JACOBS PUBLISHERS

OPEN ACCESS

Jacobs Journal of Nursing and Care

Research Article

Factors Affecting Intracranial Pressure and Nursing Interventions

Gulay Altun Ugras*[1], Serpil Yuksel[2]

[1]*Mersin University, Health School of Surgical Nursing Department, Mersin, Turkey*

[2]*Necmettin Erbakan University Faculty of Health Science, Division of Nursing, Department of Surgical Nursing, Konya, Turkey*

**Corresponding author: Dr. Gülay Altun Uğraş, Mersin University, Health School, Department of Surgical Nursing, Çiftlikköy Campus, Yenişehir/Mersin, Turkey, Tel:+90 505 2170188; Fax: +90 324 3610571, Email: carpediem0803@yahoo.com*

Received: 12-12-2014

Accepted: 06-01-2015

Published: 01-16-2015

Abstract

Intracranial pressure is the amount of pressure that the cranium exerts on brain tissue, the brain's blood volume and cerebrospinal fluid. Accosrding to Monro-Kellie hypothesis, the body has various mechanisms with the ability to keep the intracranial pressure stable by changing the volume of one of the cranial constituents (blood, cerebrospinal fluid, and brain tissue). When these compensatory mechanisms fail to maintain normal balance, intracranial pressure begins to rise. In neurosurgical patients, many factors such as hypercapnia, hypoxemia, endotracheal aspiration, valsalva maneuver, noxious stimuli and activities increasing cerebral metabolism affect intracranial pressure. The interventions applied in the care of a neurosurgical patient mainly focus on determining the frequency of observations, detecting early signs and symptoms of increased intracranial pressure, administering the appropriate treatment and care in a timely manner, preventing herniation and thus reducing the risk of morbidity and mortality. Nurses providing care for neurosurgical patients should be well aware of the factors affecting intracranial pressure, care interventions to prevent intracranial pressure increase, as well as a thorough understanding of the early signs of increased intracranial pressure. They should also be capable of both planning and implementing specific individual care interventions. This review is designed to identify the factors affecting intracranial pressure and explain the mechanism of increased intracranial pressure with an emphasis on the current literature, which will serve as a guide for neurosurgical nurses in planning the proper nursing care for these patients in line with the current clinical practice guidelines and recommendations.

Keywords: Nursing Care; Intracranial Pressure; Neurosurgery

Introduction

Intracranial pressure (ICP) is the pressure exerted by the cerebrospinal fluid (CSF), blood and brain tissue inside the cranium. According to the Monro-Kellie hypothesis, body is capable of changing the volume of blood, CSF, and brain tissue contained in the cranial cavity in order to maintain normal ICP. The failure of these compensatory mechanisms to maintain homeostasis results in increased ICP [1-9]. Among neurosurgical patients, the factors involved in increased ICP include hypercarbia, hypoxemia, endotracheal suction, Trendelenburg's and prone positions, isometric muscle contractions, valsalva maneuver, noxious stimulations, activities that increase cerebral metabolism, and clustering of treatment and care interventions within the same time period [1-5,7,10].

This review is designed to identify the factors affecting ICP and explain the mechanism of increased ICP with an emphasis on the current literature, which will serve as a guide for neurosurgical nurses in planning the proper nursing care for these patients in line with the current clinical practice guidelines and recommendations.

Methods

In this review, scientific reviews and research reports published in PubMed, ScienceDirect, Cochrane, EbscoHost's Dynamed, EbscoHost Health Source, Ovid LWW Journals, Springer Link, Thieme E-Journals, Google Scholar and ULAKBIM; data in neurosurgery textbooks; and clinical guidelines published by Brain Trauma Foundation (BTF), American Association of Neuroscience Nurses (AANN) and various other institutions were analyzed. During our literature review, the following keywords were used: neurosurgery, intracranial pressure increase, hypercarbia, hypoxemia, endotracheal suctioning, body positions (Trendelenburg's, prone, etc), isometric muscle contractions, valsalva maneuver, vasodilator drugs, seizure, hyperthermia. The titles searched for this review included factors affecting increased intracranial pressure, and nursing management of a patient with increased intracranial pressure.

