪ Fresh whole blood transfusion if available provides superior hemostasis	
▪ FFP and Cryoprecipitate transfusion is beneficial in prolonged PT,PTT or ACT	

8. **Order** new chest X-ray and compare with the base-line for mediastinal widening or pleural collection

9. **Watch for signs of tamponade:**
    - Decreased urine output
    - Increased CVP
    - Persistent acidosis
    - Patient irritability
    - Cold periphery
    - Decreased blood pressure
    - Increased heart rate

NB: All these signs might be masked by inotropic and dilator therapy so high clinical sense of suspicion should be present and ask for TTE or TEE to exclude tamponade

10. **Re-exploration:** when to re-explore the patient
    - Explore the patient immediately on evidence or even suspicion of tamponade
    - Explore if the total drainage exceeds **1000 ml** and still active or if drainage is
        - 500 ml/h for 1 hour
        - 400ml/h for 2 hours
        - 300ml/h for 3 hours
        - 200ml/h for 4 hours
    - Always explore in theatre unless the patient is compromised haemodynamically
    - Exploration should be- authorized by the consultant of the case and he should decide who is in charge of re-exploration

Management of acute respiratory insufficiency/short term ventilatory support

Definition: it's defined as inadequate oxygenation (PaO_2 <60 torr on FIO_2 0.5) or ventilation (Pco_2 >50 torr) during mechanical ventilatory support

Etiology during the first 48 hours, oxygenation problems predominate and hypercapnia at this time is mostly due to a mechanical problem

1. **Inadequate O_2 delivery and ventilation (mechanical problems)**
    a. Ventilator malfunction
    b. Improper ventilator settings :low FIO_2 , tidal volume or respiratory rate
    c. Endotracheal tube problems : cuff leak, incorrect ETT placement (larynx, main stem bronchus, esophagus) or kinking or occlusion of the tube
2. **Low cardiac output states**
3. **Pulmonary problems**
    a. Atelectasis or lobar collapse
    b. Pulmonary edema either cardiogenic or non cardiogenic
    c. Pneumonia
    d. Intrinsic pulmonary disease(COPD) ,bronchospasm or air trapping
    e. Microembolization from blood transfusion
4. **Intrapleural problems**
    a. Pneumothorax
    b. Haemothorax or pleural effusion

Notice that the development of shortness of breath or an abrupt change in the ABGs after an uneventful early postoperative course should raise the suspicion of the following problems:

- Pneumothorax possibly tension
- Atelectasis or lobar collapse from poor inspiratory effort or mucous plugging
- Aspiration pneumonia
- Cardiac tamponade

- Acute pulmonary edema (from ischaemic LV dysfunction or undetected renal insufficiency)
- Pulmonary embolism

Manifestations

1. Tachypnea (rate >30 breaths/min) with shallow breaths
2. Paradoxical inward movement of the abdomen during inspiration
3. Agitation or mental status changes
4. Tachycardia or bradycardia
5. Arrhythmias
6. Hypertension or hypotension

Management of acute ventilator insufficiency

1. **Examine patient**
   Auscaltate the patient for bilateral breath sounds and listen over the stomach to be sure the ETT has not slipped into the Main stem larynx or the esophagus

2. **Hand ventilate with 100% oxygen** (Ambu bag connected to oxygen line) and examine the ventilator carefully if suspecting ventilator malfunction

3. **Increase** FIO_2 **to 1.0 on ventilator** until problem is sorted out

4. **Ensure adequate alveolar ventilation** by correcting mechanical problems:

   i) Check ventilator function and settings with optimizing the following
      a) Tidal volume
      b) Ventilator trigger sensitivity
      c) Inspiratory flow rate
      d) Respiratory rate

   ii) Obtain a chest X-ray looking for ETT position and pneumothorax. Repositioning ETT or inserting chest tubes for pneumothorax if indicated.

iii) Repeat ABGs

iv) Notice that an increased peak inspiratory pressure may be cause by
   a) Pneumothorax
   b) Severe bronchospasm
   c) Pulmonary edema
   d) Main stem intubation
   e) An obstructed airway(like copious secretions or patient biting ETT)

5. Assess and optimize haemodynamic status

6. **Add PEEP** in 2.5 to 5 cm H_2O increments while decreasing FIO_2 to 0.5 or less; serially evaluate hemodynamics at higher levels of PEEP to ensure optimal systemic oxygen delivery

7. **Sedation with/without paralysis** if patient-ventilator dyssynchrony or to reduce "oxygen cost" of breathing effort

8. **Additional supportive measures**
   i) **Diuresis** usually with IV furosemide shots or continuous infusion (according to haemodynamic stability and renal functions) when suspecting pulmonary edema
   ii) **Antibiotics** for chest infection according to culture and sensitivity
   iii) Bronchodilators
      a) Inhalational : ventoline inhaler via ETT, Farcolin or Atrovent nebulizer on ventilator
      b) IV : Aminophyllin and/or steroids
   iv) **Blood transfusion** for low Hct value below 28%

