In conclusion, even when taking the most diligent care in protecting the anesthetized patient from postoperative peripheral neuropathy, these injuries can occur but fortunately appear to completely resolve in the majority of cases.

REFERENCES

1. Martin JT: The Prone Position: Anesthesiologic Considerations, Positioning in Anesthesia and Surgery. Edited by Martin JT. Philadelphia, WB Saunders, 1987, pp 191–222
2. Fuller JE, Thomas DV: Facial nerve paralysis after general anesthesia. JAMA 162:645, 1956
3. Nightingale PJ, Longreen A: Iatrogenic facial nerve paresis. Anaesthesia 37:322–323, 1982
4. Azar I, Lear E: Lower lip numbness following general anesthesia. ANESTHESIOLOGY 65:450–451, 1986
5. Glauber DT: Facial paralysis after general anesthesia. ANESTHESIOLOGY 65:516–517, 1986
6. Lorentz A, Podstawski H, Osswald PM: Lower lip numbness after general anesthesia. Anaesthesist 37:381–383, 1988
7. James FM: Hypesthesia of the tongue. ANESTHESIOLOGY 42:359, 1975
8. Agnoli A, Strauss P: Isolated paresis of the hypoglossal nerve and combined paresis of the hypoglossal nerve and the lingual nerve following intubation and direct laryngoscopy. HNO 18:237–239, 1970
9. Woodburne RT: Essentials of Human Anatomy. New York, Oxford University Press, 1983, pp 215–224
10. Nicholson MJ, Eversole UH: Nerve injuries incident to anesthesia and operation. Anesth Analg 36:19–32, 1957
11. Britt BA, Gordon RA: Peripheral nerve injuries associated with anesthesia. Can Anaesth Soc J 11:514–536, 1964
12. Dornette WHL: Compression neuropathies: Medical aspects and legal implications. Int Anesthesiol Clin 24:201–229, 1986
13. Parks BJ: Post operative peripheral neuropathies. Surgery 74:348–357, 1973

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Pulse Oximetry and Patient Positioning: A Report of Eight Cases

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Pulse oximetry, used to measure arterial hemoglobin oxygen saturation, can also serve to monitor the adequacy of arterial blood flow.[1-3] The use of pulse oximetry helps to ensure proper positioning of patients on the operating table. Eight cases are presented in which the use of pulse oximetry alerted the anesthesiologist of a patient's improper position.

CASE REPORTS

Case 1. A 27-yr-old obese woman (90 kg, 1.7 m) with persistent pelvic pain was scheduled for diagnostic laparoscopy. In addition to other monitors, a pulse oximeter sensor (Nellcor N-100, software version 68-1, Hayward, California) was applied to the patient's left index finger. After induction of general anesthesia, the patient was positioned in the lithotomy position with the upper extremities at 90° angles to her body. Immediately thereafter, the pulse oximeter was unable to detect a pulse. Palpation confirmed the absence of left forearm pulses; they remained palpable in the right forearm. No observable change in skin color or skin temperature was detected at that time. Repositioning the armboard to less than 90° was followed by prompt return of peripheral pulses as detected by the pulse oximeter and palpation.

Case 2. A 49-yr-old man with a right middle lobe lung mass was scheduled for thoracotomy. In addition to other monitors, a pulse oximeter sensor was applied to the patient's left index finger. General anesthesia was induced and the patient was positioned in the left lateral decubitus position. After placement of an axillary roll, the pulse oximeter did not detect a pulse. Palpation confirmed the absence of left forearm pulses. The axillary roll was noted to be located high in the axilla and immediately repositioned further caudad, after which there was a prompt return of peripheral pulses.

Case 3. A 42-yr-old woman with persistent hemoptysis and fever was scheduled for an open lung biopsy. In addition to other monitors, a pulse oximeter sensor was placed on the left index finger. After induction of general anesthesia, the patient was placed in a 45° semilateral position supported by folded sheets under the left chest. The left (upper) arm was suspended from the anesthesia screen, which was subsequently angled cephalad to aid surgical exposure. At that point, the pulse oximeter was unable to detect a pulse. Palpation confirmed the absence of left forearm pulses; they remained palpable in the right forearm. It was then noted that the left arm was hyperabducted greater than 90°. Return of the screen to its original position was followed by return of peripheral pulses.

Case 4. A 33-yr-old man, a victim of a motorcycle accident, was scheduled for an emergent exploratory laparotomy. In addition, he also suffered bilateral clavicular fractures. His chest x-ray revealed a right lung contusion and a right upper lobe hematoma near the fractured and markedly dislocated right clavicle. In addition to other monitors, a pulse oximeter sensor was placed on the right index finger.

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Both arms were secured on armboards and positioned at an angle of approximately 45° to the operating table. Prior to the start of surgery, they were moved out to 90°. At that time, the pulse oximeter failed to detect a pulse, nor did the right forearm pulses remain palpable. Repositioning of the right armboard to approximately 75° caused the return of peripheral pulses.

Case 5. A 62-yr-old woman with a parasagittal brain mass was scheduled for a craniotomy in the prone position. She was morbidly obese, weighed 90 kg and was 1.5 m tall (body mass index = 40). After general anesthesia had been induced, the patient was turned to the prone position. Two blanket rolls were positioned longitudinally from the patient's shoulders to her hips, raising her chest and abdomen from the table. Five minutes later, a pulse oximeter revealed that the patient's oxyhemoglobin saturation decreased progressively from 100% to 60%. Blood pressure, heart rate, and end-tidal CO_2 values remained stable. Inspection revealed that one of the blanket rolls had shifted laterally; as a result, the patient's abdomen was resting on the operating table. The patient was repositioned with immediate improvement of the oxyhemoglobin saturation as detected by the pulse oximeter.