Factors Associated with Increased Intracranial Pressure

Hypercarbia: Hypercarbia is defined as a carbon dioxide partial pressure (PaCO2) of higher than 45 mmHg. BTF recommends PaCO2 to be maintained range of 35-40 mmHg (normocarbia) [11]. An increased PaCO2 leads to dilation of cerebral blood vessels, thus increasing cerebral blood flow [1,3,5,12,13]. An increased cerebral blood volume results in increased ICP. The etiology of hypercapnia in neurosurgical patients includes pulmonary pathologies (atelectasis, pneumonia, chronic obstructive pulmonary disease, acute respiratory distress syndrome, pulmonary edema, etc), severe pain, insufficient sedation and analgesia, shallow respiration due to excessive sedation or patient-ventilator dyssynchrony, compression of respiratory centers in the brainstem, ventilatory insufficiency due to faulty or improper calibration of the ventilator circuit (velocity, sensitivity, etc) [5].

Hypoxemia: It is defined as a partial pressure of oxygen (PaO2) of less than 50 mmHg. Oxygen (O2) is a less potent vasodilator compared to carbon dioxide (CO2). BTF recommends PaO2 to be maintained above 60 mmHg to prevent hypoxia and oxygen saturation (SpO2) above 90% [11]. When cerebral oxygen tension drops below 50 mmHg, anaerobic metabolism begins, resulting in increased lactic acid and acidosis. Lactic acidosis causes vasodilation and increases cerebral blood flow and ICP [1,5,9,13]. Hypoxia in neurosurgical patients is caused by insufficient oxygen concentration under oxygen therapy; insufficient ventilation during intubation, suctioning and after suctioning; partial or complete airway obstruction, and increased consumption of oxygen [5].

Endotracheal suctioning: Endotracheal suctioning is a common nursing procedure performed in care of neurosurgical patients on mechanical ventilation. Endotracheal suctioning reduces CO2 levels caused by accumulation of secretions, thus preventing an increase in ICP. However, several studies demonstrated that suctioning causes a transient increase of ICP [1,3,5,10,12,14-18]. Endotracheal suctioning increases ICP by stimulating the cough reflex. Disconnecting the ventilator circuit from the endotracheal tube before suctioning and placing the patient back on mechanical ventilation immediately after aspiration cause movement of the endotracheal tube, which stimulates tracheal and laryngeal afferent neurons, leading to coughing. Stimulation of the cough reflex causes the valsalva maneuver and results in increased intrathoracic and intraabdominal pressure [19], and thus increased ICP [1,3,5,10,12,14,20]. In addition, a brief cease in mechanical ventilation support during suctioning procedure and suctioning oxygen as well as secretions might result in a dramatic decrease of PaO2, leading to hypoxemia. A decreased PaO2 and increased PaCO2 cause vasodilation [19,21-24], and increase cerebral blood flow and ICP [1,3,5,12].

Body positions: Body positions including Trendelenburg's and prone, excessive flexion of the hip towards the abdomen, flexion and extension of the neck lead to increased ICP [5]. Cerebral venous system does not have valves, as do other veins in the body. Therefore, increased intraabdominal and intrathoracic pressures, or pressure in the neck or any condition that obstructs or compromises venous outflow result in decreased venous drainage out of the brain and increased cerebral blood volume and ICP because blood is backed up into the intracranial cavity [1,5,8,25-26]. Trendelenburg's position is contraindicated in neurosurgical patients. Prone positioning of the patient increases intraabdominal and intrathoracic pressure. In this position, flexion of the neck prohibits venous drainage from the brain and increases ICP. Excessive flexion of the hip towards the abdomen increases intraabdominal pressure, leading to increased ICP. Flexion of the neck due to a misplaced pillow, neck extension due to inappropriate lateral positioning during turning the patient, or rotation of the neck (producing pressure on jugular vein) decrease venous return from the brain and increase ICP. Devices that apply pressure through a similar mechanism, including rigid cervical collars and other immobilization devices have been shown to increase ICP [5,27]. In addition to all these positions, turning or positioning patient might also cause a transient increase in ICP and subsequently, alterations in cerebral and cardiovascular parameters [25].

