Perioperative Haemodynamic Monitoring In Cardiac Surgical Patients & Nurse Interventions: Policy Review

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ABSTRACT
This paper stresses the role of the anaesthesiology nurse in the monitoring of the patients' haemodynamic status. As a Policy review it focuses on nursing practice, in the cardioanaesthesiology department. Pubmed search keys were <Anaesthesia nursing care>, <Electrocardiogram >, <Haemodynamic monitoring >, <Invasive pressure, Non-invasive pressure>, <Pulse oxymetry>, <Pulmonary artery catheter>, < Transesophageal echocardiography>. Out of the one hundred twenty five papers were found, fifty were included in this review. Exclusion criteria were non-English papers and publication date later than 1993. Results: The preparation and the management of all the necessary equipment, which will be used during the operation and the procedures for the monitoring of the electrocardiogram (ECG), the pulse oxymetry (Sp02), the arterial blood pressure (AP)-invasive and non invasive method- as well as the introduction of the pulmonary artery catheter (PAC) and the transesophageal echocardiogram (TEE) are aforementioned. The interpretation and dealing with the data and the detection and prevention of possible complications as part of the nurses' work are understressed. Conclusion: The anaesthesiology nurse works on models of expert nursing care by providing optimal quality services for the greater safety of the cardiac surgical patient.

Key words:
• Anaesthesia nursing care • Electrocardiogram • Haemodynamic monitoring • Invasive pressure , Non-invasive pressure • Pulse oxymetry • Pulmonary artery catheter • Transesophageal echocardiography

Statements of:
What is already known about the topics?
• The existence of an ill recognized anaesthesia nurse skill
• Existence of various monitoring methods

What does this paper add?
• Nursing role in the preparation of the operating theatre.
• Nursing role in the advanced monitoring of the anaesthetized patients.

Introduction

The anaesthesia specialty fills the gap of the need for continuous monitoring of the vital parameters and their minute-to-minute variations during the course of the operation.

Nowadays, the application of various monitoring techniques, in everyday practice has lead to a more effective treatment of patients with many, until then, unpredictable fluctuations of their general condition. It has also allowed for a more comprehensive evaluation and prevention of the treatment side effects. (Boldt, 2002; Pinsky and Payen, 2005)

The 1970s' was declared as the decade of invasive monitoring. The need for continuous monitoring of the patient's haemodynamic parameters is determined by the clinical status and the severity of the surgical procedure. (Sandham, 2003)

During cardiac surgery, continuous recording and monitoring of the patients' cardiovascular parameters is done by the attending anaesthetist and the expert nurse. Cardiac surgery demands a more specialized haemodynamic monitoring, namely continuous electrocardiography, pulse oxymetry, invasive and non-invasive blood pressure monitoring, use of pulmonary artery catheter and transesophageal ultrasonography.

Therefore, the aim of this review is to understress the essential role of the anaesthesiology nurse in the cardioanesthesiology department in the monitoring of the patients' haemodynamic condition. This aims to improve the quality of the services provided for the patients' greater safety, and additionally the provision of specialized nursing care.

I. Electrocardiogram

The electrocardiogram (ECG) is a safe, non-invasive monitoring method of heart rate, and detection of arrhythmias, myocardial ischemia, conduction disorders and pacing disturbances perioperatively. (Meek, 2002)

The depolarisation and the repolarisation of myocardial cells produce electrical potentials which are recorded on the body surface. The body surface electrodes detect the depolarization of myocardial cells by measuring the potential difference between the electrodes.

I.I. Placing the electrodes

On arrival in the operating theatre, an O2 mask is fitted and the patient is connected to an ECG monitor.

The electrodes are placed in specific positions on the surface of the body. The electrodes of the arm are placed on the shoulders as close as possible to the point where the arm and the trunk are connected, whereas the lower limb electrodes are placed in the midaxillary line or above the hips. (Jacobson, 2003)

The electrodes are coloured. For the right shoulder the electrode has red colour, for the left shoulder is yellow. The left leg is encoded with green colour; the right leg with black and for the precordial electrode, the white colour is used. Also, the electrodes are marked by the initials of the placement sites (RA, RL, LA, LL, V). The coding simplifies the nurse's work and avoids improper placement. A false cable connection will cause morphological changes in the electrocardiogram. (Velisvan, 2007; Rudiger, 2007; Conrath, 2007) The 12 lead ECG is the most important detector of acute myocardial ischemia. (Finlay, 2007; Jahrs, 2005) It is also important to connect the patient to a defibrillator via 3 limb leads, as cardiac surgery patients have a high incidence of fatal arrhythmias. (Wahr, 1999)

In reoperations and high risk patients, an intraaortic pump is also connected via 5 leads.