9. Institute chest physiotherapy

10. Begin nutritional support [Ryle Feeding Or TPN]

11. **Bronchoscopy** may be beneficial when postural drainage and suctioning fail to resolve atelectasis because of the presence of tenacious secretions

Renal management

Factors contributing to postoperative renal insufficiency:

1. **Preoperative factors**
   - ❖ Low cardiac output states
   - ❖ Hypotension (cardiogenic shock from acute MI, mechanical complications of MI)
   - ❖ Medications that interfere with renal autoregulation (ACE inhibitors, NSAIDs)
   - ❖ Nephrotoxins (contrast induced ATN especially in diabetic vasculopathy, metformin, aminoglycosides)
   - ❖ Renal atheroembolism (catheterization, IABP)
   - ❖ Interstitial nephritis (antibiotics, NSAIDs, furosemide)
   - ❖ Glomerulonephritis (endocarditis)

2. **Intraoperative factors**
   - ❖ Cardiopulmonary bypass (non pulsatile, low flow, low pressure perfusion)
   - ❖ Low cardiac output syndrome/hypotension after CPB
   - ❖ Hemolysis and haemoglobinuria from prolonged duration of CPB

3. **Postoperative factors**
   - ❖ Low cardiac output states (decreased contractility, hypovolemia, absent AV synchrony in hypertrophied hearts)
   - ❖ Hypotension
   - ❖ Intense vasoconstriction (low flow states, α agents)
   - ❖ Atheroembolism (IABP)
   - ❖ Sepsis
   - ❖ Medications: (cephalosporins, aminoglycosides, ACE inhibitors)

Assessment

- Amount of urine decrease below 0.5 ml/kg/hour for two consecutive hours

- Evaluate serum urea and creatinine. A high urea level, out of proportion of creatinine, indicates dehydration , excessive catabolism or GIT bleeding
- Urine Osmolality above 500 indicates pre-renal factor

Management

1) Ensure that Foley catheter in the bladder and is functioning
2) Optimize cardiac output using a combination of inotropes and vasodilators
3) Optimize the filling pressure by keeping CVP between 8-12 cm water.
4) Check that the CVP line is in place by a chest X-ray
5) Restrict Fluid & potassium intake
6) Adjust drug doses **according to serum creatinine & eGFR.**
7) Give the following medications and wait for the response of each step:
  a) Add renal dopamine at a dose of 3-5 µgm/kg/minute.
  b) Lasix bolus at a dose 40mgs.
  c) Lasix infusion at a rate of 20-40 mg/hour
  d) Stop the Lasix infusion and replace it temporary by 250 ml mannitol 20%+240 mgs Lasix to be infused at a rate of 50 ml/hour. This could be repeated once**.**
8) Albumin 20% (100 ml) + 150 ml normal saline 0.9% or dextrose 5% + 80mg Lasix to be given by IV drip at a rate of 100 ml/hour.
9) If all these measures fail to salvage the patient from the oliguria, initiate haemodialysis after consulting with the nephrologist.
10) Stop all nephrotoxic drugs including Lasix
11) Restrict fluid intake and adjust CVP carefully.
12) Daily sessions is recommended for 4 days then a session every 48 hours is advised after that
13) After 48 hours of initiation of dialysis and if the heamodynamics and filling pressures are optimized, re-start the Lasix infusion again for 24 hours
14) Once the patient passes into the polyuric phase, compensation of hourly urinary output is maintained with Ringers' solution to which calcium and magnesium are added to keep the daily balance positive 500 ml
15) During the whole process monitor the serum creatinine every 12 hours and serum potassium every 4 hours

Indications of dialysis

- Start dialysis as early as possible as this gives the best chance for recovery
- Dialysis is also indicated to control hypervolemia, hyperkalemia or acidosis
- Dialysis is also indicated **in** hyperkalemia even without oliguric renal failure.

Management of low cardiac output

The achievement of a satisfactory cardiac output is the primary objective of post operative cardiovascular management

Important notes to be taken into consideration:

- Low cardiac output states are more common in patients with compromised LV systolic or diastolic function, longer durations of CPB and in women.
- Myocardial function generally declines for about 6-8 hours following surgery
- When marginal ventricular function is present, compensatory mechanisms include sympathetic autonomic stimulation and endogenous catecholamine production.
- When compensatory mechanisms are exhausted, the advanced clinical manifestations of low cardiac output will be noted. These include:
    - Decreased urine output
    - Increased CVP
    - Persistent acidosis
    - Patient irritability
    - Cold periphery
    - Decreased blood pressure
    - Increased heart rate

