Prone Surgical Position And Associated hemodynamic instability: Meta-analysis

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List of abbreviations

ARDS	Adult respiratory distress syndrome
CBF	Cerebral blood flow
CI	Cardiac index
CSF	Cerebrospinal fluid
DBP	Diastolic blood pressure
ETT	EndotTracheal tube
HR	Heart rate
ION	Ischemic optic neuropathy
IVC	Inferior vena cava
LMA	Laryngeal mask airway
MBP	Mean blood pressure
POVL	Post-operative visual loss
PVR	Pulmonary vascular resistance
SBP	Systolic blood pressure
SV	Stroke volume
SVR	Systemic vascular resistance

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Introduction

The aim of optimal positioning for surgery is to provide the best surgical access while minimizing potential risk to the patient. Each position carries some degree of risk and this is magnified in the anaesthetized patient who cannot make others aware of compromised positions. Commonly adopted positions include supine, lithotomy, lateral, seated and prone. Many of these are modified with the addition of a vertical tilt (Trendelenburg or reverse Trendelenburg) ***(Fleisch et al., 2015)***.

Prone positioning is a common position used for access to the posterior head, neck, and spine during spinal surgery, access to the retroperitoneum and upper urinary tracts and access to posterior structures when required during plastic surgery ***(Melissa et al., 2015)***.

When moving a patient into the prone position, an almost universal finding is a decrease in cardiac index (CI) which reflected a decrease in stroke volume, with little change in heart rate. Mean arterial pressure (MAP) is maintained by increased systemic vascular resistance (SVR), and pulmonary vascular resistance (PVR) also increased in the majority of patients ***(Shimizu et al., 2015)***.

Perioperative eye injuries can be caused by prolonged hypotension, duration of surgery, blood loss, anemia, and pressure secondary to prone positioning. Corneal abrasions are the most common and blindness is the most rare ***(DePasse et al., 2015)***.

Aim of the Work

The aim of this work is to identify the effects of prone position on hemodynamic stability of patients during different surgeries.

Review of Literature

Prone positioning is a common position used for access to the posterior head, neck, and spine during spinal surgery, access to the retroperitoneum upper urinary tracts and access to posterior structures when required during plastic surgery ***(Melissa et al., 2015)***.

Historical development

The prone position has been described, used, and developed as a result of the requirement for surgical access. However, pioneers of spinal surgery in the 1930s and 1940s were hampered because no effort was made to avoid abdominal compression when positioning the patient. Increased intra-abdominal pressure forced blood from the inferior vena cava (IVC) into the extradural venous plexus, resulting in increased bleeding and a poor surgical field ***(Yang et al., 2013)***.

The position adopted enhanced the natural anterior curvature of the lumbar spine, making surgical access even more difficult. In addition, the aorta, vena cava, and small bowel were forced against the lumbar spine where they were at risk of injury during surgery. Surgical access was also hindered by the limitations of contemporary anaesthetic techniques (most operations were performed with the patient breathing spontaneously, and increased muscle tone served to increase bleeding and impair the surgical field even more. In 1949, physicians provided the first description of a new position (prone with chest rolls) which attempted to overcome some of the adverse effects of increased intra-abdominal pressure in the prone position ***(Yang et al., 2013)***.

Physiological changes with prone position

1) Respiratory:

In anaesthetized patients, the prone position confers a number of benefits in physiological parameters when compared with the supine position. As long as abdominal movement is unimpeded, functional residual capacity and arterial partial pressure of oxygen are increased, yet chest wall and lung compliance remain unchanged. These changes form part of the reason for the use of prone position in ventilated intensive care unit patients with severe refractory ARDS ***(Yang et al., 2013)***.

A gravitational theory to explain the improvements has been proposed and widely accepted. It suggests that pulmonary blood flow favours the dependent areas of the lung and better matching of ventilation and perfusion occurs, brought about by the following:

(i) Gravity displacing the heart and smaller volumes of the lung being compressed.

(ii) Improved diaphragmatic excursion, unhindered by the intra-abdominal contents ***(Melissa et al., 2015)***.

However, single-photon emission computed tomography measurements in healthy ventilated patients have shown no change in the distribution of ventilation, but a more evenly distributed pulmonary blood flow, and improved matching of ventilation and perfusion. The gravitational theory has been challenged, and a model based on the branching architecture of the airways and pulmonary vessels has recently been proposed that provides an alternative explanation for the improvements in matching of ventilation and perfusion seen in the prone position ***(Yang et al., 2013)***.

2) Cardiovascular:

When moving a patient into the prone position, an almost universal finding is a decrease in cardiac index (CI) which reflected a decrease in stroke volume, with little change in heart rate. Mean arterial pressure (MAP) is maintained by increased systemic vascular resistance (SVR), and pulmonary vascular resistance (PVR) also increased in the majority of patients ***(Shimizu et al., 2015)***.

