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Implications of Obesity on Anaesthetics - A Case Study

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ABSTRACT

As the proportion of obese patients within the general population rapidly increases, more obese patients are requiring anaesthesia. Obesity is associated with anatomical and physiological differences and co-morbidities that impinge on the administration of anaesthesia. A surgical case, which could have been performed under a GA or a spinal anaesthetic is used as a basis of discussion. Various factors affecting airway choice, breathing problems, circulation and other issues are discussed.

Introduction

500 million adults worldwide have a BMI >30kg/m^2 and are thus classified as obese.[1] With an increasing obese population it is not surprising that the number of obese patients being anaesthetised is also rising. [2] It is well known that obesity is a risk factor for many health conditions such as ischaemic heart disease and respiratory problems.[3] Due to the anatomical and physiological differences and co-morbidities associated with obesity, anaesthetists will need to consider carefully how they anaesthetise and care for these patients.

Case

A 27 year old male with a BMI of 51 (height 1.84m, weight 174kg) required open reduction and internal fixation to treat a left distal fibular fracture. His co-existing co-morbidities consisted of gastro-oesophageal reflux disease (GORD), for which he takes Lansoprazole, and untreated hypertension. He had no known drug allergies.

Normally, the majority of healthy patients of this age would have been offered either the option of a general anaesthetic (GA) or spinal anaesthetic for this procedure. Obesity itself and its associated co-morbidities can increase the risks of GA. This case is used as a basis for discussion of some of these issues and considers whether in fact a GA or spinal anaesthetic is better for this patient.

Airway

Airway maintenance is required during anaesthesia as patients are more prone to airway collapse due to the loss of pharyngeal muscle tone. [4] Airway maintenance can be more difficult in obese patients.

To ensure adequate oxygenation after the induction of anaesthesia and prior to airway device insertion, patients are pre-oxygenated using facemask ventilation. Patients with a higher BMI have bigger, fatter tongues decreasing the size of their upper airway and also have larger quantities of fat in their necks resulting in greater extra-luminal pressures. This combination results in a narrower and less adequately supported upper airway, which is more prone to collapse and obstruction when unconscious. Airway opening techniques, such as head-tilt-chin-lift and jaw-thrust are often required to overcome this obstruction. However, excessive posterior neck fat pads limiting extension of the atlanto-occipital joint makes ideal positioning less achievable. The lack of an optimal airway makes face mask ventilation more difficult[2, 5] and the use of a "Guedel" airway may be considered.

Two main airway devices are available for the maintenance of airway patency during GA: a laryngeal mask airway (LMA) and an endotracheal (ET) tube. Risk of reflux and subsequent aspiration determines which one is used. [6+7]

A recumbent position during anaesthesia increases the risk of reflux in all patients.[8] Loss of consciousness dampens protective airway reflexes making aspiration more likely.[9] This risk is often potentiated in obese patients as they frequently have co-existing GORD, another risk factor for reflux. There are many reasons thought to contribute to this including reduced lower oesophageal sphincter (LOS) pressure, delayed gastric emptying, high intragastric pressure, hiatus hernia and increased frequency of LOS relaxation.[10] It is important to protect the trachea to lessen the risk of aspiration and its associated problems.[8]

An LMA is an airway device inserted without visual aid. It is designed to have a low pressure seal around the laryngeal inlet[6] with its tip sitting on the upper oesophageal sphincter (Figure 1).[7] Since this seal is above the entry to the trachea, it does is not adequately protect the trachea from stomach contents in the event of reflux. Furthermore, an inadequate seal increases the likelihood of air escaping into the stomach, which also adds to an already high risk of reflux. Therefore, the use of an LMA is discouraged in those at risk of reflux including obese individuals.[5]

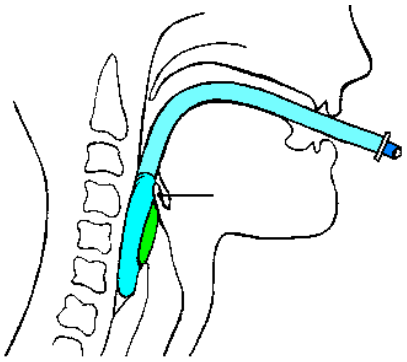
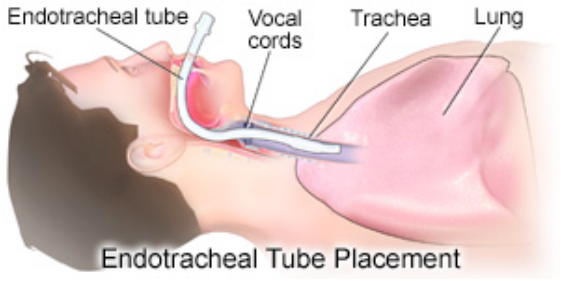


Figure 1: The correct positioning of an LMA [6]