Etiology

1. Decreased LV preload
    a. Hypovolemia (bleeding, vasodilatation from warming, vasodilators, narcotics, or sedatives)
    b. Cardiac tamponade
    c. Positive pressure ventilation and peep
    d. RV dysfunction: (infarction or pulmonary hypertension)
2. Decreased contractility
    a. Low ejection fraction
    b. Myocardial stunning from transient ischemic/reperfusion injury, myocardial ischemia or infarction
        i. Poor intraoperative myocardial protection

ii. Incomplete myocardial revascularization
iii. Evolving infarction at time of surgery
iv. Native coronary artery or graft spasm

c. Hypoxia, hypercarbia, or acidosis

3. Tachyarrhythmias and bradyarrhythmias
    a. Tachycardia with reduced cardiac filling time
    b. Bradycardia
    c. Atrial arrhythmia with loss of atrial contaraction
    d. Ventricular arrhythmias
4. Increased afterload
    a. Vasoconstriction
    b. Fluid overload and ventricular distention
    c. LVOT following mitral valve repair or replacement
5. Diastolic dysfunction with impaired relaxation and high filling pressure
6. Syndromes associated with cardiovascular instability and hypotension
    a. Sepsis
    b. Anaphylactic reactions
    c. Adrenal insufficiency
    d. Protamine reactions

Assessment

1. Bedside physical examination(breath sounds, murmurs, warmth of extremities , peripheral pulses)
2. ABG (hypoxia , hypercarbia , acidosis/alkalosis), Hct (anemia), and serum potassium (hypo or hyperkalemia)
3. ECG: (ischemia, arrhythmias, conduction abnormalities)
4. Chest x-ray (pneumothorax, Haemothorax, position of ETT or IABP)
5. Urinary output (oliguria)
6. Chest tube drainage (mediastinal bleeding)
7. Echocardiography (transthoracic and or TEE)

Management

1. Ensure satisfactory oxygenation and ventilation
2. Look for non cardiac correctable causes (respiratory, acid-base, electrolytes)
3. Treat ischemia or coronary spasm
4. Optimize preload [CVP 6 – 8]
5. Optimize heart rate at 90-100/min with pacing if needed.

6. Control arrhythmias
7. Assess cardiac output clinically and start inotrope
    a. Adrenaline
    b. Dopamine
    c. Inamrinone/milrinone
    d. Insert IABP
    e. Nesiritide
8. Start vasodilator if the patient is still vasoconstricted or if SVR over 1500 [in patients with Swan Ganz Catheter].
    a. Nitroprusside if high filling pressures and blood pressure
    b. Nitroglycerin if high filling pressures or evidence of coronary ischemia or spasm
9. If blood pressure is low with low SVR
    a. Noradrenalin if marginal COP
    b. Phenylephrine if satisfactory COP
10. Give blood transfusion if Hct less than 26%

Management of hemodynamic problems [Swan Ganz]				
BP	**PCW**	**CO**	**SVR**	**Plan**
↓	↓	↓	↓	**volume**
N	↑	N	↑	**Venodilator or diuretic**
↓	↑	↓	↑	**inotrope**
↑	↑	↓	↑	**vasodilator**
↑↓	↑	↓	↑	**Inotrope/vasodialtor/IABP**
↓	↑	N↑	↓	**α agent**

Treatment of right ventricular failure

1. Optimize preload with CVP of 18-20 mm Hg
2. Ensure AV conduction
3. Maintain adequate systemic perfusion pressure with vasoactive medications or an IABP
4. Lower RV afterload (PVR) and improve RV contractility
    a. Correct hypothermia, hypoxemia, hypercarbia, acidosis

b. Select inotropes with vasodilator properties (inamrinone, milrinone, low-dose epinephrine ,dobutamine)
c. Use a pulmonary vasodilator
    i. Nesiritide
    ii. Inhaled nitric oxide
    iii. Inhaled prostacyclin
    iv. Iv prostaglandin E_1
    v. Adenosine
5. Optimize left ventricular function
6. Mechanical circulatory assist (RVAD) if no response to the above [if available].

Management of cardiac arrhythmias

The development of cardiac arrhythmias following open heart surgery is fairly common

Etiology

1. Cardiac problems
    a. Underlying heart disease
    b. Preexisting arrhythmias
    c. Myocardial ischemia or infarction
    d. Poor Intraoperative myocardial protection
    e. Pericardial inflammation
2. Respiratory problems
    a. Endotracheal tube irritation or misplacement
    b. Hypoxia , hypercarbia, acidosis
    c. Pneumothorax
3. Electrolyte imbalance(hypo or hyperkalemia, hypomagnesemia)
4. Intracardiac monitoring lines (PA catheter)
5. Surgical trauma (atriotomy, ventriculotomy, dissection near the conduction system)
6. Drugs (digoxin, vasoactive medications, proarrhythmic effects of antiarrhythmic medications)
7. Hypothermia
8. Fever ,anxiety, pain
9. Gastric dilatation

General assessment

1. Check the ABGs, ventilator function, position of the endotracheal tube, and chest x ray, for mechanical problems
2. Check serum electrolytes(especially potassium)
3. Review 12 lead ECG for ischemia and a more detailed examination of the arrhythmia

Management of Most Common Arrhythmias:

Sinus bradycardia

- Rate less than 60/min is commonly due to previous B-blockade activity and wanes-off in few hours if not affecting the hemodynamics.