The decrease in cardiac output seen on turning prone is considered to be a result of reduced stroke volume. A decrease in pre-load is thought to be responsible for the reduced stroke volume that is seen. The resulting decrease in arterial pressure is, to some extent, countered by a compensatory sympathetic tachycardia and an increase in peripheral vascular resistance. Many factors contribute to a decrease in pre-load and include:

(i) Blood sequestration in dependent body parts;

(ii) Caval compression;

(iii) Increased intra-thoracic pressure with poor positioning and chest wall compression;

(iv) Positive pressure ventilation and PEEP.

Variabilities in pulse pressure and stroke volume are greater in the prone position, compared with the supine position, and both can be used to predict whether the anaesthetized ventilated prone patient will respond to a fluid challenge. For practical purposes, patients with a pulse pressure variation of 14% are likely to respond to a fluid challenge ***(Yang et al., 2013)***.

3) Cerebral blood flow:

It is postulated that a rotated head position will reduce cerebral blood flow (CBF) and raise intracranial pressure by partial occlusion of the internal carotid and vertebral arteries, spinal vessels, and by compression of venous drainage. Vessel distortion can also occur from external pressure during positioning (e.g. by pillows), or from flexion or extension of the neck. Transcranial Doppler measurements of flow velocity (as a marker of CBF) across the middle cerebral artery demonstrated a reduction in CBF when the head was rotated to the side in healthy subjects ventilated with positive pressure. The diameter of the internal jugular vein was also reduced indicating a reduction in cerebral venous drainage. In patients where even modest reductions in CBF would be deleterious, for example, the elderly with vascular disease or those with raised intracranial pressure, the head and neck should be kept in the neutral position during turning and while in the prone position ***((Feix and Sturgess, 2014)***.

Positioning Steps

Six members of staff are needed to position a patient prone: one person (usually the anaesthetist, except in cases of unstable spine injury) at the head, one moving the feet, and two on either side of the patient. Additional members of staff may be required for obese patients or patients with unstable spines requiring ‘log-rolling’. Alternatively, specialized equipment such as the Jackson table can be used to turn the patient. It is our practice to disconnect monitoring, infusions, and the breathing system while turning the patient to decrease the risk of accidentally dislodging lines or the tracheal tube (TT). As soon as the patient is prone all lines, monitoring and the breathing circuit are reconnected ***(Edgcombe et al., 2015)***.

The following steps should be fulfilled:

1) The patient is anesthetized and intubated, and the endotracheal tube is secured, while patient is lying in the supine position, on either a stretcher or bed. This is accomplished by moving the OR table to one side, so the patient (on stretcher or bed) can be pulled into position for induction, near the anesthesia machine and needed equipment ***(Daniels et al., 2015)***.

2) After intubation and induction are accomplished, the anesthesia provider gives permission for other OR team members to assist in moving the OR table back, next to the stretcher or bed, aligning both in front of the anesthesia machine. The anesthetist frees and secures

all lines (Intravenous line, Arterial line, Central-lines, etc.) in preparation for turning of the patient. There should be a draw sheet on the OR table before moving patient onto it, for later positioning of the patient arms ***(Daniels et al., 2015)***.

3) With multiple assistants, the anesthesia circuit is briefly disconnected by the anesthesiologist as he or she simultaneously commands the head, with one hand securing the airway (or ETT), and attends to the position of all lines. At the command or 1-2-3count of the anesthesiologist, the patient is carefully flipped prone onto the OR table ***(Daniels et al., 2015)***.
4) While other OR team members assist in the prone positioning of the patient, the anesthesiologist continues to maintain the airway, reconnects the circuit, ensures proper functioning of the ventilator (or ability to hand ventilate patient in the case of a LMA), and checks and secures lines ***(Daniels et al., 2015)***.
5) Parallel thoracic or chest rolls (made from tightly rolled sheets and blankets or manufactured gel rolls) are placed under the thorax, lateral to the breasts, following the long line of the body to free the abdomen from compression. Care is given not to compress the breasts with the rolls or cause undue pressure under the axilla ***(Daniels et al., 2015)***.
6) The head is positioned prone, with face placed in a foam prone-cutout pillow (with TT exiting out the side). Eyes, ears, and nose should be checked to assure

that these areas are free from pressure. Most important that the cervical spine should be in neutral alignment. The tube should be free without kinking or undue traction, and the anesthesia provider should be able to visually see or reach in and check all connections ***(Daniels et al., 2015)***.

7) The arms are padded and positioned to prevent nerve stretch or compression. This can be accomplished in a variety of ways depending on the exact nature of the surgery and access required (check with the surgeon). The arms are secured to prevent accidental dislocation or trauma from movement or falling off of table during the procedure ***(Daniels et al., 2015)***.

8) Legs are maintained in the long axis of the body. Knees should be padded with egg crate or gel. Pillows should be placed under the calves and feet to take pressure off the lumbar spine and prevent pressure sores on toes ***(Daniels et al., 2015)***.

9) The patient is secured to the table with tape or a belt across the thighs immediately under the buttocks ***(Daniels et al., 2015)***.