I.2. The selection of parameters

The choice and the number of the monitoring leads determine the diagnostic sensitivity. Ideally, leads II and V5 monitored. Lead II is used for rhythm recognition and detection of inferior wall ischemia. Lead V5 is invaluable for detecting anterior wall ischemia. (Klic, 2007) Continuous monitoring is necessary. Arrhythmogenic factors include endotracheal intubation, central venous catheter insertion and electrolyte disturbances. (Szaho, 2003)

The automated analysis of ST segment on the monitor is considered necessary in cardiac surgery patients, since disturbances are frequent. Changes of the ST segment and the T wave are an early sign of myocardial ischemia, such as ST elevation of more than 1mm or reversal of the T wave. (Hersi, 2003)

The 12 ECG lead monitoring and the analysis of the ST segment offer an overview of the heart function. (Enseleit, 2006; Adams-Hamoda, 2003) The automated analysis of the Q-T space is currently available in the latest generation of monitors, indicative of ventricular arrythmias. (Drew, 2004)

I.2. Interference reduction

One of the possible causes of a pathological ECG is the artefacts, and it is essential to be removed in order for an accurate reproduction and a recording of ECG signal to be achieved. For this purpose, a good contact between the electrodes of the surface and the patient is to be assured, by cleaning and scrubbing the skin with alcohol, in order for the desquamated cells to be removed, by shaving if necessary, or by using an inductive cream. The electrodes are placed on a dry skin surface and not in a moist one, as the resistance increases. The correct position of the electrodes is selected, the one that allows them to get the maximum of the heart's electrical signal. It is selected in a bony surface and not in areas with loose skin. The protection of the electrodes with adhesive tape is required, if they are located near to the surgical field in order not to get wet. (Conrath, 2007; Duffy-Gross, 1997) (Table 1)

2. Pulse oxymetry

The pulse oxymetry (SpO2) is a simple, non-invasive monitoring method of the percentage saturation of haemoglobin with oxygen. Pulse oxymetry is considered to be an essential monitoring parameter in patients who are to be operated on. (Jubran, 1999)

Immediately following the ECG placement, the pulse oxymetry is applied as patients are often premedicated and thus sedated.

2.1. Contraindications and precautions

There is no absolute contraindication for the pulse oxymetry. There are some cases where the measurements can be interpreted incorrectly and the nurse must be able to act accordingly. (Havell, 2002) Diminished peripheral blood flow produced by peripheral vasoconstriction, hypovolemia, severe hypotension, hypothermia, heart failure, shock, cardiac arrest provide poor or no signal, as movement produces artefacts (Monnet, 2005) Increasing levels carbomonoxyhaemoglobin and methaemoglobinaemia show falsely elevated levels of SpO2. The use of methylene blue in surgical procedures, can lead to falsely low levels of SpO2. (Respir, 1999) Having an arterial line inserted is wise as the presence of a blood pressure cuff for the direct measurement of arterial blood pressure in the same limb the sensor has been placed, results in intermittent cessation of blood flow. The exposure of the photo detector to strong ambient light should be avoided. (Fearnley, 1995) Blue, black or green nail polish hue all affects the pulse oxymetry. (Rodden, 2007) Very small fingers or very large nails may cause difficulty in applying the probe. Skin pigmentation usually does not affect the accuracy of pulse oxymetry. However, the pulse oxymetry may be affected in patients with fairly dark skin. The pulse oxymetry is accurate in haemoglobin levels to 2-3g / dl. (A greater degree of anaemia affects reading by 0.5% only). (Attin, 2002)

2.2. Nurse interventions

Select the appropriate sensor in relation to the size of the patient. There are disposable sensors, for infants, children and adults depending on their size. The most common position for adults is the index finger. In patients with long nails the sensor is applied to the lateral surfaces of the finger.