- Rate less than 50 needs immediate attention by:
    1. Stopping B-blocker and Digoxin.
    2. 12-lead ECG to confirm the diagnosis.
    3. Atropine 1 mg IV bolus and see the effect.
    4. Attach patient to external pacing wires if available.
    5. Isoprenaline infusion could be titrated if pacing wires are not available.
    6. If bradycardia persists consider transvenous pacing.

Conduction abnormalities and heart block

- Transient disturbances of AV conduction are noted in about 25% of patients following coronary bypass surgery. They are more frequent when cold cardioplegic arrest is used for myocardial protection, especially when calcium channel blockers are used as additives
    1. Conduction abnormalities are more common in patients with
        a. Compromised LV function
        b. Hypertension
        c. Severe coronary disease(especially involving the right coronary artery in a right dominant system)
        d. Long aortic cross clamp periods
        e. Extremely low myocardial temperatures

        These findings suggest that ischemic or cold injury to the conduction system may be responsible for these problems. Although most resolve within 24-48 hours, the persistence of a new left bundle branch block (LBBB) suggests the possible occurrence of a perioperative infarction.

    2. Conduction abnormalities occurring after aortic valve replacement may be caused by
        a. Hemorrhage
        b. Edema
        c. Suturing
        d. Debridement near the AV node and His bundle

    3. Exposure of the mitral valve by biatrial transeptal approach involves division of the sinus node artery and anterior internodal pathways

Treatment

1. First degree heart block usually doesn't require treatment
2. Second degree AV block
    a. Mobitz type I usually doesn't need treatment unless the ventricular rate is slow. In this situation it can be treated by AV pacing DVI at a slightly faster rate; if the atrial rate is too fast to override, it can be treated by DDD pacing
    b. Mobitz type II, if the ventricular rate is too slow ,AV pacing in the DVI or DDD mode should be used
3. Complete heart block requires AV pacing in the DDD or DVI mode if there is atrial inactivity or a slow atrial rate
4. If heart block persists, the patient's medications should be reviewed. Beta blockers, calcium channel blockers and digoxin should be withheld to assess the patient's intrinsic rate and conduction. If complete heart block persists for more than few days with the patient off these medications, a permanent pacemaker system should be placed.

Sinus tachycardia

It is present when the sinus rate exceeds 100 beats /min generally occurring at rates less than 130.

Etiology

1. Benign hyperdynamic reflex response to sympathetic overactivity
    a. Pain, anxiety, fever
    b. Adrenergic rebound(patient on β blockers preoperatively)
    c. Drugs(catecholamines, Pancuronium)
    d. Gastric dilatation
    e. Anemia
    f. Hypermetabolic states(sepsis)
2. Compensatory response to myocardial injury or impaired cardiorespiratory status
    a. Hypoxia, hypercarbia, acidosis
    b. Hypovolemia, or low stroke volumes noted with small stiff left ventricles with LVH and diastolic dysfunction

c. Myocardial ischemia or infarction
d. Cardiac tamponade
e. Tension pneumothorax