Isometric muscle contractions: During isometric muscle contraction, fiber length of the contracting muscle does not change and muscle tone increases. Pushing against the bed with one's feet, pushing upon the bed, pulling on a restraint, shivering, decortication and decerebration are examples of isometric muscle contractions. Isometric muscle contractions increase systemic blood pressure, which, in turn, increase ICP in high-risk patients or patients with limited brain compliance [5].

Valsalva maneuver: Activities such as vomiting, straining, coughing, sneezing, and enema increase ICP, by causing the valsalva maneuver. During valsalva maneuver, closing off the epiglottis while contracting the muscles of expiration increases intraabdominal and intrathoracic pressure, thus preventing venous return from the brain and increases ICP [1,3,5].

Noxious stimuli: Noxious nursing interventions including blood drawing, and removal of adhesive tapes off the skin and invasive procedures such as lumbar puncture, stimulate sympathetic nervous system. Sympathetic nervous system elevates systemic blood pressure and cerebral blood flow, thus increasing ICP [1,3,5].

Factors increasing cerebral metabolism: Seizures and hyperthermia increase cerebral metabolism, which in turn increases cerebral blood flow, resulting in increased ICP [3,5,9-10]. Each 10C rise in body temperature increases cerebral blood flow by 5-6%, and the metabolic demand by 10%. Recent studies highlight the importance of maintaining normothermia in neurosurgical patients [1,3,5-7,9-10,12,26].

Clustering of nursing activities within the same time period: The clustering of care activities (bath, turning patient in bed, etc) and other activities known to be associated with increased ICP within the same time period leads to a dramatic increase in ICP, resulting in increased risk of production of plateau waves in patients. The clustering of all these activities within the same time period increases blood pressure, as well as cerebral blood flow, and ICP. An increased ICP might lead to pathologic plateau waves and cerebral ischemia [5].

Nursing Interventions Aiming to Prevent Increased Intracranial Pressure

The aims of nursing care for patients with increased ICP include maintaining adequate cerebral perfusion, preventing further brain injury by maintaining ICP in the normal range, and controlling factors known to increase ICP [3,5,7,27]. Therefore, it is important to perform certain nursing interventions including ensuring adequate oxygenation, proper patient positioning, preventing isometric muscle contractions, avoiding the valsalva maneuver, minimizing noxious stimuli, preventing conditions associated with increased cerebral metabolism and planning nursing care [1,3,10,12,25].

Ensuring and maintaining the patient's oxygenation: The first step in the management of increased ICP and primary responsibility of a nurse is supplying adequate oxygenation in order to support brain functions. The use of an endotracheal tube or tracheostomy tube may be needed to maintain adequate ventilation. In order to prevent hypercarbia which is associated with increased ICP, PaCO2 level should be maintained at 35 mmHg and PaO2 level should be maintained in a range of 80-100 mmHg. Endotracheal tube suctioning is performed to maintain airway patency and to optimize oxygenation. In order to minimize the risk of hypoxemia, accurate endotracheal suctioning requires 100% oxygenation before and after suctioning, as well as in between the sessions. During each suctioning session, catheter insertion should be restricted to 2 times and the duration of each suctioning should not exceed 10 seconds [1,3-5,9-10,12,28]. The closed-endotracheal tube suctioning method has been reported to decrease stimulation of the cough reflex and to prevent hypoxia [18-19,24,29], resulting in less increased ICP and safer use in neurosurgical patients [18]. In endotracheal suctioning, thoracic and abdominal movements should be observed to assess respiratory distress and breath sounds should be auscultated every 8 hours to maintain oxygenation in neurosurgical patients. Patient-ventilator synchrony should be monitored and particular attention should be paid to changes of skin color (mild cyanosis) and presence of discomfort. The physician's orders should be informed of the presence of any alterations in breathing pattern. The results of arterial blood gas analyses should be monitored regularly and objective data on patient's oxygenation level should be retrieved. In addition, other data indicating oxygenation status of the patient, including pulse oximetry and end-tidal carbon dioxide (ETCO2) readings should be recorded [1,3-5,9-10,12,28].