The accuracy of the measurements depends on the proper placement of the sensor. The two light sources must be facing the photo detector. The sensor must be well secured as access to it during surgery is difficult. (Tschupp and Fanconi, 2003)

2.3. Instructions in case of problems

In case of measurement difficulties, care must be given to the circulation, capillary refill, colour and temperature of the measuring site. Re-examine the sensors' correct position. Reduce the light of the environment (e.g. Operating Lights) covering the probe square. If the problem continues, try changing the position, the type of sensor or test the cable connection to the monitor. (Hill, 2000) (Table 2)

3. Invasive and non-invasive measurment of the arterial pressure

The blood pressure is a general indicator of the function of the cardiovascular system. There are two methods for measuring the blood pressure (AP): a) the invasive and b) non-invasive.

3.1. Non-invasive measurement of blood pressure

In all patients, undergoing surgery, a non-invasive measurement of the arterial blood pressure is required. (Hoover, 2000)

3.1.1. Techniques of measurement

The indirect measurement of the blood pressure is done by using an inflatable cuff device. The pressure cuff is wrapped around the arm or the leg and the bladder inflates in order a pressure to be created, compressing the underlying artery. Then the cuff is being deflated slowly, allowing the circulation of the blood to the compressed artery. The blood pressure is defined either by detecting sounds, which are produced, (auscultatory method) or by recording the arterial pulse (oscillometry). (Pickering, 2002) (Table 3)

3.1.2. Dimensions of the pressure cuff

In order for the best pressure recording to be ensured, the cuff should be homogeneously inflated over the underlying artery. This depends on the size of the bladder in comparison to the size of the limb. Its' length should be at least 80% and its width should be at least 40% of the circumference of the upper limb. If the size of the cuff is very small in reference to the perimeter of the limb, the measurements of the pressure will be falsely high, while the opposite occurs with the larger cuff. (Bur, 2003)

3.1.3. Disadvantages-contraindications

Disadvantages of the technique include the delay and even the failure in measurement, caused by movement, arrhythmia, bradycardia, etc. Inaccurate readings are custom in overweight patients. Under ideal conditions, bloodless methods tend to underestimate the systolic pressure and to overestimate the diastolic. (Araghi, 2006) Particular attention is paid in applying the cuff, the tighter will record falsely high pressure, the looser one will record the AP lower. (Bur, 2000)

The cuff should not be placed at the same with the intravenous line limb, because the flow is interrupted during measurement, while blood reciprocates in the infusion line. Also, the pulse oxymeter is not placed at the same limb with the pressure cuff, because the tracing ceases during pressure measurement.

3.2. Invasive measurement of the blood pressure (AP)

The invasive measurement of AP requires the cannulation of a peripheral artery and provides a beat by beat reading of the blood pressure. Indications for the cannulation of the peripheral artery are the accurate and the continuous monitoring of blood pressure, the continuous monitoring of the response to vasoactive drugs and the frequent arterial blood sampling for the measurement of the arterial blood gases.

3.2.1. Puncture sites for the placement of the arterial catheter

The puncture sites for the placement of the arterial catheter depend on the surgical procedure and on the anaesthesiologists' preference. The right radial artery is the most commonly selected position for the cannulation because the vessel is superficial and easily accessible, it accepts retrograde blood flow from the ulna artery and the accuracy of the recordings is not affected by the manipulations done for the internal mammary grafting. Arterial access follows the venous one. (Mignin, 2006)

3.2.2. General precautions for vascular access

The following recommendations are applied during the placement of vascular catheters:

The hands must be washed before the placement of the vascular catheter. Protective gloves must be used in all cannulations. Surgical gown and protective glasses are not necessary, unless droplets of blood are expected to be spilled. These measures do not reduce the incidence of sepsis, associated with the catheters. The recapping and removal of the needle from a syringe by hand are avoided. The sharp objects are put immediately after their use in a special plastic container. (Rossoll, 1999)

3.2.3. Measurement System

After the placement of the arterial catheter, the catheter is connected with the system, which includes heparin solution pressurized to 300 mmHg, a flush device, stop-cocks, tubing and a transducer.

To ensure accuracy of the hemodynamic values obtained from the transducer system, the nurse must level, zero and check the mechanics of the system.

