pressure disconnect alarms, although such threshold alarms are not failsafe.[5] Low-flow techniques with standing bellows[6] also assist monitoring for circuit leaks. A high-pressure monitor (e.g., Norrie "pop-off" valve) detects and warns of airway obstruction. This is more useful than the airway pressure manometer which does not serve the warning function.

The last three causes of hypoxaemia can be detected only by monitoring arterial or tissue PO_2. Three techniques are available:

1. transcutaneous oxygen analyzers ($TcPO_2$)
2. intra-arterial PO_2 sensors
3. oximetry

All three techniques have inherent limitations. $TcPO_2$ detects capillary PO_2 but has limited usefulness in underperfusion and obese states and needs a 30–45 minute warm-up.[7] Intra-arterial PO_2 sensors[8] are expensive, invasive and are altered by temperature, blood flow rate and N_2O concentration. Pulse oximetry,[9] a non-invasive routine monitor of oxyhaemoglobin saturation, is the most likely of the three techniques to be adopted routinely.

In conclusion, current technology provides reliable, versatile techniques to monitor lung function. However, some factors are so vital to patient survival that they should always be monitored, i.e., inspired oxygen concentration, airway pressure and disconnect alarms.

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Monitoring the heart

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Monitoring the heart may be considered from two aspects: (1) the function and (2) perfusion and oxygenation.

Cardiac function

The function of the heart is to generate sufficient pressure and flow to perfuse the body organ systems, including itself. Although pressure monitoring today is not difficult, measurement of organ flow remains a critical problem. Unless the patient is at relatively high risk, most practitioners are unwilling to accept the morbidity and (rare) mortality associated with the placement of a thermodilution pulmonary artery (PA) catheter. Various attempts at noninvasive monitoring of cardiac output have met with limited success. Analysis of arterial pulse contours and measurement of thoracic impedance have serious limitations of quantitation, although both give valuable information in terms of trends in cardiac output. Use of more sophisticated, complicated and expensive devices is possible, but may be cost-limited. The various types of ultrasound, including echocardiography and Doppler flow analysis can quantitatively measure the pumping function of the heart. However, for access to meaningful information, rather complicated computer application is necessary. The same problem also applies to the use of radioactive labelled compounds injected intravenously.

Even with the availability of cardiac output measurements, therapeutic application requires that the determinants of cardiac output be available. Although heart rate monitoring is not difficult, preload and afterload are not easy to measure clinically. Preload can be estimated from PA occluded pressure if a PA catheter is used. However, there is increasing evidence that the real measure of preload, end diastolic fibre length or ventricular volume, may be dissociated from pressure in a variety of circumstances. Volume measurements may be possible in future with a new type of PA catheter. Also, diastolic diameter measurement can be made from radiolabelled precordial scintillation counting and echocardiography, but cost is a problem. Afterload can be grossly estimated from arterial pressure, but for better assessment, a quantitative cardiac output is necessary so that vascular resistance may be approximated from the quotient of arterial pressure and cardiac ouput.

Myocardial perfusion and oxygenation

If the patient can undergo regional anaesthesia, then an obvious monitor of inadequate myocardial perfusion and oxygenation is the presence of angina pectoris. But if general anaesthesia is undertaken, currently there is severe limitation to detect imbalance between myocardial oxygen supply and demand. The time-honoured monitor is the electrocardiogram. However, an appropriate lead is necessary (usually V4, V5 or the equivalent) and even so, episodes of ischaemia may be missed or ST and T wave changes misinterpreted. Also, the regional nature of myocardial ischaemia is a problem. Some clinicians believe that monitoring pulmonary artery occlusion pressure (PA_{op}) gives advance information about impending myocardial ischaemia, either because of change in compliance of the ventricle with rising PA_{op} or decrease in global ventricular function. Several more recent approaches to non-invasive detection of myocardial ischaemia include: echocardiography, showing changes in ventricular wall motion which may be a very early sign of regional ischaemia, and the cardiokymograph, which detects similar changes in precordial wall motion through changes in the magnetic field of the chest. However, for best results with either method, either the ultrasound transducer or the magnetic crystal must be directed at the area of ischaemia.

At present, the most practical method for assuming that there is sufficient myocardial oxygen supply for the demand is to consider blood pressure and heart rate separately. Thus, arterial pressure should be controlled within 10 to 15 per cent of the symptom-free awake state and heart rate should be kept as low as feasible without interfering with cardiac function. Considering rate pressure product in isolation makes no sense, for the implication of changes in heart rate and changes in arterial blood pressure are considerably different.

Thus, clinical monitoring of the heart depends on the physical status of the patient and the surgical procedure to be performed. In patients with minimal heart disease, monitoring of heart sounds, ECG with a precordial lead, and indirect blood pressure are sufficient. If there is to be trespass on the heart, lungs, or cross-clamping of major vessels, then direct arterial and central venous pressure monitoring should be used even in relatively healthy patients. For those with moderately severe heart disease undergoing relatively minor surgery, these two modalities should also be considered. Patients with severe heart disease (non-compensated congestive heart failure, unremitting angina, or a myocardial infarction within three months of surgery) should be monitored with everything that is available today (direct arterial and thermodilution pulmonary artery catheter monitoring).

Monitoring the kidney

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Anaesthetists use renal function tests to assess either preoperative kidney function or postoperative renal failure.