Treatment

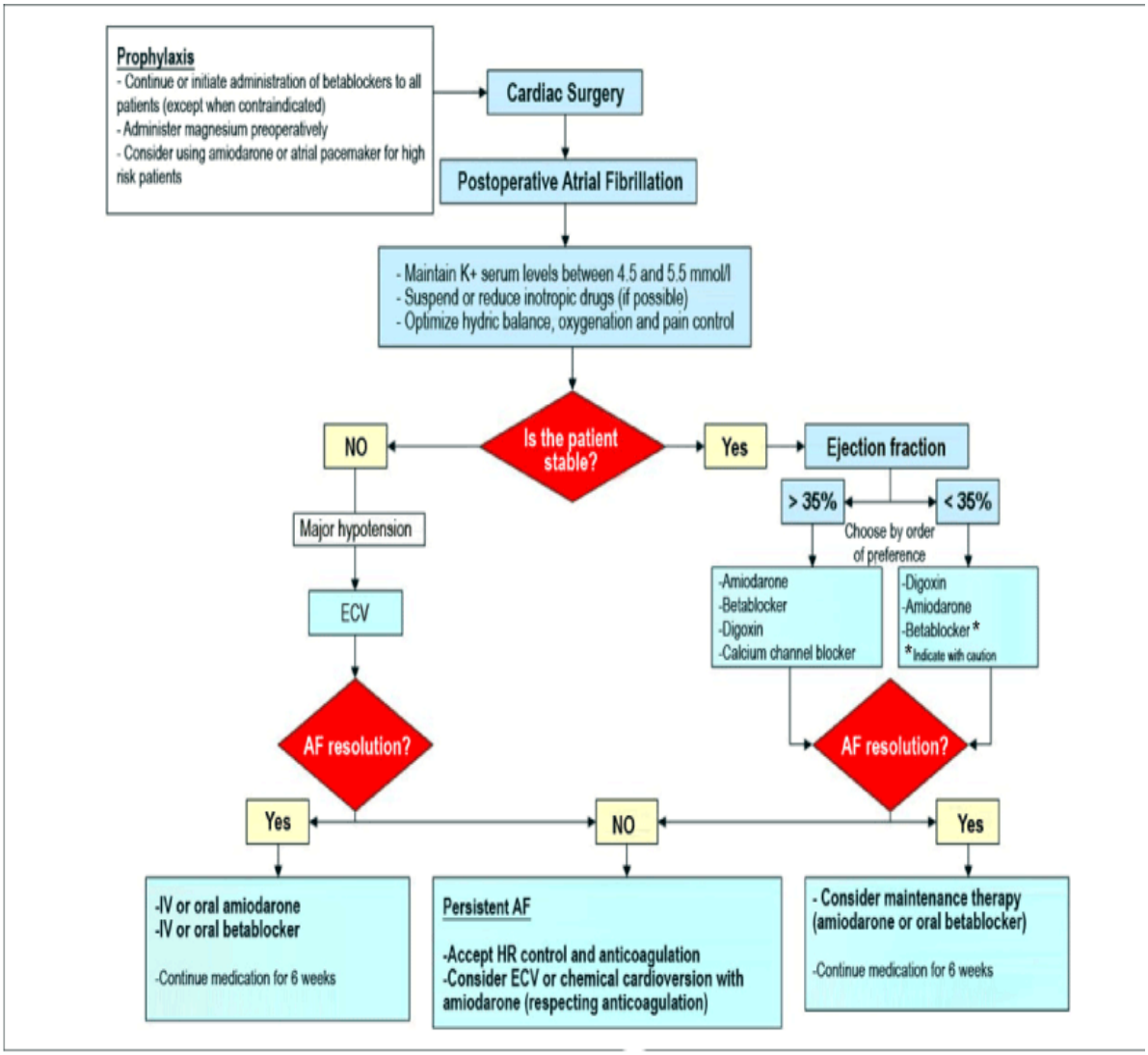
1. Correction of the underlying cause
2. Sedation and analgesia
3. Beta blockers can be used if the heart is hyperdynamic with an excellent cardiac output. They must be cautiously used when cardiac function is marginal:
    a. Propranolol is the first choice here in Egypt provided the other 2 drugs are not available. 1 mg slowly IV over 10 minutes to be repeated when needed provided that blood pressure is not affected.
    b. Esmolol 0.25-0.5 mg/kg IV over 1 minute followed by continuous infusion of 50-200 µg/kg/min. a trial bolus of 0.125 mg/kg is frequently beneficial in determining whether the patient can tolerate esmolol
    c. Metoprolol 5 mg IV increments every 5 minutes for 3 doses
    d. Calcium channel blockers have mild chronotropic effects on the SAN but they don't play a major role in treatment of sinus tachycardia
    e. Both Beta blockers and calcium channel blockers individually are safe to administer intravenously but their simultaneous use should only be considered if functional pacing wires are present.

Atrial Fibrillation or Flutter:

- Most common arrhythmias occurring after open heart surgery.
- Usually present in the second or third day postoperative.
- Incidence of AF is greater in:
    1. Old patients.
    2. History of atrial arrhythmias.
    3. Lung diseases.

4. Right coronary artery stenosis.
5. Valve Surgery.
6. Increased P wave duration
7. Patients not receiving beta blockers before or after surgery.

Algorithm for management of AF:



*Cardioversion [ECV]: 50 – 100 joules.

*Amiodarone will be given as Follows:

Standard IV load [Give 150 mg over 15 minutes followed by 60mg/hr infusion for 6 hours and then 30mg/hr infusions for 18 hours. Oral taper then follows by giving: 400 mg two times daily for 1 week and then 400 mg once daily for 1 week and then 200 once daily for 2 weeks.

Intra-aortic balloon pump IABP

Mechanism:

- The use of intra-aortic balloon pump (IABP) for post-operative myocardial support has proved invaluable in improving the survival of patients undergoing cardiac surgical procedures.
- Despite its invasive nature and potential complications, it provides physiological assistance to the failing heart by decreasing myocardial oxygen demand and increasing 0_2 supply
- It decreases the afterload in front of the failing ventricle and also increases the diastolic coronary flow.

Contraindications:

a. Aortic insufficiency

b. Aortic Dissection

c. Severe peripheral vascular disease (PVD).