Levelling is performed to eliminate the effects of hydrostatic pressure on the transducer. The transducer should be in level with the right atrium (at the point where the midaxillary line meets the 4th intercostal space). The levelling should be done prior to zeroing and calibration, before and after connecting the pressure system to the patient and after any significant changes in patient's haemodynamic variables. (Duffy-Gross, 1997)

Zeroing is performed to eliminate the effects of the atmospheric pressure on the transducer. Zeroing should be performed before and after connecting the pressure system to the patient, after any levelling, and whenever there is a significant change in the hemodynamic variables. (Ahrens, 1995)

Wave test (square wave), is a quick flush of the catheter-tube system, done to determine if the monitoring system can accurately reproduce patient's cardiovascular pressures. It identifies problems such as: air bubbles, kinking in the tubing, loose connections, catheter potency, length etc. (Ghee, 2001) (Table 4.5)

3.2.4. Complications of the arterial pressure measurement

Air embolism can occur when the tubes and the transducer are not thoroughly flushed before connected with the arterial catheter. If the connections are loose or the catheter is dislodged there may be severe loss of blood. Imprecise measurements of pressure occur from a wrong placement of the pressure's transducer, if the zeroing isn't accurate, if there are air bubbles in the system. Dumping of the waveform occurs when the tip of the probe touches the inner surface of an artery or when blood clot is formed, when the probe bends or if air is in the system. Infection can occur, unless an aseptic technique is followed or if there are. (Ahrens, 1995; Ghee, 2001; Beate, 2000)

4. Pulmonary artery catheter

In the late 70's HJG Swanz and W. Ganz developed a special catheter which carried at the end an air cuff, which enabled it to be driven by the blood flow to the pulmonary artery.

Despite the initial widespread use of the catheter, nowadays it is not generally recommended. The pulmonary catheter plays a central role in the management of high risk patients. (Kaluski, 2003)

The cannulation of the pulmonary artery is usually done after the induction of anaesthesia, or depending on the clinical status of the patient it is done so in advance.

4.1. Central venous access

The accessing sites for the insertion of the pulmonary artery of the catheter are multiple. The choice of the position depends on the type of the surgery and on individual preferences. The right internal jugular vein is the most commonly central access site in the cardiosurgical patients, because it is easily accessible and leads directly into the right atrium. The left internal jugular vein is the most common alternative choice. (Hocking, 2002)

4.2. Basic characteristics of the catheter

The pulmonary artery catheter is a flexible catheter of multiple lumens, carried by the blood flow to the pulmonary artery. There are usually four ports:

The proximal port is approximately 25cm from the tip of the catheter. It lies in the right atrium when in place and measures the central venous pressure (if linked to the pressure's tranducer). It can be used for the infusion of IV solutions or drugs, for blood sampling, for the injection of cold solution of known volume for the measurement of the cardiac output. It is coded with a blue colour.

The distal port is known as the lumen of the pulmonary artery. It measures the pulmonary artery and wedge pressure. It can be used for the sampling of the mixed venous blood but should never be used for injections. It is coded with yellow colour. (Pinsky, 2007)

The thermistor is a lumen at the end of the catheter. It connects the pulmonary catheter with the monitor for the measuring of the cardiac output. A special wire transmits the temperature of the blood. It is yellow coloured and carries a red adaptor.

The balloon port is located at about 1cm from the tip of the catheter. When the balloon is inflated with approximately 0,8 -1,5 cc air, it wedges in the pulmonary artery to give a wedge tracing. The balloon is always inflated with air and never with liquid. When deflated, turn the stop-cock to the off position and leave the syringe connected to the port. It is red coloured. (Rogers, 1999)

4.3. Introduction of pulmonary catheter

Before the introduction of the pulmonary catheter the surgical table is placed in a Trendelemburg position at an angle of 15o -20o in order for the pulmonary valve to be at a higher level. (Szaho, 2003) The pulmonary artery catheter is inserted through an introducer which has been placed in the right internal jugular vein. The proximal port is connected to the pressure measuring system. When the PA catheter enters by 20 cm, namely at the junction of the superior cava vena and the right atrium, the balloon is inflated to head in the direction of the right ventricle and the tricuspid valve. The balloon's inflation allows the catheter to flow from the right ventricle (30-35cm) to the pulmonary artery (40-45 mm).

During the introduction of the catheter the ECG must be continuously monitored. The waveform of the arterial pressure and the pressure recording from the cavities, from which the tip of the pulmonary catheter passes, must be also continuously monitored. The constant monitoring of the waveform determines the terminal position of the catheter. (Mathews, 2007; Amin, 1993) (Table 4, 6)

4.4. Measurement of the parameters

Through the pulmonary catheter the following parameters will be measured: the cardiac output and the saturation of mixed venous blood.

