COMMENTARY

Physiological Responses in Relation to Robotic Prostatectomy

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ABSTRACT

Learning physiological responses through clinical application provides a meaningful experience that engraves itself in one's mind forever. Robotic prostatectomy requires a patient to be positioned in a steep Trendelenburg, and this is associated with many physiological responses that involve the cardiovascular, respiratory, and central nervous system. Understanding the physiological responses during the robotic prostatectomy provides vital intraoperative monitoring and ensures the patient's safety.
Malaysian Journal of Medicine and Health Sciences (2023) 19(SUPP12): 126-128. doi:10.47836/mjmhs.19.s12.16

Keywords: Robotic prostatectomy; Steep Trendelenburg

INTRODUCTION

Learning is a lifelong process. Education without application is just entertainment. Learning physiology through application brings meaningful experience and knowledge. Robotic surgery has been widely available elsewhere around the world, yet it is relatively new in Malaysia. Only a few hospitals in Malaysia offer such services. Having knowledge and understanding about physiological responses during an operation is vital to provide adequate care to the patient. Robotic surgery involves surgeons from surgical fields such as in urology, ear nose and throat, gynaecology, orthopaedic and general surgery. Operation with the assistance of the robotic arm not only increases the precision of cutting but also provides better visualisation of the operative field. Besides that, robotic prostatectomy is associated with fewer blood loss and hospitalisation compared to open prostatectomy (1).

During a traditional open prostatectomy, the patient is positioned in a supine position. Robotic prostatectomy is one of the operations that requires the patient to be positioned in a steep Trendelenburg position. This steep Trendelenburg position refers to the extreme head-down tilt of the operating table during the surgery (Figure 1). In this position, the patient's abdominal organs will fall away from the pelvis, providing enough space for the manoeuvring of the robotic instrument with optimal visualization and access to the prostate gland. As the patient is placed in position and the docking of the robotic arm is in place, the position of the patient will remain the same until the end of the operation. Thus, understanding the physiological responses in relation to the positioning of patient during operation is crucial for optimising patient care and better surgical outcomes.

Figure 1 : Steep Trendelenburg position.

Cardiovascular

The normal cardiovascular function involves the heart contact rhythmically pumping out oxygenated blood from the left ventricles to the systemic circulation throughout the body. The blood flows through the large arteries, arterioles and capillaries. The deoxygenated blood (along with the waste products) will be returned back to the right side of the heart (venous return) through the veins. Initial positioning of the patient in a steep Trendelenburg position will cause redistribution of blood from the abdomen and lower limbs to the chest. This will lead to increase in venous return which and eventually causes an increase in the volume of blood in the heart (preload), leading to an increase in amount of blood pumped out of the heart during each heartbeat. However, this will only occur briefly as subsequent increases in intraperitoneal pressure from pneumoperitoneum will cause an increase in systemic vascular resistance and hence a reduce in cardiac output and stroke volume (2). Thus, the patient's blood pressure may initially rise due to increase in venous return and it may subsequently stabilise or decrease depending on the patient's compensatory mechanism or cardiovascular status. Patients with poor cardiac reserves may not be able to withstand the physiological responses during the process. Complications such as myocardial infarction or even cardiac arrest can ensue in patients with poor heart functions.

Respiratory

In a normal respiratory system, the breathing process facilitates the intake of oxygen into the bloodstream and the removal of carbon dioxide via the alveoli. This process involved coordination of the diaphragm and intercoastal muscles creating changes in lung volume and air pressure to aid the gas exchange. During inhalation, the diaphragm will contract and move downward, creating a negative pressure in the thoracic cavity, allowing air to be drawn into the lungs. At the same time, the lung tissue tends to recoil inward due to its elastic properties and the chest wall tends to recoil outward. As the patient is in the steep Trendelenburg position, the shifting of abdominal organs upward leads to an increase in pressure against the diaphragm, reducing its movement and ability to contract effectively. This reduces lung volume leading to a decrease in the volume of air remaining in the lungs after a normal exhalation, termed functional residual capacity (FRC). FRC is important as it keeps the airways patent, prevents alveolar collapse and promotes optimal gas exchange. This may compromise lung compliance, causing an increase in the work of breathing as it will be more challenging to inflate the lungs. In addition, the reduction in lung volume mentioned above may also be contributed by pneumoperitoneum created intraoperatively, which causes compression of the airways and blood vessels. This may cause disruptions in both the ventilation and perfusion process. As matching of ventilation and perfusion is crucial for optimal gas exchange, placing a patient in the steep Trendelenburg position will cause a ventilation-perfusion mismatch. Some areas of the lungs may receive adequate ventilation but have reduced in in blood flow, causing wasted ventilation, while other areas may receive adequate blood flow but reduced ventilation, causing wasted perfusion. Other than ventilation-perfusion mismatch, reduced lung volume during the position may leads to a decrease in the amount of air present in the alveoli, making them more susceptible to collapse leading to atelectasis. Furthermore, compression of the lung tissue occurred due to the positioning and pneumoperitoneum may cause atelectasis as it decreases the ability of the alveoli to remain open and inflated. Eventually, all the above conditions result in hypoxemia and respiratory acidosis. To overcome the above physiological response, ventilation strategies such as using higher positive end expiratory pressure, increasing minute ventilation, and achieving optimum tidal volumes are essential to provide safe ventilation to the patient without causing barotrauma.

Central Nervous system

The central nervous system (CNS) consists of the brain and spinal cord along with a complex network of structures. It controls and coordinates various body functions, including movement, sensory perception, cognition and autonomic functions.

Intracranial pressure (ICP) refers to the pressure within the cranial cavity, which consists of the brain, cerebrospinal fluid (CSF) and blood vessels. It is crucial for the ICP to be maintained at an optimal level to ensure the brain can function normally as well as normal blood flow. The steep Trendelenburg positions cause a pool of blood in the head and upper body due to gravity leading to increase in venous pressure that can impede the venous outflow from the brain. This results in an increase in intracranial pressure. The position may also cause the CSF that surrounds the brain and spinal cord to pool in the cranial compartment, affecting the normal distribution of CSF throughout the nervous system. This may also affect the absorption of CSF by arachnoid villi, adding to the effect of increasing ICP. Swelling of the tongue and brain due to venous engorgement may lead to delayed awakening and airway obstruction postoperatively if not managed properly.

In addition, the combination of the increase in ICP and the reduced blood pressure mentioned previously will further compromise the cerebral perfusion pressure (CPP), the pressure gradient that drives blood flow to the brain. In the steep Trendelenburg position, the reduction in blood pressure (or mean arterial pressure) with concurrent increase in ICP results in a decrease in CPP, affecting cerebral blood flow and oxygen delivery to the brain (3). Intra-ocular pressure can also be affected by the steep Trendelenburg position as it can result in increased venous pressure in the head and neck region. This leads to venous congestion that can raise intraocular pressure.

CONCLUSION

Learning physiological responses to each of the organs during the robotic prostatectomy provides a better understanding of how the human body works. The first step is to acquire adequate physiological knowledge in order to screen and select suitable patients who have planned for robotic prostatectomy. This is to ensure patients can have a successful, safe surgery, as patients who have poor heart function, significant respiratory disease, or increased intracranial pressure are contraindicated for such an operation.

ACKNOWLEDGEMENT

We would like to thank Hospital Sultan Abdul Aziz Shah for the permission to use the facilities

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