Postoperatively, on the ward, episodes of airway obstruction during sleep are common and may aggravate borderline oxygenation due to the above factors. This is due to the use of opioid analgesia and a change in sleep pattern that occurs on the second and third postoperative nights. It is clear that after major surgery the risk of hypoxaemia extends well into the postoperative period. Small degrees of cyanosis are not easy to detect clinically, especially in anaemic patients, and therefore oxygen should be given to these patients wherever possible. It is especially important to give it overnight to patients at special risk (ischaemic heart disease). Postoperative pain should be effectively treated (see Update 7) as patients in pain following abdominal or thoracic surgery will be reluctant to breathe deeply. If opioid analgesics are indicated, hypoventilation should be anticipated, and oxygen given.

PROBLEMS ASSOCIATED WITH OXYGEN ADMINISTRATION

It is has been suggested that high concentrations of oxygen (90-100%) administered to patients for a prolonged period (several days) may cause pulmonary damage. There is little evidence to support this and should never prevent its use in treating severe hypoxia.

High concentrations of oxygen will encourage collapse of alveoli with low ventilation/perfusion ratios. Oxygen is rapidly and completely absorbed from these alveoli, and when it is the only gas being given, these underventilated alveoli collapse. When air and oxygen is used, the nitrogen present is absorbed more slowly and prevents the alveolus from collapsing.

Oxygen therapy may rarely depress ventilation in patients suffering from severe chronic obstructive airways disease. Some of these patients lose their sensitivity to carbon dioxide and rely on hypoxia to stimulate breathing. In these patients, when high concentrations of oxygen are given, serious hypoventilation and hypercapnia can result due to the fact that their hypoxia is reversed. This is extremely rare.

In the second part of this article we plan to discuss the more practical aspects of oxygen production and storage and the equipment needed to safely administer oxygen to patients.

References:

PHARMACOLOGY OF VASOPRESSORS AND INOTROPES

Dr Karen Gilmore, Frenchay Hospital, Bristol, UK & Christine Nanyanzi, Gihundwe Hospital, Rwanda.

A “vasopressor” causes vasoconstriction and an “inotrope” increases the force of cardiac contraction. Vasopressors and inotropes work via the Autonomic Nervous System.

Neurotransmission at postganglionic receptors. The postganglionic receptors of the Parasympathetic Nervous System PNS are termed muscarinic, and acetylcholine (Ach) is the neurotransmitter. The equivalent receptors in the Sympathetic Nervous System (SNS) are noradrenergic receptors and noradrenaline (Norad) is the endogenous (naturally occurring) neurotransmitter (table 1). These noradrenergic receptors are further subdivided, the subdivisions relevant to this article are Alpha1 (α1), Beta1 (β1), Beta2 (β2) and Dopamine (D). The main actions of each receptor subtype are as shown in table 2.

VASOPRESSORS AND INOTROPES

This group of drugs is useful for resuscitation of seriously ill patients, and for the treatment of hypotension in theatre. All of these drugs act directly or indirectly on the SNS, but the effect of each varies according to which sympathetic receptor the drug has greatest affinity for. The duration of action also varies. Direct acting drugs act by stimulating the SNS receptor whereas indirect acting drugs cause the release of noradrenaline from the receptor which produces the effect. Some drugs have a mixed effect.

ADRENALINE (EPINEPHRINE)

Adrenaline acts on α1, β1 and β2 receptors. It is said to prepare the body for a “fight or flight” response.
Actions
CVS: Increased heart rate and force of contraction produce an increase in cardiac output. Systolic blood pressure (SBP) rises, but with low doses diastolic blood pressure (DBP) may fall due to vasodilation and increased blood flow through skeletal muscle beds (β2). At higher doses the vasoconstrictor effects of α1 stimulation become more apparent, causing the cool pale extremities of a frightened person.

RS: Bronchial smooth muscle is relaxed resulting in bronchodilation (β2).

Other: Adrenaline mobilises glucose from glycogen and raises blood sugar. Pupillary dilation (mydriasis) occurs.

Side effects Ventricular arrhythmias, hypertension. Care with halothane anaesthesia as arrhythmias may occur.