4.4.1. Measurement of the cardiac output

For the measuring of the cardiac output with the thermodilution technique, a bolus of cold or room temperature injectate is given rapidly (2-4 sec) through the proximal port of the catheter. This bolus of cold injectate produces a variation in pulmonary artery blood temperature which can be sensed by the thermistor and is dependent on right ventricular output at the time of injection. For each assessment of the cardiac output three successive measurements are recorded. (Renner, 1993)

The cardiac output (CO) is more accurate when the solution's volume is 10ml and its temperature 0oC. (Boldt, 1994) (Table 6)

Monitors of new generation are capable of measuring the cardiac output from the invasive arterial pressure recording, analysing its waveform. The cardiac output appears by multiplying the pulse rate and the estimated stroke volume, as determined by the pressure waveform.

4.4.2. Measurement of the saturation of the mixed venous blood (SVO2)

Another function of the pulmonary catheter is the calculation of the O2 consumption by recording the O2 saturation of the mixed venous blood. The determination of SVO2 is done by taking a sample of blood from the pulmonary artery catheter when wedged or through a special catheter, which bears a special fibber channel for continuous determination of the saturation. (Surum, 2004)

The sampling of mixed venous blood is done after discarding the initial 5 ml of blood rich in heparin. Then, a 2.5 ml syringe is applied and 1 ml of blood is aspirated. The aspiration should be done slowly at all times. In this way, mixing of the mixed venous blood with oxygenated blood from the pulmonary circulation is avoided. (Rossoll, 1999) (Table 6)

5. Transesophageal echocardiography

The transesophageal echocardiography is a bloodless method of haemodynamic monitoring. It provides valuable information about cardiovascular anatomy, myocardial and valvular function and various haemodynamical abnormalities. (Click, 2000) It contributes increasingly more and more in the better assessment of the patients, affecting their treatment either from the anaesthesiology or from the surgical side. (Couture, 2000)

5.1. Probe

A main care of the nurse is the maintenance and the storage the probe. The transducer is very sensitive and in order to avoid any damage special attention is required during its use. Great attention must also be paid during the introduction in the oesophagus, where it must be in a neutral position; unlocked and any unnecessary manipulations must be avoided. The manufacturer's instructions, regarding the disinfection, must be also followed, in order to avoid contamination.

Before the introduction of the probe at the oesophagus, a careful check at the outer lining must be done for possible damage, deficits and cuts from bites so to avoid mechanical, thermal or electrical damage to the patient. Recognize any contraindications. At the same time, check whether the probe's handler operates and is in the unlocked position.Also, in accordance with the manufacturer's recommendations, a sterile transparent cover is placed over the probe (an additional precaution in order to avoid infection).

The introduction of the probe in a patient with anaesthesia is technically easier.The head of the patient must be placed in middle and slightly flexed position.The tracheal tube should be positioned in one of the angles of the mouth, so that there is enough space for the introduction of the probe.The oral cavity and at the condition of the teeth are checked.The placement of endoscopic airways will prevent an abrasion at the probe from the teeth.The flexible edge of the probe is lubricated with lidocaine gel, it is introduced and then it is headed blindly in the middle line of the rear part of the pharynx.At the same time the lower jaw is lifted upwards. Often, the use of the laryngoscope is necessary for the introduction of the probe in the oesophagus. (Papadopoulos, 2005)

After each use, the probe is checked for damages, is then washed with water and enzymic detergent for the removal of secretions and is then put in a special disinfectant solution. Through this process viral and bacterial organisms are destroyed.

At the end of this process, the endoscope is washed with distilled water and it is dried well. At its edge a protective sponge cover is placed. It is hanged for storage. (Taillefer, 2002) (Table 7)

6. Conclusion

The advent of Anaesthesiology was inevitable and was done not only thanks to knowledge and the progression of modern technology, but also in a large part due to specialized nursing care.

The anaesthesia nurse is a valuable and skilful partner of the anaesthesiologist, works on models of expert nursing care by providing optimal quality services for the greater safety of the cardiac surgical patient.