Indications:

a. The earlier you insert the IABP the better the outcome of the patient. There is usually a time window for insertion after which insertion might be useless.
b. Planned pre-operative insertion in patients 'with unstable angina or with very poor LV function.
c. Low cardiac output unresponsive to moderate doses of inotropic support.
d. Intractable arrhythmias.
e. Possibility of developing ischemia or infarction.
f. After resuscitation of a CABG patient.

Insertion:

1. Performed by the most senior resident on call
2. Need permission from the consultant in-charge (if unavailable ask the unit Director).
3. Percutaneous sheathless insertion using Seldinger's technique is the rule.
4. CXR should be taken after balloon insertion to determine the site. The metal indicator should be 5 cms below the origin of the subclavian artery to give ideal augmentation.

5. Check pedal pulse by Doppler after insertion.

Setting Up the Machine to Commence Pumping:

1. Connect to main power to ensure the battery is preserved. The battery can withstand pumping for approximately 24 hours (depending on the battery charge).
2. Check the helium tank is open at the back of the pump.
3. Ensure both an ECG and pressure trace can be obtained from the patient on the screen of the IABP. This can be obtained from either direct monitoring or the use of the slave cables taking the signal from the monitor.
4. Frequency: when first commencing, pumping is on 1:1, which means that for each heart beat the balloon, will be inflated. When proceeding to weaning or timing, the frequency is changed.
5. To commence balloon pumping, **Auto mode is our institutional policy**. Otherwise, inflation and deflation points should be set at the midline and then once pumping is established, timing should be reassessed.
6. Connect the extension tubing to the balloon catheter and on the balloon console at the back.
7. Once filled, commence pumping by pressing the assist/standby button. Then increase slowly the augmentation to maximum. This will unwrap the balloon; if done too fast, the balloon may unwrap incompletely. Maximum augmentation is maintained at all times to ensure that the balloon is fully inflated and blood clots are not able to form beside the balloon or in wrapping.

Timing: Auto Mode is the rule, otherwise

a. ECG trigger is the default and should be always used at 1: 1 mode.

b. If heart rate above 120/minute augment 1:2.

c. BP trigger if:

- ECG interference
- B.P. of patient must be above 50 mmHg.

d. Pacing mode for paced patients.

e. Internal trigger during cardiac arrest with no ECG.

Anticoagulation

a. All patients with IABP should be considered for anticoagulation with IV heparin infusion (according to PTT to be double the normal) to prevent systemic emboli.

b. Anticoagulation could be delayed until the drains are acceptably dry.

c. Anticoagulation is essential when the IABP has been in place for more than 48 hours. If heparin is contra-indicated because of residual bleeding, start clexane.

Orders Which are given to nurses after insertion:

1. Record Hourly hemodynamics
2. Check pedal pulse by Doppler every hour.
3. Patient is Nursed supine at 30^{o} elevated (ensuring that the leg which has the balloon inserted through the groin is straight at all times, avoid bending it).
4. Note hourly urine output to indicate an early sign of IAB catheter migration.
5. Daily CXR to monitor position of IAB catheter
6. Observe insertion site for infection and bleeding.
7. Observe and maintain normal coagulation and electrolyte balance
8. Monitor and observe the external tubing from the catheter to pump for any condensation or bloodstains.
9. Ensure patient is quiet and relaxed with minimal movement around the bed.
10. DO NOT HESITATE TO Ask for Sedation If required.

Problems and complications with IABP

a. Inability to balloon.

- Disconnected ECG leads.
- Rapid rate: adjust rate to 1:2 if heart rate above 120/minute.
- Arrhythmias: Control arrhythmias. .
- Volume loss from the balloon due to leak in the system – check connections and check with technician.
- Balloon rupture when blood appears in balloon tubing – replace balloon. If the Balloon is inserted through a sheath, it will not get out through the sheath when ruptured. You have to remove the sheath together with the balloon.

b. Vascular complications.

- Distal ischemia in the limb of insertion.
- Distal embolization in the contra-lateral limb, bowel or renal.
- Catastrophic aortic dissection.

***** Remove the balloon in the above situations. *****

d. Thrombocytopenia: Platelet destruction due to continuous inflation and deflation of the balloon.

e. Wound infection.

f. Pseudo-aneurysm of femoral artery.

g. Lymphorea.

Weaning criteria:

- Inotropic support should not be more than 100 ngm/kg/minute adrenaline or 10 µgm/kg/minute dobutrex.
- Systolic blood pressure must be more than 90 mmHg.
- Heart rate less than100/minute.
- Urine output more than 1ml/kg/hour.