An ET tube consists of hollow tubing that is passed through the vocal cords and sits in the trachea. It is inserted into the trachea with the aid of a laryngoscope to ensure correct positioning (Figure 2). A cuff surrounding the distal portion of the tube is inflated once it is in position ensuring a complete seal of the trachea. This protects

the trachea from the risk of aspiration[11,12] and hence is a superior choice for airway maintenance in obese patients and others at risk of reflux.[5]

Figure 2: Correct positioning of an ET tube [11]



It is essential to confirm the correct positioning of an ET tube by listening with a stethoscope to the lungs and over the epigastrium. There should be equal air entry over both lungs and no air entry over the epigastrium. Air entry over the epigastrium indicates that the ET tube is in the oesophagus and not the trachea. If not rectified quickly, ventilation of the stomach will occur which heightens the risk of reflux but more importantly, the lungs are not being ventilated and the patient will de-saturate resulting in hypoxia and death.[12] It should be remembered that the larger tongues and limited neck extension seen in obese patients makes intubation more difficult.[5] Patients at risk of reflux during anaesthesia are often prescribed a H_2 agonist or proton pump inhibitor in an attempt to minimise the risk of reflux.[5]

When using an ET tube for intubation, the risk of reflux and aspiration can be further reduced by using the technique known as rapid sequence induction. This is done as any other intubation but with two differences. Pressure is exerted on the cricoid cartilage during the induction of anaesthesia and compresses the upper airway lessening the chance of aspiration if reflux occurs. Secondly, a fast and short acting muscle relaxant, Suxamethonium, is administered as opposed to a slower longer acting drug. If the intubation fails no further attempts are made. By using a short acting muscle relaxant the patient can promptly take over their airway and breathing in the event of intubation failure.[13] This is of added value due to the short time to de-saturation in obese patients, discussed below.[2]

Breathing

During GA patients are mechanically ventilated. Obese individuals have a third of the respiratory compliance of normal individuals due to reduced lung and chest wall compliance.[14]

During inspiration, a larger chest volume is created by the contraction of the diaphragm moving the chest wall upward and the intercostal muscles expanding it outward. The resulting increase in chest volume lowers the air pressure within the

lungs facilitating air entry down a pressure gradient.[5] Obese patients have high proportions of fat within their ribs, chest wall, abdomen and diaphragm reducing chest wall compliance. Consequently, their inspiratory chest expansion is less resulting in a lower inspiratory volume with less oxygen available for diffusion. Thus, obese patients have an increased work of breathing and subsequently require higher pressures of mechanical ventilation.[15]

It is well known that mechanical ventilation reduces functional residual capacity (FRC) by 20% in non-obese patients. However in the morbidly obese, due to a heavy chest wall and diaphragmatic splinting, which is worse in the supine position, mechanical ventilation results in a 50% reduction in their FRC. A low FRC results in a ventilation perfusion mismatch i.e. the collapsed alveoli are still perfused but not ventilated. Subsequently, obese patients de-saturate more quickly than non-obese individuals. For this reason, an airway must be obtained quickly after cessation of facemask ventilation in order to prevent the patient becoming hypoxic such that time is of the essence.[2,14,16,17.18.19]

The small time window to perform a potentially difficult intubation in an obese patient can be tackled in a few ways. One method is to position an obese patient at a 25° head-up angle during pre-oxygenation as this can delay the time to desaturation.[20] Alternatively, a fibreoptic intubation can be performed in an awake patient. This also has the benefit of avoiding the need for facemask ventilation that is likely to be difficult. During this method the patient remains awake and in control of their airway until successful intubation has taken place. It is easier and more comfortable for the patient if it is done nasally rather than orally. A fibreoptic scope is inserted into the nose with an additional port to apply topical local anaesthetic as required. Once the ET tube is in place and correct positioning confirmed the patient is anaesthetised. Keeping the patient awake and in control of their airway and breathing averts the risk of breathing arrest and subsequent hypoxia from failed intubation.[10,21,22]

Circulation

Adequate blood pressure (BP) is required to maintain circulation at all times. Anaesthesia, surgery and medications (including anaesthetic agents) all affect BP and thus it is important to monitor BP during anaesthesia. Obese patients are 6 times more likely to suffer from hypertension. BP is a product of cardiac output (CO) and systemic vascular resistance (SVR) SVR is increased in obese patients due to such factors as insulin resistance, endothelial dysfunction and substances released from adipocytes. In addition, excess adipose tissue in obese patient's results in an increased oxygen demand and thus a compensatory increase in CO. As with any newly diagnosed hypertensive patient, secondary causes must be excluded before attributing it solely to obesity. For example, advanced renal disease is often associated with hypertension and significantly reduces renal excretion of drugs.[23,24,25]

