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Technologies of Measuring Cardiac Output and Nursing Strategies

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An average adult has about five to six liters of blood (70 ml/kg). Paramount is the continuous flow of oxygenated blood. This flow is central to metabolism, the production of energy and other materials necessary for life. One molecule of glucose is oxidized in the cells' mitochondria to produce 36 adenosine triphosphate (ATP) molecules. The Aerobic metabolism are by products of more water and carbon dioxide. About 2/5th of the body fluids come from aerobic metabolism from what is oxidized rather than what is taken in. And carbon dioxide is readily breathed off at about 20 times the rate that oxygen diffuses into the blood stream. When energy demand surpasses the supply of vital energy precursors such as oxygen, cells are left with the efficient anaerobic energy production. Anaerobic metabolism yields only two ATP. Also, the production of lactic acid can alter the acid base balance and hamper several vital intercellular chemical reactions [1,2].

Cardiac output is one of the most important parameters for cardiac function monitoring, providing an estimate of whole body perfusion oxygen delivery and allowing for an understanding of the causes of high blood pressure. Derangements in the circulation are a common feature in sepsis, trauma, major surgery and other critical illnesses. Detailed evaluation of the circulation is essential for such patients. The use of cardiac output monitoring technology is an increasingly important aspect of evaluating patients in operation theaters and intensive care units. The bedside nurse should be knowledgeable about the components that influence cardiac output, because these factors determine not only the initial therapy, but also evaluation of therapy [3].

Parameters that affect cardiac output [1,2]

Parameters that increase cardiac output	*Parameters that reduce cardiac output*
Heart rate between 50 – 150 beats/ minute Atrial click Adequate filling time Frank Starling law- more myocardial stretch Increased preload Low after load	Heart rate less than 50 or more than 150 beats/ minute Lack of atrial click Inadequate filling time Frank Starling law- less myocardial stretch Decreased preload High after load

Technologies of Neasuring Cardiac Output

Accurate clinical assessment of the circulatory status is particularLY desirable in critically ill patients in the Intensive Care Unit and patients undergoing cardiac, thoracic or vascular interventions. Since the patient's hemodynamic status may change rapidly, continuous monitoring of cardiac output can provide information,

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thereby allowing rapid adjustment of therapy. The methods of measuring cardiac output are given below:

Fick method

This method is based on the principle described by Adolofo Fick in 1870. According to this principle, the total uptake or release of a substance by an organ is the product of the blood flow through the organ and the arteriovenous concentration difference of the substance. Cardiac output can be calculated via oxygen consumption by lungs divided by the difference of arteriovenous oxygen.

Thermodilution method

This method uses a special thermistor- tipped catheter inserted from a central vein into the pulmonary artery. Cold solution of 5% dextrose or normal saline is injected into the right atrium from a proximal catheter port. This solution causes a decrease in blood temperature, which is measured by a thermistor placed in the pulmonary catheter. The decrease in temperature is inversely proportional to the dilution of the injectate. Cardiac output can be derived by the modified Stewart-Hamilton conservation of heat equation.

Oesophageal Doppler

A Doppler probe is inserted into the distal oesophagus and is directed to measure the blood flow in the descending aorta at about 35 -40 cm from the incisors. The monitor calculates cardiac output using descending aorta diameter, which is either obtained from an age related nomogram or measured directly. The system is small and relatively portable but requires an electrical power source. Cardiac output data is best used as a trend to guide the effectiveness of interventions such as fluid challenges.

Transoesophageal echocardiography

A specialized oesophageal probe is inserted into the oesophagus, providing real- time, high-resolution ultrasound images. Both qualitative and quantitative values for cardiac output are available using a two-dimensional cross-sectional area measurement, a Doppler flow measurement at that point, and the heart rate. A large amount of hemodynamic information is available beyond, cardiac output.

Lithium dilution monitoring

This technique combines the techniques of lithium dilution and pulse contour analysis. A small dose of lithium is injected into a peripheral vein and an ion selective electrode is attached to a peripheral arterial line. The area under the curve in a plot of lithium concentration against time allows accurate calculation of cardiac output. A figure of stroke volume variation is produced which is an indicator of volume responsiveness to fluid therapy.

