Anaesthesia tutorial of the week 112:
Prone Positioning

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Self-assessment

Before reading this tutorial, please answer the following questions as a framework for considering the prone position.

1. What are the common types of operation that require prone positioning?
2. What physiological systems are most affected?
3. What specific problems can be encountered with the airway, and how should these be managed?
4. What co-morbidities increase the difficulty and therefore risk of prone positioning?
5. What variations of the prone position are used commonly in clinical practice?

Key Points

- Secure the airway
- Have enough staff to safely turn the patient
- Protect the eyes
- Ensure the abdomen is not compressed

Introduction

Prone positioning of a patient under anaesthetic is a safe way of ensuring optimum surgical access for a number of procedures, providing that the risks are fully understood. Common procedures requiring prone positioning are back surgery, pilonoidal sinus surgery and some types of ankle surgery e.g. Achilles tendon repair. An understanding of the changes in physiology and the particular risks associated with the prone position is vital.

Physiological changes on turning

1. Cardiovascular system

The most important feature of turning a patient prone under anaesthesia is a drop in cardiac output. Cardiac index in one study dropped by an average of 24%. This was mainly as a result of decreasing stroke volume with little change in heart rate. Of the three factors involved in cardiac output (preload, afterload and contractility), it seems likely that decreased preload was most to

blame – compression of the inferior vena cava (IVC) reducing venous return to the heart. When the IVC is itself obstructed, blood uses a collateral return route – the vertebral wall venous plexuses. As prone positioning is often used for spinal surgery, this can cause increased bleeding in the surgical field. It is important to decrease the pressure on the abdomen directly – this can be achieved with specially designed operating tables, or by placing wedges under the chest and pelvis – care must be taken not to stress the back too much.

2. Respiratory system

Prone positioning has a broadly positive effect on the respiratory system providing that abdominal compression is avoided as described above. Functional residual capacity and arterial oxygen tension both increase. This is partly the reason why prone positioning has been used in intensive care settings for patients with poor lung function – often secondary to acute lung injury. The exact reason for this improved function is unclear, although it is most likely that changes in ventilation and perfusion result in better V/Q matching, and thus improved arterial oxygen tension.

Potential sources of injury

There are a number of body structures that can be injured – these are generally as a result of direct pressure to structures on which body weight would not normally rest.

Pressure injuries

Since pressure equals force divided by area, care must be taken to ensure that small or vulnerable areas such as the eyes or nose do not bear a disproportionate load. Pressure can cause damage by direct pressure, or by occlusion to an arterial supply or venous drainage. Areas at risk depend on exactly which prone positioning technique is being used – this tutorial will focus on two commonly used. Firstly a simple prone position with a Montreal mattress (a standard soft operating table with a hole cut out to avoid pressure on the abdomen) and the ‘tuck’ position, where the hips and knees are flexed to allow better access to cervical/thoracic spine.

Direct pressure – musculoskeletal damage

Dependent areas must be carefully noted and protected – these include the forehead, nose, chest, arms, breasts and genitalia, pelvis (superior iliac spines), knees and feet. During long procedures pressure sores can develop. The knees and pelvis are at higher risk in the ‘tuck’ position than on a Montreal mattress. During pre-assessment, the normal range of movement (ROM) at the various joints must be elucidated, and care taken particularly with joint replacements not to exceed the maximum ROM, as this could result in dislocation and other soft tissue injuries.

Direct pressure – nerve damage

The distribution of nerve injury is different to that associated with the supine position. Briefly the nerves exiting at the superior orbital fissure are at risk, as are the brachial plexus, ulnar nerve and lateral cutaneous nerve of the thigh.

Ocular damage

Ocular damage is caused by two mechanisms. First is direct pressure to the eye - incorrect positioning leading to the weight of the head being supported by the globe will intuitively result in damage secondary to ischaemia. The second is a result of poor perfusion. In the same way that cerebral perfusion pressure equals mean arterial pressure (MAP) minus the intracranial pressure (ICP), ocular perfusion pressure can be defined as MAP minus the intraocular pressure (IOP) Occlusion to the venous drainage, or any generalised rise in venous pressure will raise the IOP, as will use of a head-down position. MAP may be reduced either by deliberate hypotension or abdominal compression. If ocular perfusion pressure is too low to adequately perfuse the eyes then ischaemic damage will result

Indirect pressure injury

These are broadly due to pressure on the head and neck, chest, abdomen and vessels supplying lower and upper limbs.

Swelling of the tongue and mouth has been reported, causing potential airway obstruction and delayed extubation. The mechanism is assumed to be obstruction of venous drainage from the head and neck secondary to excessive flexion of the neck. The subsequent increase in hydrostatic pressure causes the equivalent of dependent oedema.

The chest wall is normally able to withstand the pressure put on it under anaesthesia. However, it can be weakened by a congenital abnormality (scoliosis or pectus excavatum), or by previous chest surgery. Cardiac output can be severely compromised by right ventricular compression against the sternum. If the sternum itself is abnormal, this is more likely to occur.

Compression of the abdomen can be reduced if a Montreal mattress is used and the patient correctly positioned on it. However, both pancreatitis and hepatic ischaemia and infarction have occurred, presumably as a result of impaired blood flow to the visceral organs. Prone positioning of centrally obese patients presents a particular challenge, and special care must be taken to avoid direct abdominal pressure.