Appropriate patient positioning: Studies performed in neurosurgical intensive care units recommend keeping the head of the bed elevated to decrease ICP [25]. However, the degree to which the head of the bed should be elevated is highly debated. The guidelines for the management of severe traumatic brain injury published by BTF (2007), include several recommendations regarding patient positioning after severe brain injury. Similarly, appropriate patient positioning has not been clarified in guidelines for the care of patients with subarachnoid hemorrhage [30]. However, another guideline for the care of the patient with craniotomy post-brain tumor resection published by AANN, recommends keeping neck in neutral position and elevation of the head of the bed to 300-450 [31]. This position enables decreasing ICP without affecting cerebral perfusion pressure (CPP) and cardiac output, so that adequate CPP is maintained [25,27,32]. A head-elevated position decreases sagittal sinus pressure and promotes venous drainage via valveless jugular system and decreases vascular congestion causing cerebral edema. On the other hand, elevating the head of the bed more than 30o might decrease CPP [1-5,8-10,12,26,33-35].

One of the studies investigating the impact of head elevation on ICP and CPP demonstrated that elevation of the head of the bed to 300 was associated with significantly decreased ICP when compared to supine position [33]. A similar study of severely head-injured patients by Ng, et al. (2004) reported that ICP was significantly lower at 30 degrees than at 0 degrees of head elevation, whereas CPP was slightly higher at 30 degrees than at 0 degrees. In the mentioned study, it was concluded that 300 of head elevation lead to an improvement in CPP, and reduction in ICP, without deleterious changes in the mean arterial pressure, and thus, the position was a safe one to use in routine care of patients with head injury [32]. On the other hand, Palazon, et al. (2008) reported the mean ICP values were lower when the head was elevated to 300-450, but the mean CPP values were significantly lower at 450 head elevation compared to 300. It is essential to offer different angles of head of bed elevation and body positions to ensure optimal care and comfort in neurosurgical intensive care units [27]. Besides, the lack of proper positioning of patients is likely to be associated with the increased risk of pressure ulcers [36]. The catabolic state after trauma and decreased blood flow might result in ischemia of the skin and subcutaneous tissues. Pressure from bony prominences can be removed by rolling patient onto side [25]. Accordingly, in a study examining the effects of 12 different positions on neurodynamic and hemodynamic outcomes by Ledwith, et al. (2010), statistically significant decreases were observed in ICP for supine head of bed elevated 300-450 and for supine head of bed 450 and knee elevation. In that study, the authors also suggested that lateral positioning without the head of the bed elevated was likely to be the most dangerous position for neurosurgical patients, and emphasized the importance of close monitorization of patients with severe brain injury, placed in the lateral position [25]. Furthermore, Kose and Hatipoglu (2012) suggested that the head elevation of patients who underwent cranial surgery should be 300 to provide optimum cerebral blood flow and in the absence of any medical contraindications, right and left lateral positioning were also safe for this patient group.

Excessive rotation or flexion of the neck, which has been reported to cause pressure on the jugular veins and increases ICP, should be avoided. For the patients who are unable to maintain a neutral neck position independently, a soft neck collar, rolled-up towel, or a small cushion can be used [27]. Kose and Hatipoglu (2012) demonstrated that temporary flexion or extension of the head had no impact on the cerebral blood flow, however, prolonged flexion and extension of the head caused alterations in cerebral blood flow and should be avoided in patients who underwent cranial surgery.

Excessive hip flexion, which is known to be associated with increased intraabdominal and intrathoracic pressure, thus raising ICP, is not recommended. Rapid position changes may increase the ICP and therefore, patients should be turned gently and repositioned slowly during nursing care [1-5,8-10,12,26,33,35].