Preparation
- 1:1000 i.e. 1mg in 1 ml.
- 1:10,000 i.e. 1mg in 10ml

Indications and doses
Cardiac Arrest - see page 21
Anaphylactic shock - 1:10,000 adrenaline given iv in 1 ml doses until effective. If no iv access available then 0.5ml of 1:1,000 im.
Additive to local anaesthetic - add adrenaline to local anaesthetic to make a concentration of 1:200,000 - see page 50
Acute severe asthma attack unresponsive to normal treatment may require infusions of adrenaline, though 0.5ml of 1:1000 s/c may be used.

Septic shock - require infusions of adrenaline

Length of action Short, few minutes only with intravenous bolus.

EPHEDRINE
Ephedrine acts directly on β1 and β2 receptors, and indirectly on α1 receptors by causing noradrenaline release.

Action It causes a rise in blood pressure and heart rate, and some bronchodilation.

Side effects May cause tachycardia and hypertension. Possible arrhythmias if used with halothane.

Preparation 3% or 5% solution: 1 ml ampoules.

Indications Low blood pressure due to vasodilation e.g. following spinal or epidural anaesthesia and drug overdoses. Best vasopressor to use in pregnancy as it does not reduce placental blood flow.

Dose 3-10 mg boluses iv, repeat until effective. Maximum dose is 60mg.

Length of action 5-15 minutes, repeated doses less effective (i.e. it demonstrates tachyphylaxis).

METHOXAMINE
Methoxamine acts on α1 receptors.

Actions Increases blood pressure. There may be a reflex decrease in heart rate, and therefore it is good for hypotension with tachycardia. Useful during spinal anaesthesia.

Table 1

<table>
<thead>
<tr>
<th>Preganglionic receptor type (and neurotransmitter)</th>
<th>Post ganglionic receptor type (and neurotransmitter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNS Nicotinic (Ach)</td>
<td>Muscarinic (Ach)</td>
</tr>
<tr>
<td>SNS Nicotinic (Ach)</td>
<td>Noradrenergic (Norad)</td>
</tr>
</tbody>
</table>

Table 2

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>α1</td>
<td>Peripheral arteriolar vasoconstriction</td>
</tr>
<tr>
<td>β1</td>
<td>Cardiac increased heart rate and force of contraction.</td>
</tr>
<tr>
<td>β2</td>
<td>Bronchial smooth muscle dilation.</td>
</tr>
<tr>
<td>D</td>
<td>Increased renal blood flow</td>
</tr>
</tbody>
</table>

For a full explanation of receptors and their actions refer to Update in Anaesthesia 1995:5
Side effects May produce bradycardia
Dose 2-4mg boluses IV, repeated as necessary.

METARAMINOL
Acts directly on $\alpha_1$ receptors and also causes noradrenaline and adrenaline release.

**Actions** Increases blood pressure and cardiac output. Less likely to cause a reflex bradycardia than methoxamine or phenylephrine.
Dose - 1mg boluses iv, 2-10mg s/c or im, by infusion at 1-20mg/hr.

PHENYLEPHRINE
Acts directly on $\alpha_1$ receptors,

**Action** Hypertension and a reflex decrease in heart rate.

Dose 2-5mg im or sc, 0.1-0.5mg iv, by infusion 20-50mcg/min.

INOTROPES GIVEN BY INFUSION
Adrenaline is the most commonly available inotrope, and in many cases the most appropriate drug to maintain blood pressure. When other inotropes are available, some may offer advantages in certain situations. The inotropes listed below are only given by infusion unless a bolus dose is stated. They are mostly very short acting, their effects lasting from a few seconds to one or two minutes and should be given via a central line (except for aminophylline and salbutamol) via an infusion controller. The patient must be closely monitored, particularly the ECG and blood pressure. Tachycardia, arrhythmias, and hypertension or hypotension are side effects of these drugs. Although called inotropes some of these drugs also have vasoconstrictor properties.

NORADRENALINE
Acts mainly on $\alpha_1$ receptors with few effects on $\beta$ receptors.

**Actions** Increases blood pressure by vasoconstriction. Less likely to cause tachycardia than adrenaline.

**Indications** Septic shock where peripheral vasodilation may be causing hypotension.

**Cautions** Acts by increasing afterload and therefore not appropriate for use in patients in cardiogenic shock. Blood supply to kidneys and peripheries may be reduced.

**Dose**
- 1-30mcg/min
  - Add 4mg to 250ml 0.9% NaCl or 5% dextrose to give 16mcg/ml.
  - Run at 0-112ml/hr

DOPAMINE
Acts on D, $\beta_1$, $\beta_2$ and $\alpha_1$ receptors, depending on the dose administered.