Protocol For Weaning

- Decrease frequency to 1:2 for two hours.
- Decrease frequency to 1:3 for two hours.
- Decrease augmentation to 50% for one hour.
- Put the patient on fluttering (1: 1 with minimal augmentation) for one hour.
- Stop heparin infusion 1 hour of fluttering at least.
- Remove the balloon and compress for 1 hour.
- Put bandage compression for 4 hours before allowing the patient to mobilize.

Discharging patient from the ICU

Usually the patient is discharged from the ICU 24 hours following surgery. Discharge is usually to the Ward. Patient is discharged to the intermediate care in the following conditions:

1. Patient still need the drains for few hours.
2. Patients on minimal support and needs time for weaning.
3. Patient needs special nursing help and medically stable. Patient is not discharged from the ICU under the following conditions:

- Patient ventilated
- Patient unconscious.
- Patient on IABP
- Patient on high support.
- Patient with uncontrolled arrhythmias.

Commonly prescribed medications after discharge from the ICU:

Antibiotics: according to the department protocol.

Pain killers:

Paramol 500 mgs tabs: 2 tablets every 6 hours
Catatlam 50 mgs tabs: 1 tablet every 8 hours after meals

Anti-ulcer:

Zantac 150 mgs tabs: 1 tablets every 8 hours
Omeprazole 20 mg capsules: 1 capsule every 24 hours for patients at high risk of GIT bleeding.

Laxative:
lactulose syrup 10 mls orally every 12 hours for all patients for 48 hours to prevent constipation and straining.

Nebulizer:

a. Saline nebulizer: Every 6 hours for 10 minutes for all patients during the first 48 hours.

b. Sulbutamol or Atrovent nebulizer For patients with severe Bronchospasm every 6 hours. It can induce AF in· susceptible patients.

For CABG with good LV function

Beta Blocker:
Concor 5 mg: 2.5 - 5 mg every 12 hours according to heart rate and blood pressure.

Calcium channel blocker:
Altiazem 60 mg: 30 - 60 mgs every 8 hours is mandatory for all patients with radial artery grafts. Start the first dose immediately after extubation.

Antiplatelets:
Aspirin: 150 mgs after lunch (start as early as possible post-operatively).
Plavix: 75 mgs after lunch is added after end-artrectomy or on-demand for patients with poor vessels or after patch angioplasty of the LAD
Persantin: 75 mgs every 8 hours. For patients with Aspirin sensitivity. .

Nitrates:
Effox: 20 - 40 mgs every 12 hours is used in patients who are under vascularised due to bad targets.
Nitroderm patch 10 mg:. 1 patch for 18 hours daily. Used for patients with total arterial grafts for the first 48 hours only.

Diuretics:
Lasilactone: 50-100 mgs orally once daily for 48 hours. Duration is increased for patients with congested chest Xray.

For CABG with poor LV function

Diuretics:
Lasilactone 100 mgs :100 mgs orally once daily.

Burinex 1 mg: 1 mg at 5 p.m. once daily in cases needing more diuresis.

Alfa - Beta Blocker:
Dilatrol 6.25 mg orally once or twice daily according to blood pressure and heart rate.

ACE Inhibitor:
Capoten 25 mg tablets: 6.25 - 25 mgs every 8 hours according to blood pressure.

Digitalis:
Lanoxin 0.25 mgs: orally once daily. It will help in controlling the heart rate especially if the patient goes into AF.

Nitrates:
Effox 20 - 40 mgs orally every 12 hours especially if the patient is under vascularised.

For mitral valve replacement

Anticoagulant:
Marivan 1, 3 or 5 mgs tablets: Start with 3 mgs daily from the first day post-operatively. Subsequent doses guided by INR to maintain between 2.5 - 3.5.

Diuretic:
Lasilactone 100 mgs :100 mgs orally once daily.

ACE Inhibitor:
Capoten 25 mg tablets: 6.25 - 25 mgs every 8 hours according to blood pressure.

Digitalis:
Lanoxin 0.25 mgs: orally once daily. It will help in controlling the heart rate especially if the patient goes into AF.

For aortic valve replacement

Anticoagulant:
Marivan 1, 3 or 5 mgs tablets: Start with 3 mgs daily from the first day post-operatively. Subsequent doses guided by INR to maintain between 2 - 3.

Beta Blocker:
Concor 5 mg : 2.5 - 5 mgs every 12 hours according to heart rate and blood pressure .

Highlights on oral anticoagulation:

Indications:

a. For mechanical valve replacement.

b. For tissue mitral valve replacements and mitral valve repair rings in first 3 months .

c. For chronic or paroxysmal AF.

d. Following pulmonary embolism or recurrent DVT.

e. LV aneuresmectomy or endarterectomy (for 6 months).

Precautions:

1. All patients should have extensive instructions by the resident in charge. The patient should be given the pre-printed chart and given the date of the next test on discharge from hospital.
2. Mitral valve replacement patients should have INR between 2.5- 3.5.
3. All other patients should have an INR between 2 – 3.
4. Observe interactions:
    - Liver disease.
    - Chronic simvastatin use
    - Chronic amiodarone use.
    - Use of NSAID drugs.
    - Use of aspirin.