Table 1. Electrocardiogram monitoring to the cardio surgical patient

OPERATIVE PREPARATION

Equipment • ECG monitoring device (monitor) • Defibrillator • Intraaortic pump (if requested) • Single use adhesive electrodes (8 or12)

PROCEDURE	RATIONALE
Please check the monitor, connect to mains supply	Power failure
Check all ECG cables	May be damaged, kinked
Monitor's calibration	
Set the monitor in order to enable continuous recording of leads II and V5 , possibility of 12 lead ECG monitoring and possibility of automated analysis of ST space in relation to time	Leads II and V5 help for the diagnosis of complex arrhythmias, myocardial ischemia. ST space analysis for diagnosis of ischemia
Set monitor device so that the sound of QRS can be heard	Change in rhythm to be detected
Connect the 5 lead cables	Electrodes coded with different colours Red for the right shoulder • Yellow for the left shoulder • Black on the right leg • Green on the left leg • White for the precardial electrode Application site initials shown on cable ECG (RA, RL, LA, LL, V)
Place 3 lead cables of a defibrillator	The cardiac surgical patients have a high possibility of dangerous to life arrhythmias
Place 5 lead cables ready to connect to intraaortic pump (if is requested by the anaesthesiologist)	Placed in reoperations and high risk patients, where there is a possibility of mechanical support after the cardiopulmonary bypass.

PREOPERATIVE PREPARATION

PROCEDURE	RATIONALE
Apply the electrodes pads to dry skin	Minimize the resistance
Do not use electrodes pads which the conduct gel is dried out	Creates strong resistance
Use induction cream - gel	The conductive gel lowers the skin's electrical and permits good electrical contact
Place the electrodes over bony rather than in areas with loose skin	Loose skin can create contraction artefacts .
Seal the electrodes dry	Artefacts - detachment
Place 3 electrodes pads in the right shoulder or 5 if is requested intraaortic pump	The two electrode pads are connected with the monitor, one with the defibrillator and the other two will be connected to the intraaortic pump.
Place 2 electrodes in the left shoulder or 3 if requested intraaortic pump.	One electrode pad is connected to the monitor, the other with the defibrillator and the third will link to the intraaortic pump
Place 3 or 5 electrodes pads if is requested intraaortic pump	Two pads connected with the monitor, the other with the defibrillator and the other two will be connected with the intraaortic pump.

Table 2. Apply pulse oxymetry

PROCEDURE	RATIONALE
Connect the device to mains supply	
Open the device and wait for the automatic control	
Set audio alarms	The pitch of the tone lowers according to SpO2 level
Select the appropriate sensor in relation to the size of the patient and the site of application	Disposable sensors for neonates, children and adults, finger, nose and earlobes
Remove any nail polish or dry blood	Imprecise measurements
Apply the sensor to the position selected. To ensure the accuracy of the measurements the two light sources should be opposite to the photo detector	The most common position in the adult is the index finger
Fix the sensor safely around the finger	It reduces the degree of movement but also prevents the light source surroundings (Operating headlights) to affect the accuracy of the analyst
Wait a few seconds for the analyser to detect the pulse and to calculate the oxygen saturation	Any digital reading has no sense in the absence of a waveform
Check the waveform	
Check the emergence of digital reading of SpO2 and pulse frequency pulse	

Table 3. Non-invasive pressure monitoring

SELECTION OF BLOOD PRESSURE CUFF
The width of blood pressure cuff should be about 40% of the limb perimeter
The length of blood pressure cuff should be approximately 80% of the limb perimeter. It is about twice the width of the proposed
PROCEDURE
Turn the oscillometry device on.
Choose the appropriate size of the cuff depending on the size of the patient
Level the cuff so as for its' longitudinal axis to be parallel to the longitudinal axis of the arm
Apply the cuff around the arm, over the brachial artery
The cuff should be neither too tight nor too loose

Table 4. Preoperative preparation for arterial line and pulmonary catheter

The basic principles concerning the preparation of equipment and surgical room apply both for cannulation the arterial and the introduction of the pulmonary artery catheter and for they will be analysed together	
PREPARATION OF NECESSARY EQUIPMENT Use aseptic technique for the all procedure	
PROCEDURE	**RATIONALE**
Pressure System	
Heparin solution of 5000 units in 1000 ml of normal saline	Heparin solution composition follows the individual hospital regime
A continuous flush device with double tranducer and extension pressure tubes	Need for double tranducer if simultaneous measuring of AP and PAP
Pressurize the solution at 300 mmHg	A continuous flush device is required to prevent clot formation in the catheter and remove air bubbles
Trolley for cannulation	
On the top of the trolley	**On the bottom of the trolley:**
Artery catheters 18-20G	3 lumen, 4 lumen central venous catheters, introducer, Swan-Ganz catheter
Antiseptic solution	Sterilised gloves
Adhesive tape	Sterilised dressings
Benzoate solution	Sterile jugular set (dressings, tools for the cannulation of internal jugular vein)
Sutures	
Surgical blades	
Guide wire	
Sterile adhesive dressing	
Special container for sharp objects	
Lidocaine 2% for local anaesthesia	
Heparinized flush syringes	