Prevention of isometric muscle contractions: Passive range of motion (ROM) should be used in the management of neurosurgical patients since it does not necessitate isometric muscle contractions. Pharmacological agents such as chlorpromazine, can be considered to prevent shivering causing isometric muscle contractions. Pancuronium bromide and baclofen can be used to prevent the development of decerebration in patients at risk for developing an elevated ICP. Since confusion, agitation and seizures are associated with increased risk of injury in patients with altered consciousness and raised ICP, an arm restraint and other soft restraints can be used for patients who are at risk for self-extubation or falling out of bed. However, these restraints might cause isometric muscle contractions and mild sedation may be required [5].

Nursing Interventions to minimize the valsalva maneuver: The patient should be instructed to exhale, which opens the glottis, in order to avoid the valsalva maneuver. To prevent constipation, stool softeners should be used instead of enema [3,5,28].

Minimizing noxious stimuli: Pain management and sedation decrease cerebral metabolic rate for oxygen consumption as well as cerebral blood flow, thus decreasing the ICP. In order to achieve this, propofol, benzodiazepines, and narcotics (morphine or fentanyl) are commonly used. Since these agents may compromise neurologic assessment, their use in patients without ICP monitoring is debated [1,5-6,8,12]. In neurosurgical patients, the management of transient increases in the ICP due to positioning and coughing, and an easy ventilation can be achieved with the use of neuromuscular blockers as ordered by the physician in charge [2,5-6,10,35]. Several studies have demonstrated that the use of several pharmacologic agents before and during endotracheal suctioning to inhibit the stimulation of the cough reflex and the sympathetic nervous system, actually has minor effects on the ICP [14,20].

Minimizing/preventing the conditions associated with increased cerebral metabolism: Hyperthermia is known to increase the ICP by increasing the metabolic demands. A cooling blanket, ice bath, other cooling methods such as the use of an intravenous cooling device, and antipyretics (e.g. acetaminophen) can be used to decrease body temperature in patients with increased ICP. In case of the development of hyperthermia in a patient, the physician in charge should be immediately informed, the body temperature should be monitored hourly, body temperature should be decreased through use of a cooling blanket and other rapid cooling techniques recommended, and the prescribed antipyretic drugs (e.g. acetaminophen) should be administered. If a cooling blanket is used, cooling should be terminated when the patient's temperature reaches 10C above the desired level (because the body temperature will continue to fall naturally after the blanket is turned off) and the temperature should be decreased gradually to prevent shivering [1,3,5-7,9-10,12,26,28]. One of the conditions associated with increased cerebral metabolism is seizure. Patients who have seizures or are at high risk for developing seizures, should be carefully identified and monitored closely, and anticonvulsant drugs (e.g. phenytoin, carbamazepine, etc) should be administered in a timely manner under the physician's order, and serum concentrations of these drugs should be monitored closely [3,5,9-10].

Planning nursing interventions: One of the factors associated with increased ICP is clustering of all nursing interventions within the same time period. Spacing of nursing interventions may prevent transient increases in ICP. During all nursing interventions, the ICP should be maintained below 25 mmHg and it should return to baseline levels within 5 minutes. Duration of each break between nursing interventions should be planned. In addition, patients should be turned slowly and moved gently to prevent pain and agitation. Prior to nursing care, sedatives and paralytic agents can be administered in patients at high risk for increased ICP [3,5,12].

Conclusion

In conclusion, treatment and care interventions for neurosurgical patients focus on recognition of early signs and symptoms of increased ICP, proper monitoring, and treatment and care in a timely manner to prevent a possible brain herniation and death. The nurse providing care to a neurosurgical patient should be aware of the factors associated with increased ICP, be capable of performing necessary interventions to prevent an increase in ICP and to establish early diagnosis, and be competent in planning and performing personal care tasks.

References

1. Barker E. Intracranial pressure and monitoring. In Neuroscience Nursing, a Spectrum of Care. 3rd edition. St. Louis: Mosby Elsevier. 2008, 305- 336.

2. Lee ELT, Armstrong TS. Increased intracranial pressure. Clin J Ongol Nurs. 2008, 12(1): 37-41.

3. LeMone P, Burke K: Nursing care of clients with intracranial disorders. In Medical-Surgical Nursing Critical Thinking in Client Care. 4 th edition. New Jersey: Pearson Prentice Hall. 2008, 1527-1577.