The lower limbs are at increased risk of compartment syndrome in the ‘tuck’ position, where both knees and hips are flexed. Arterial blood flow and MAP decrease, and limb pressure increases. This can result in rhabdomyolysis and compartment syndrome, which when complicated by renal failure can be fatal.

Prone positioning – a practical guide

In this section, a safe method of approaching a case requiring prone positioning will be discussed. This is not the only method that can be used, other variations are available.

Pre-assessment
First discuss with the surgeon the position required and the anticipated length of the procedure. Then fully pre-assess the patient, including examination and consent for anaesthesia. Assess the airway carefully - cervical spine surgery is one indication for prone positioning, and limited head and neck movements will be more common in this group, complicating airway management. Focus on risk factors for peripheral neuropathy (diabetes, alcohol consumption, B12 deficiency), and document pre-existing nerve injuries and neuropathies. Check for signs of vertebro-basilar insufficiency. Consider the need for invasive monitoring and consent appropriately. Perform pre-operative investigations as appropriate.

Pre-induction
Standard monitoring should be instituted with the patient in the supine position, and appropriate venous access gained. Avoid using the anterior cubital fossae – flexion of the arms will occlude this route after the patient is positioned prone for surgery. Place ECG electrodes on the patient's back in a position where they will not interfere with surgery. Ensure that there is an adequate number of staff present to turn the patient after induction – they should be drilled in the technique, using an awake volunteer for practice. The correct operating table should be in place, and induction take place on a separate moveable trolley.

Induction
Induce anaesthesia appropriately, and then secure the airway. A reinforced endo-tracheal tube (ETT) is often used. The laryngeal mask airway has been used in the prone position, but it is intuitively safer to fully secure the airway as access intra-operatively is difficult. Secure the tube, preferably with tape and not a tube tie. This is because when the patient is positioned prone the tie may become tighter and occlude venous drainage from the head and neck resulting in morbidity as discussed earlier.

Protect the eyes carefully. Initially tape shut, and then place extra protective padding over them, and tape that in place also. Hard goggles have been designed to help protect the eyes in the prone position – if used, ensure that they are correctly fitted, taking the pressure off the globes. Consider temperature monitoring – if continuous naso-pharyngeal monitoring is needed, then insert prior to taping the ETT as access to the nose and mouth may be difficult. Place arterial and central lines if required, although be aware that CVP interpretation may be difficult in the prone position. A urinary catheter is recommended in major procedures to aid in assessment of the circulation.

Positioning
When the airway and all lines are secure, tell other members of the theatre team that you are ready to position the patient prone. Place the trolley with

the patient next to the operating table. Take control of the head and airway – as with all positioning it is safest to disconnect the patient from the breathing circuit at this point. At least five other staff (one of whom should be the surgeon) are required to safely turn the patient – two on each side and one controlling the legs and feet. The patient should be turned slowly and gently prone onto the operating table next to the trolley, with the anaesthetist co-ordinating the procedure. Particular care should be taken to avoid misplacement of intravenous lines and cannulae. Once placed, position the head and neck carefully, preferably in a neutral position on a soft head ring avoiding ocular pressure. Then perform a rapid but thorough assessment of the airway, breathing and circulation. Commonly the endo-tracheal tube may move into right main bronchus, as a result of increased neck flexion.

Arm positioning depends on the indication for surgery. For a Montreal mattress prone position, arms should be placed up by the head on an additional arm board. When moving the arms do so individually not simultaneously, as this allows a greater ROM at the shoulder joint (as per butterfly versus freestyle swimming strokes). Ensure that the axillae are not under tension to avoid stretching of the brachial plexus.

Perform a full top to toe assessment of the patient to ensure every pressure point is protected by padded material. If on a Montreal mattress ensure that the abdomen is correctly placed. Then perform another assessment of airway, breathing and circulation prior to the commencement of surgery.

Intra-operative management

The same principles of intra-operative management apply to prone positioning as to any other anaesthetic. The main difference is that if a problem arises that requires a return to the supine position, there may be some delay before this can happen safely. As with all anaesthetics, preventing problems occurring by careful preparation and double-checking prior to commencement of surgery is crucial.

Emergence from anaesthesia

Maintain adequate anaesthesia until the patient is repositioned in the supine position on the trolley, as a coughing or non-compliant patient is hard to reposition safely. Anaesthetic emergence then follows the same principles as from any other anaesthetic, including post-operative visit.

Summary

- Discuss with the operating team the exact position and expected duration of surgery.
- Carefully pre-assess the patient
- Ensure that adequate numbers of theatre staff who are well trained in prone positioning are available.
- The airway must be secure prior to turning the patient prone. Check this again after positioning.

- A top to toe assessment of all pressure points should be performed, paying particular attention to those discussed throughout this tutorial.
- Maintain anaesthesia until the patient is placed supine at the end of the procedure.

References

This tutorial is based upon the following review of prone anaesthesia:

Edgecombe H, Carter K and Yarrow S. Anaesthesia in the prone position. British Journal of Anaesthesia 2008;100(2):165-183.