PREPARATION OF THE SURGICAL ROOM

PROCEDURE	RATIONALE
Check electrical equipment. Check the connections and the condition of the cables	For patient and personal safety
Connect the cables of the monitoring device to the transducers	For the transmission of the signal
Open the monitor's screen and calibrate the system	
Select the appropriate pressure scale	Required to display the waveform and accurate decision-pressure
Ensure that monitor alarms are on at all times	Better security
Level the transducer to the right atrium (at the point where the midaxillary line meets the 4th intercostals space)	Falsely low pressure readings if the transducer is higher than this axis. The opposite if the transducer is placed lower
Ensure secure connections	For any leakage of the system pressure
Continuously flush the system for air bubbles	All bubbles must be removed to ensure the accuracy of transducer
Correctly zero the transducer	Zeroing is performed to eliminate the effects of atmospheric pressure on the transducer

LEVELING - ZEROING

Leveling

PROCEDURE	RATIONALE
Ensure that the transducer is securely attached	To keep the transducer from falling on the floor
Locate correct level (the point where the midaxillary line meets the 4th intercostals space)	Accuracy of the measurements
Place the stopcock(air-fluid interface) of the transducer level with the phlebostatic axis	The pressures recorded using this as a zero reference level. If the transducer is lower there is added hydrostatic pressure on the air-fluid interface, which causing an error high pressure reading. Conversely, occurs when the tranducer is higher than the hydrostatic pressure is lower in stopcock which causes error low pressure

LEVELING - ZEROING

Zeroing

PROCEDURE	RATIONALE
Before zeroing, check that transducer is correctly leveled	For precise measurements
Remove vent cap from stopcock. Keep cap clean	
Open the stopcock to air	Subjects the system to the atmospheric pressure
Press the "zero" button on the monitor	To eliminate the effects of atmospheric pressure in the transducer
Once the monitor indicates that zeroing has been successful, close the vent port off the atmosphere and replace the cap	

Table 5. Intraoperative preparation • potential arterial cannulation

PROCEDURE	RATIONALE
Fit an O2 mask to the patient	Necessary because of the effect of premedication to the respiration
Connect the patient with ECG monitor and pulse oxymetry	
Ensure good iv access in place and connect with iv solution	For medication if necessary
Review the point of catheterisation	Look for skin lesions, scars, wounds, swelling, in the presence of vascular disease
Check the efficiency of the collateral circulation of the hand with the Allen test	Reduces the risk ischemia
Place the limb in a supinated position	The artery moves at a more superficial position
Clean the area with antiseptic solution	Reduce risk of infection
Locally infiltrate the point of insertion with Local anaesthetic	Eliminate pain
Assist the anaesthesiologist for the cannulation of artery	Provide for the necessary equipment
Connect heparin syringe with extension	
Fix the catheter with sterile cover	Prevention of infection
Connect the catheter to the pressure transducer	The transducer converts mechanical energy of the wave pressure to electrical signal
Flush the catheter	Cleanse the arterial line from blood remnants
Rezeroe the transducer	
Observe the wave	It is the best way to ascertain the correct position of the catheter
Read digital display of pressure	
Apply wrist plaster cast	For better stabilization of the hand

OBTAIN ARTERY BLOOD SAMPLE

Equipment: 5ml syringe, heparinized syringe 2,5ml.	
PROCEDURE	
Wash hands Wear gloves Remove the vent cap from stopcock Attach 5-ml syringe to stopcock Turn the stopcock open Discard the first 5ml of aspirate Close the stopcock Attach 2,5ml heparin syringe	Open the stopcock Aspirate Iml blood Close the stopcock Remove the syringe Flush the system and the stopcock opening Replace the cap Remove air from the syringe 2,5 ml and send the blood sample for analysis machine gas

Table 6. Intraoperative preparation for pulmonary artery pressure monitoring

The first choice for central venous access is the right internal jugular vein. The cannulation of the pulmonary artery is usually done after the induction of anaesthesia, and depending on the clinical picture of the patient and the possibility or not to have peripheral intravenous line