4. Basavanthappa BT. Neurological nursing. In Medical Surgical Nursing. 2nd edition. New Delhi. Jaypee Brothers Medical Publishers. 2009, 783-890.

5. Hickey JV, Olson DM. Intracranial hipertension: theory and management of increased intracranial pressure. In The Clinical Practice of Neurological and Neurosurgical Nursing. 6th edition. Edited by Hickey JV. USA: Wolters Kluwer Health, Lippincott Williams& Wilkins. 2009, 270-307.

6. Powers J, Schulman CS. Head injury and dysfunction. In AACN Advanced Critical Care Nursing. Edited by Carlson KK. St. Louis: Saunders Elsevier. 2009, 529-575.

7. Karadakovan A. Diseases of the nervous system. In Dahili ve Cerrahi Hastalıklarda Bakım. Edited by Karadakovan A, Eti Aslan F. Adana: Nobel Tıp Kitabevleri. 2010, 1176-1214.

8. Koenig MA. Cerebral edema and intracranial hypertension. In Handbook of Neurocritical Care. 2nd edition. Edited by Bhardwaj A, Mirski MA. New York: Springer Science, Business Media, LLC. 2011, 73-88.

9. Zomorodi M. Nursing management acute intracranial problems. In Medical-Surgical Nursing Assessment and Management of Clinical Problems. 8th edition. Edited by Lewis SL, Dirksen SR, Heitkemper MM, Bucher L, Camera IM. St. Louis: Elsevier Mosby. 2011, 1425-1458.

10. McNair ND, Kurig JL. Manegement of clients with neurologic trauma. In Medical Surgical Nursing, Clinical Management for Positive Outcomes. 8th edition. Edited by Black JM, Hawks JH. St.Louis: Elsevier Saunders. 2009, 1921-1973.

11. Brain Trauma Foundation (BTF), American Association of Neuroscience Nurses (AANN), Congress of Neurological Surgeons (CNS), Joint Section on Neurotrauma and Critical Care, AANN/CNS, et al: Guidelines for the management of severe traumatic brain injury. 3rd edition. Edited by Bullock MR, Povlishock JT. Journal of Neurotrauma. 2007, 24 (1): S1-S106.

12. Smeltzer SC, Bare BG, Hinkle JL, Cheever KH. Management of patients with neurologic dysfunction. In Brunner&Suddarth's Textbook of Medical Surgical Nursing. 11th edition. Philadelphia: Lippincott Williams& Wilkins. 2008, 2160-2204.

13. Curley G, Kavanagh BP, Laffey JG. Hypocapnia and the injured brain: more harm than benefit. Crit Care Med. 2010, 38(5): 1348-1359.

14. Gemma M, Tommasino C, Cerri M, Giannotti A, Piazzi B, et al. Intracranial effects of endotracheal suctioning in the acute phase of head injury. J Neurosurg Anesthesiol. 2002, 14(1): 50-54.

15. Leone M, Albanèse J, Viviand X, Garnier F, Bourgoin A et al. The effects of remifentanil on endotracheal suctioning-induced increases in intracranial pressure in head-injured patients. Anesth Analg. 2004, 99(4): 1193-1198.

16. Thiesen RA, Dragosavac D, Roquejani AC, Falcão AL, Araujo S et al. Influence of the respiratory physiotherapy on intracranial pressure in severe head trauma patients. Arg Neuropsiquiatr. 2005, 63(1): 110-113.

17. Cerqueira-Neto ML, Moura ÀV, Scola RH, Aquim EE, Rea-Neto À et al. The effect of breath physiotherapeutic maneuvers on cerebral hemodynamics. Arq Neuropsiquiatr. 2010, 68(4): 567-572.

18. Altun Uğraş G, Aksoy G. The effects of open and closed endotracheal suctioning on intracranial pressure and cerebral perfusion pressure: a crossover, single-blind clinical trial. J Neurosci Nurs. 2012, 44(6): E1-E8.

19. Bourgault AM, Brown CA, Hains SMJ, Parlow JL. Effects of endotracheal tube suctioning on arterial oxygen tension and heart rate variability. Biol Res Nurs. 2006, 7(4): 268-278.