Highlights of patient management in the ward

1. The vital signs are taken and recorded in the ward nursing chart.
2. A 12-1ead ECG is recorded and the doctor-in-charge revise and sign it.
3. A blood sugar test (haemotest) is performed and recorded.
4. The nursing notes are initiated.
5. The patient is allowed to sleep for a couple of hours after giving him any scheduled medications.

Rounds:
A daily round is carried out by the senior resident at 8.00 a.m. daily. He is accompanied by the head nurse of the ward and the junior residents. The junior resident is responsible for documenting all the progressive notes for all patients. The senior resident is responsible of writing all the medication change in the drug, reviewing the investigations and informing the consultant daily with the progress of his patients. An evening round is performed daily by the residents at 8 p.m. to ensure the implementation of the morning standing orders.

Wound Care:

1. The nurse is responsible for the dressing of patients with clean wounds.
2. The clean wounds are kept exposed after 48 hours.
3. The resident is the only one allowed to dress and assess the patients with infected wounds.

Nursing Care:

1. The first 24 hours the patients vital signs are recorded every 4 hours.
2. From the second day in the ward, the patients' vital signs are recorded every 6 hours.
3. Haemotests are performed every 4 hours for diabetic patients for the length of their hospital stay.
4. Haemotests are performed every 8 hours for non-diabetic patients for the first 48 hours only.
S. Early mobilization is encouraged from the day of arrival to the ward with gradual increase in effort to be able to walk at least 10 minutes unassisted prior to discharge.
6. A shower is given to the patient daily if his wound is clean.
7. Patients with minimal discharge should be also showered daily with a precaution of covering the discharging area before the shower and re-dressing the wound by the nurse after the shower.

Respiratory care:

Oxygenation is impaired in the first few days following surgery due to:
1. Fluid overload.
2. Chest pain leading to atelectasis.
3. Minimal pleural effusion leading to localized atelectasis.
4. Bronchospasm leading to atelectasis.

This can be improved by:
1. Early mobilization.
2. Chest physiotherapy with adequate analgesia.
3. Saline nebulizer every 6 hours for the *first* 48 hours.
4. Ventoline and atrovent nebulizer in cases of severe bronchospasm.
S. Mucolytic **in** the form of Acetyl Cystiene Sachets every 8 hours in cases of thick secretions.
6. Follow-up chest X-ray for patients with dyspnea to exclude:
    - Increasing pleural effusion that will need aspiration.
    - Increasig congestion in the lungs that will need to add or increase diuretics.
    - Pneumothorax that will need chest tube.

Highlights of Common problems in the ward

Postoperative fever

Fever up to 38 degrees Celsius in the first 48 hours following surgery is reactionary and normal finding and warrants treatment only by antipyretics. If fever outside this scale then consider:
1. Check chest clinicaIIy for evidence of secretions.
2. Chest X-:ray.
3. Sputum C &. S.-
4. C.B.C.
5. If valve patient, send blood cultures and sensitivity.
6. Check leg wounds.
7. Check chest wound.
8. Consider pericardiotomy syndrome
9. In cases of valve patient keep close eye on temperature chart and frequent blood cultures.

Moderate to severe pleural effusion:

a. Mild effusion: 2 spaces on the left side is a normal finding after LIMA harvest and warrants no treatment.

b. Moderate to severe effusion unilaterally is usually reactionary and recovers spontaneously, however, if it caused increased dyspnea should be treated by increasing diuretics and if failed, by drainage.
c. Immediate aspiration could be performed under complete aseptic condition by the resident in cases of moderate or severe effusion causing dyspnea to the patient.
d. The aspirate should be send for culture and sensitivity.
e. An X-ray should be ordered immediately after aspiration and if satisfactory the patient discharge could be processed and asked to repeat the X-ray after 2 weeks in the out-patient clinic.
In case of unsuccessful aspiration, arrangement of chest tube insertion under complete aseptic conditions in the intermediate care unit after informing the consultant in charge of the case.

INR not adjusted:

a. In cases of mitral prosthetic valve, INR should be kept 2.5 – 3.5.
b. In cases of prosthetic aortic valve or AF or any other indications of using marivan, INR should be kept 2 - 3.
c. Immediately after surgery, and after confirming minimal drainage from chest tubes, the patient is given Clexane 60-80 mg/12 hours s.c. for 48 hours or until the INR reaches target levels. .
d. If the patient was on Marivan pre-operatively, the patients is started on the same dose as the preoperative dose; otherwise start 3 mgs daily and titrate according to INR in the dedicated chart.
e. Once the INR is adjusted, the patient is allowed home and asked to come to the outpatient clinic after one week with new INR result. .
g. Patient education about the importance of the INR is the responsibility of the resident.