PROCEDURE	RATIONALE
Apply ECG monitor, a non-invasive blood pressure cuff, pulse oximeter	There is risk of arrhythmia during the introduction of the catheter
Insert peripheral intravenous line and arterial line	Dispensing medicines if necessary
Turn the head in the opposite of the cannulation side	The vein aligns with a straight line running from the earlobe to the sternokleidomastoid contribution
Place patient in a slight Trendelemburg position	For the vessels to be filled and the embolization risk
Assist the anaesthesiologist to wear sterile gloves and coat	
Open the jugular set, maintain aseptic technique	
Give to the anaesthesiologist the catheters	
Give 2,5ml syringe, surgical blade and suture	The syringe will help locate the vein, the blade to open the insertion site and the suture to secure the catheter
* Clean the insertion point with antiseptic solution	
* Cover the head and the area around the point of cannulation with sterile dressings	
* Cannulate the vein with the technique selected and introduce the catheter (introducer)	
* Wear new sterile gloves, change the area dressings	
* Take the pulmonary artery catheter	
* Put the sheath over the pulmonary catheter	Break in aseptic technique is the greatest cause infection
Check balloon tip, inflate with approximately 0,8-1,5 cc of air	Balloon may be ruptured
Flush each port of the PA catheter separately	Ensure patency and integrity of the catheter
* Promote the PA catheter into the introducer for about 20cm and secure it	
* Fix the introducer and the 3-lumen with a skin suture	
Maintain sterility of plastic sleeve over catheter	
Flush each port of the introducer and of the 3-lumen catheter	

The PA catheter is attached to the pressure line. Then it is inserted through the introducer onto the vena cava. When the PA catheter enters the right atrium, a waveform and pressure registers on the monitor. Inflate the balloon at this point	
Observe incoming waveforms	Waveform site and appearance change as the catheter advances its way to the pulmonary artery
Monitor for ventricular dysrhythmias	Ventricular dysrhythmias may occur when the tip of the catheter enters the right ventricle
*Insert the catheter in the pulmonary artery with balloon inflated	
Passively deflate balloon after measuring wedge pressure. Turn the stopcock off	Thus the balloon can not rise by mistake

MEASUREMENT OF CARDIAC OUTPUT

Equipment: Filled syringe 10ml with sodium chloride solution or dextrose 5%

PROCEDURE

Remove the tap of the stopcock at the proximal port

Attach 10ml syringe of cold injectate or room temperature

Press the button <<CO>> on the monitor

Administer the injectate rapidly through the proximal catheter port

Close the stopcock

Look at the digital recording to monitor

OBTAIN BLOOD SAMPLE OF MIXED VENOUS BLOOD

Collection material: 5ml syringe , heparinized 2,5 ml syringe, sterilized cap

PROCEDURE

Wash hands

Wear non sterile gloves

Remove the cap of the distal PA catheter port

Attach 5ml syringe

Open the stopcock

Discard the first 5ml of aspirate

Close the stopcock

Attach the 2,5 ml heparin syringe

Open the stopcock again

Gently aspirate 1ml blood sample over one minute

Close the stopcock and remove syringe

Ενεργο Flush stopcock port

Καλύψ Replace the cap

Remove any air from the 2,5 ml syringe and send the mixed venous blood sample for blood gas analysis

Table 7. Transesophageal Echocardiography

PROCEDURE	RATIONALE
Check the external surface of the probe for damage, deficits and abrasions from bites	To avoid mechanical, thermal and electrical damage to the patient
Check the handler of the probe	
Position the head of the patient in the midline and slight flexed position	For the safe passage of the probe
Fix the TEE on the one side of the mouth	
Check the oral cavity and the condition of teeth	
Put the probe in the special protective cover	Not sterilized merely disinfected, additional precautions to avoid contamination
Lubricate with lidocaine gel	For an easier passage through the mouth and the oesophagus
Apply the endoscopic airways in the mouth of the patient	To avoid probe damage
Unlock the probe, put it into neutral position and avoid unecessarymanipulations	
Enter the probe inside the mouth cavity and then direct it blindly in the midline of the pharynx while lifting the chin upwards	
Use of the laryngoscope if there is difficulty in the introduction will help in removal of the language and to allow the passage of the oesophagus probe	Will may help the introduction by sliding the tongue sideways to allow for the passage of the probe

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