**Actions** Dose dependent. It used to be popular to increase urine output via its effect on the D receptors in the kidney. However, less commonly used for this purpose as it does not prevent renal failure.

**Indications** Hypotension.

**Dose**
- 1-2mcg/kg/min - acts on D receptors usually increasing urine output
- 2-10mcg/kg/min - also acts on $\beta$ receptors to increase cardiac output
- >10mcg/kg/min - additionally has effects on $\alpha_1$ receptors to vasoconstrict.
  - Add 3mg/kg (body weight) to 50mls 0.9%NaCl or 5% glucose
  - 1ml/hr = 1mcg/kg/min

DOBUTAMINE
Acts on $\beta_1$ and $\beta_2$, with minimal action on $\alpha_1$ receptors.

**Actions** It increases cardiac output and reduces afterload ($\beta_2$effects on skeletal muscle).

**Indications** Cardiogenic shock.

**Dose** 2-30mcg/kg/min
- Add 3mg/kg to 50mls 0.9%NaCl or 5% glucose
- 1ml/hr = 1mcg/kg/min

DOPEXAMINE
Acts on $\beta_2$ and D receptors.

**Actions** It increases cardiac output and reduces afterload. Increases blood supply to the kidneys and possibly also the gastrointestinal tract.

**Dose** 0.5-6mcg/kg/min
SALBUTAMOL
Acts on $\beta_2$ receptors
**Actions** Relaxes bronchial smooth muscle i.e. bronchodilation, may increase heart rate
**Indications** Severe acute asthma.
**Dose** By infusion 5-20mcg/min. Can also be given in bolus form iv in the initial treatment of an attack at a dose of 5mcg/kg over several minutes.

ISOPRENALINE
Acts on $\beta_1$ and $\beta_2$ receptors
**Actions** Main action is increased heart rate. Also increased force of contraction, and bronchodilation.
**Indications** Complete heart block, overdose of beta blocker or severe bradycardia unresponsive to atropine. Can be used to treat asthma, but less suitable than drugs that act only on $\beta_2$ receptors e.g. salbutamol
**Dose** 0.02-0.2mcg/kg/min by infusion
5-20mcg bolus iv

PHOSPHODIESTERASE INHIBITORS
(e.g. AMINOPHYLLINE, ENOXIMONE)
Prevent breakdown of cAMP by enzyme phosphodiesterase: this produces effects at $\beta_1$ and $\beta_2$ receptors.
**Actions** Inodilation i.e. increased rate and force of contraction, vasodilation in skeletal muscle. Also bronchodilation.
**Indications** Aminophylline: asthma, cardiac failure. Enoximone: cardiac failure in patients failing to respond to dobutamine

CLINICAL CASE STUDY – USE OF VASOPRESSORS
Lower segment Caesarean section (LSCS) under spinal anaesthesia
A patient is scheduled for LSCS under spinal anaesthesia. An iv infusion is set up and 1000 mls of Hartmanns run in whilst the spinal is performed. The patient is placed supine with a 15-degree left-lateral tilt to minimise aortocaval compression (i.e. pressure from the uterus on the inferior vena cava reducing venous return to the heart).

Despite good positioning and iv fluids, hypotension is very likely at this stage because of vasodilation due to the spinal. The patient should be given ephedrine in boluses of 6-9mg, which may need to be repeated several times. Alternatively, 30-60mg of ephedrine can be added to the intravenous infusion, and the rate titrated according to the BP. The SBP should be maintained above 100mmHg. (A hazard of adding ephedrine to the infusion is that the anaesthetist may forget to reduce the rate of infusion when the BP has returned to normal, and the patient may become dangerously hypertensive.)

Once the baby has been delivered aortocaval compression is no longer a problem, and further ephedrine is not usually required. If hypotension persists, ensure that hypovolaemia is not the cause. Intravenous fluids should be given to restore blood volume, rather than vasopressors. Ephedrine is the best vasopressor for LSCS because it has fewest effects on placental blood supply. If ephedrine is not available another vasopressor should be used. Alternatively small doses of adrenaline (20-50mcg) can be given, in a dilute preparation.

**Summary**
The common causes of hypotension during LSCS under spinal anaesthesia are:
- Vasodilation - treat with fluids and ephedrine
- Aortocaval compression – tilt patient 15 degrees to left
- Bleeding – replace blood loss with intravenous fluids