It is important to realise that BP in uncontrolled hypertensive patients may react differently to that of normotensive patients during anaesthesia as BP sways are not uncommon in the former patient group. This may be an exaggerated hypotensive

response to situations such as induction of anaesthesia or an exaggerated hypertensive response to stimuli such as laryngoscopy and intubation. Awareness of this risk helps in the preparation of these cases. In addition, hypertension, especially if poorly controlled, is a risk factor for cardiovascular events occurring during anaesthesia such as myocardial infarction, cerebral haemorrhage and renal failure. These events can lead to further morbidity and mortality. Treating hypertension pre-operatively is vital in an attempt to prevent potential devastating consequences. Ideally, hypertensive patients should have their blood pressure controlled prior to anaesthesia. A pre-assessment diastolic blood pressure of greater than 110mmHg warrants attempts at reduction with anti-hypertensive medications before elective surgery. However, in some patients it will not always be possible to have their severe pre-operative hypertension brought under control before surgery and it is recognised that these patients are more at risk of peri- and post-operative complications. [24,26,27]

Since some anti-hypertensive medications, such as ACE inhibitors, can interact with anaesthetic agents careful planning is necessary to ensure patient safety. [27] It is routine practice that all patients undergoing any type of anaesthesia have intravenous (IV) access.[28] Due to the large amounts of subcutaneous fat found in obese patients IV access is often more challenging.[29,30]

Pharamacokinetics

Morbid obesity can affect the volume of distribution, clearance and half-life of drugs. Thus, caution must be taken with drug dosing (including anaesthetic agents) in obese patients. The main issue is whether total body weight (TBW) or ideal body weight (IBW) should be used to calculate drug dosage. An important point to remember is that obese patients have more adipose tissue but their lean tissue is normally unaltered. [5,31] Generally speaking hydrophilic drugs are mainly distributed within lean body tissues, i.e. volume of distribution is unaltered in obese patients, with clearance usually unchanged or even decreased. Hence, IBW should be used to calculate the drug dosage of hydrophilic drugs. Conversely, lipophilic drugs are distributed equally in both lean and fat tissues so that there is an increased volume of distribution and clearance in obese patients. Thus TBW should be used to calculate the drug dosage of lipophilic drugs. It is essential to remember that other pharmacodynamic features also play a role and that these rules are not applicable to all drugs. For example, as obese patients are more sensitive to Thiopental a commonly used lipophilic induction agent and the calculated dosage based on TBW should be reduced.[5,31]

Other Practical Issues

Some other practical issues to consider in obese patients undergoing anaesthesia are discussed below.

Patients requiring surgery need to be transferred from their hospital bed to a trolley and then to the theatre table and back again. Due to the greater weight and size of obese patients, these transfers are more difficult than in leaner patients and may predispose to patient or staff injury. One solution would be to anaesthetise such a patient on the operating table enabling them to help with prior transfers.

Alternatively, the use of a transfer device could be considered. Another consideration is whether the operating table is able to sustain the patient's weight and accommodate their width. Furthermore, obese patients are more susceptible than leaner individuals to develop pressure sores if lying in the one position for a long time. This is of particular importance when anaesthetised for a long time. It is thought that pressure sores arise from cell death of inadequately perfused skin with consequent breakdown of the skin to form an open sore.[32] Adipose tissue is poorly vascularised and obese individuals are therefore at increased risk of this complication. In an attempt to reduce this risk a few practical actions can be done: periodical repositioning of patient, foam wedges, foam mattress and ensuring the patient is lying on a smooth surface.[33]

Case Study Patient Experience

It was felt that the associated risks with a GA were considerable and that a spinal anaesthetic (spinal) was safer. However, his spinal anaesthetic was still somewhat complicated due to his obesity as this led to difficulties in positioning him for the administration of the spinal anaesthetic. In an attempt to widen the intervertebral space two positions can be utilised. In one, the patient sits up and leans forward with their legs out straight and chin on their chest. In the second, the patient lies on one side bringing their knees towards their chest. Excess fat tissue in obese patients makes locating the posterior midline somewhat difficult in the second position so that a sitting up position was used in this case. Bony landmarks are then used to locate the correct entry site (L3/L4 or L4/L5, below the level of the spinal cord) for the spinal needle. The iliac crests are used as a guide for the level of the L4 vertebral body and the spinous processes as a guide for the intervertebral space. Given the large amounts of subcutaneous fat, the iliac crests and the spinous processes were difficult to palpate making the correct entry site difficult to establish. Nevertheless, this was carried out as best as possible. The introducer was the next potential problem. It is meant to sit in the skin, subcutaneous fat, supraspinous ligament, interspinous ligament and the ligamentum flavum. However, there was concern that the large amounts of subcutaneous fat would prevent the short introducer from reaching as far as the ligamentum flavum. Fortunately its length was adequate. If it had been too short a longer epidural needle would have been used in place of the introducer.[34] Dosing alterations must also be considered for spinal anaesthesia in obese patients as this patient group have smaller volumes of cerebral spinal fluid and thus require less anaesthetic agent(s) to achieve the same level of blockade.[35]

Summary

With an increasing obese population it is important that anaesthetists remain alert to the implications of anatomical and physiological differences and associated co-morbidities on anaesthesia. Where practical the consideration and use of non-GA methods may be the safer and hence preferred option but as in this case, even these are not without their own challenges.

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