Thermodilution pulse contour monitoring

This technique uses arterial pulse contour analysis to measure cardiac output. The system is calibrated using intermittent cold transpulmonary thermodilution, where cold fluid is injected through a central venous catheter and traverses the pulmonary circulation. The curve of blood thermodilution is measured in a systemic artery in addition to cardiac output. The arterial line can be simultaneously used for blood pressure monitoring and for blood sampling. The system is relatively easy to set up and calibrate.

Pulse contour cardiac output

This technique calls for the insertion of an arterial line and hence is considered a minimally invasive procedure. A long arterial catheter is placed in the femoral, axillary, or brachial artery and is connected to a pulse contour device. With this catheter, a continuous pulse waveform contour analysis is obtained.

Partial carbon dioxide rebreathing

Cardiac output can be estimated using Fick principle with carbon dioxide as the marker gas. A new monitor called NICO is based on the application of the Fick principle to carbon dioxide in order to estimate cardiac output non invasively. The monitor consists of a carbon dioxide sensor, a disposable airflow sensor and a pulse oximeter.

Thoracic electrical bioimpedance

This technique employs four electrodes. Two pairs are applied to the neck base on opposite sides and two pairs are placed at the level of the xiphoid junction. Each pair of electrodes comprises transmitting and sensing electrodes. With these electrodes low level of electricity conducted by the body fluid is transmitted. Additional two set of electrodes is used to monitor a single ECG signal. Changes in impedance correlate with stroke volume. Cardiac output is calculated by multiplying the heart rate and stroke volume [4,5].

Indications for Cardiac Output Monitoring

- Assessment of cardiovascular function
- Perioperative monitoring of surgical patients with major system dysfunction
- Shock of all types
- Assessment of pulmonary status
- Assessment of fluid status
- Therapeutic indications such as aspiration of air emboli, cardiac pacing etc.
- Diagnostic indications such as aspiration of arterial blood, pulmonary hypertension etc [6].

Nursing Strategies

Insertion sites

Pulmonary artery catheter or Swan-Ganz Catheter (SGC) is inserted into a major vein such as the right internal jugular vein, the right and left subclavian veins, and the femoral veins.

Preprocedure care

- Explain the procedure to the patient
- Assemble all equipments such as SGC, introducer kit, supplies to create a sterile field, gown, mask, and gloves, betadine, pressure bag, 500 ml normal saline or heparin premix, two disposable pressure monitoring kits with transducer, continuous cardiac output monitor with cables and medication line.
- Observe principles of asepsis in setting up all monitoring lines
- Check SGC package for the expiry date. Connect SGC cable to monitor and attach to transducer and ensure zero transducer
- Place monitor in wedge / insertion mode turn on, and set continuous cardiac monitor

Care during procedure

- Position patient for insertion. Flat position for femoral site and Trendenlenburg position for subclavian or jugular site
- Assist with creating a sterile field
- Connect IV line to medication port
- Connect cardiac output cable
- Remove 1.5ml syringe and connect it to the syringe port
- Zero catheter while still in package
- Inflate air into balloon to insure balloon integrity prior to insertion
- After insertion of the tube by the physician waveform should be monitored
- Once the physician inserts the catheter, the registered nurse inflates the balloon

Post procedure care

- Make sure the SGC cap is in lock position so that the catheter will not migrate
- Secure catheter to patient with tape
- Apply occlusive dressing
- Set high and low alarms on monitors as appropriate for patient
- Ensure that the physician has disposed of all sharp equipments
- Check if chest X-ray was ordered

Documentation

- Immediately after insertion of SGC, parameters such as vital signs, pulmonary artery pressures, and cardiac output should be documented
- SGC insertion site and the length of advancement of catheter in centimeters should be specified
- Amount of air required to inflate balloon to obtain values should be mentioned
- Verification of placement of SGC by X-ray should be added
- Patient's tolerance to the procedure and medications given during the procedure should be documented as well [7-10].[0]

CONCLUSION

Cardiac output monitoring provides an excellent area for nursing research. Observing the changes in cardiac output while moving a patient in order to prevent bedsores and measuring cardiac output at various phases of hospitalization constitutes an area to be dealt with ideally by nurses. Moreover, nurses should study cardiac output during the first few hours of post-operative follow up for patients in Intensive Care Units. Cardiac output monitoring by nurses in the first post-operative twenty four hours in patients having undergone bypass surgery is an interesting premise for nursing research.

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