20. Chivite Fernández N, Martínez Oroz A, Marraco Bonmcompte M, Navarro García MA, Nuin ES et al. Intracranial pressure response during secretion aspiration after administration of a muscle relaxant. Enferm Intensiva. 2005, 16(4): 143-152.

21. Baun MM, Stone KS, Rogge JA. Endotracheal suctioning: open versus closed with and without positive end-expiratory pressure. Crit Care Nurs Q. 2002, 25(2): 13-26.

22. Oh H, Seo H. A meta-analysis of the effects of various interventions in preventing endotracheal suction induced hypoxemia. J Clin Nurs. 2003, 12(6): 912-924.

23. El Masry A, Williams PF, Chipman DW, Kratohvil JP, Kacmarek RM. The impact of closed endotracheal suctioning systems on mechanical ventilator performance. Respir Care. 2005, 50(3): 345- 353.

24. Lorente L, Lecuona M, Jimenez A, Mora ML, Sierra A. Tracheal suction by closed system without daily change versus open system. Intensive Care Med. 2006, 32(4): 538-544.

25. Ledwith MB, Bloom S, Maloney-Wilensky E, Coyle B, Polomano RC et al. Effect of body position on cerebral oxygenation and physiologic parameters in patients with acute neurological conditions. J Neurosci Nurs 2010, 42(5): 280-287.

26. Mathai KI, Sudumbrekar SM, Shashivadhanan MS, Sengupta SK, Rappai TJ. Decompressive craniectomy in traumatic brain injury rationale and practice. Indian Journal of Neurotrauma. 2010, 7(1): 9-12.

27. Kose G, Hatipoglu S. Effect of head and body positioning on cerebral blood flow velocity in patients who underwent cranial surgery. J Clin Nurs. 2012, 21(13-14): 1859–1867.

28. Alexander S, Gallek M, Presciutti M, Zrelak P. Care of the patient with aneurysmal subarachnoid hemorrhage. In AANN Clinical Practice Guideline Series. American Association of Neuroscience Nurses. Edited by Thompson HJ. Lake Avenue. 2011, 1-30.

29. Lasocki S, Lu Q, Sartorius A, Fouillat D, Remerand F et al. Open and closed-circuit endotracheal suctioning in acute lung injury. Anesthesiology. 2006, 104(1): 39-47.

30. Bederson JB, Connolly ES Jr, Batjer HH, Dacey RG, Dion JE et al. Guidelines for the management of aneurysmal subarachnoid hemorrhage: a statement for healthcare professionals from a special writing group of the Stroke Council, American Heart Association. Stroke. 2009, 40(3): 994-1025.

31. Paolino A, Ruppert J, Anderson M, Garrison-Lanham J. Guide to the care of the patient with craniotomy post–brain tumor resection. In AANN Clinical Practice Guideline Series. American Association of Neuroscience Nurses. Edited by Barbour AR. Lake Avenue. 2006, 1-41.

32. Ng I, Lim J, Wong HB. Effects of head posture on cerebral hemodynamics: its influences on intracranial pressure, cerebral perfusion pressure, and cerebral oxygenation. Neurosurgery. 2004, 54(3): 593-598.

33. Fan JY. Effects of backrest position on intracranial pressure and cerebral perfusion pressure in individuals with brain injury: a systematic review. J Neurosci Nurs. 2004, 36(5): 278-288.

34. Palazón JH, Asensi PD, López SB, Bautista FP, Candel AG. Effect of head elevation on intracranial pressure, cerebral perfusion pressure and regional cerebral oxygen saturation in patinets with cerebral hemorrhage. Rev Esp Anestesiol Reanim. 2008, 55(5): 289-293.

35. Mcilvoy L, Meyer K. Nursing management of adults with severe traumatic brain injury. In AANN Clinical Practice Guideline Series. American Association of Neuroscience Nurses. Edited by Thompson HJ. Lake Avenue. 2012, 1-20.

36. Griffiths H, Gallimore D. Positioning critically ill patients in hospital. Nurs Stand. 2005, 19(42): 56-64.