Case 6. A 42-yr-old woman was scheduled for a posterior C6–7 cervical spine fusion for fracture stabilization. In addition to the other monitors, a pulse oximeter sensor was applied to the patient's right index finger, and a right radial artery catheter was inserted. An awake nasal fiberoptic endotracheal intubation was performed. While still conscious, the patient was gently log-rolled into the prone position onto a padded convex saddle frame with both arms placed at her sides. After induction of general anesthesia, the patient's shoulders were tightly secured in anterior flexion with strips of 3-inch adhesive tape extending diagonally from above the patient's head to just lateral to her iliac crests. Then the arterial pressure tracing became markedly dampened and the pulse oximeter was unable to detect a pulse. Although the arterial catheter flushed without difficulty and blood could be aspirated readily, no waveform could be transduced from it. Repositioning of the patient's right hand failed to produce a waveform. A blood pressure cuff on the opposite arm revealed normal blood pressure. Release of the securing adhesive tape over the right shoulder allowed prompt return of an arterial pressure tracing, forearm pulses, and their detection by the pulse oximeter.

Case 7. A 2-yr-old boy with a tetralogy of Fallot malformation was scheduled for a Blalock-Taussig shunt operation. As part of routine monitoring, a pulse oximeter sensor was placed on the right thumb. After the induction of general anesthesia, the right hand was hyperextended over a roll of gauze pads and immobilized with adhesive tape for placement of an arterial catheter. This resulted in blanching of the patient's hand and the pulse oximeter being unable to detect a pulse. Upon repositioning the hand with a lesser degree of hyperextension, the skin color became pink and the pulse oximeter resumed normal function.

Case 8. A 68-yr-old man with unstable angina was scheduled for coronary artery bypass grafting. Monitoring included a pulse oximeter sensor on the left index finger, a left radial artery catheter, and a pulmonary artery catheter in the right internal jugular vein. After induction of general anesthesia, both upper extremities were secured to the patient's sides with a draw sheet. Following a median sternotomy, a Favaloro chest wall retractor was attached to the patient's left chest to facilitate dissection of the left internal mammary artery. Upon adjustment of the retractor for maximal chest wall retraction, the pulse oximeter was unable to detect a pulse and the arterial pressure tracing became completely dampened. A noninvasive blood pressure measurement on the opposite arm revealed a normal blood pressure. The surgeon was advised of the situation, then elected to proceed. After approximately 35 min, the retractor was released, which resulted in prompt restoration of pulse oximeter waveform and arterial pressure tracing. The patient suffered no morbidity secondary to chest wall retraction.

DISCUSSION

The usefulness of pulse oximetry as a monitor of patient positioning has only been described as an adjunct in evaluating the traction placed on a patient's arm prior to shoulder arthroscopy.[4] However, although pulse oximetry detects arterial compromise, it does not reflect peripheral nerve compromise, which may occur prior to arterial compromise.[5] Eight cases are presented in which vascular compromise caused by improper patient positioning or surgical manipulation was detected by pulse oximetry.

The axillary neurovascular bundle is susceptible to compromise by both muscular and skeletal structures producing a variety of thoracic outlet syndromes. The most common forms of thoracic outlet syndromes include the hyperabduction syndrome,[6] the scalenus anticus syndrome,[7] the costoclavicular syndrome,[8] and the cervical rib syndrome.[9] Because there existed no evidence of the latter three syndromes in the first case, this patient's presentation was most consistent with the hyperabduction syndrome. When the arm is hyperabducted, the axillary neurovascular bundle may be compromised by several different mechanisms: 1) stretching around the coracoid process and compression by the pectoralis minor muscle,[6] 2) compression between the first rib and the clavicle,[10] or 3) stretching around the head of the humerus.[11] It has been demonstrated that the radial pulse disappears in 83% of healthy volunteers if the arm is abducted more than 90°.[6] Similarly, armboards moved cephalad may produce compression and stretching of the axillary neurovascular bundle at the head of the humerus.[11]

Positioning of the axillary roll high in the axilla rather than just caudad to it may cause compression of the axillary neurovascular bundle. The purpose of the chest roll is to relieve pressure from the head of the dependent humerus, thereby avoiding compression of the axillary neurovascular bundle.[12]

Suspension of the nondependent arm from the anesthesia screen may result in morbidity if that arm is hyperabducted. The first and only sign of vascular compromise in the third case was a loss of the pulse oximeter pulse waveform. It has been reported that suspension of a hyperabducted arm from an anesthesia screen may produce neurovascular compromise.[13,14]

Although abduction of the arm to 90° is considered to be the acceptable limit,[6] for the fourth patient in this series, this must be considered hyperabduction. The severe nature of his clavicular fracture–dislocation produced vascular compromise when his arm was abducted to 90°. Local tissue edema and hematoma formation around the fractured clavicle may have contributed to produce this vascular compromise.

Proper positioning of ventral supports (*e.g.*, blanket rolls) for the patient in the prone position is important.

Malpositioning can produce marked reduction of functional residual capacity, which can manifest as hypoxia. Proper support of a patient in the prone position allows the abdomen to hang free so as to allow optimal lung inflation and deflation.[15]

The forearm pulses were lost in case 6 once she was positioned prone with her shoulders secured in anterior flexion. Because one of the pillars of the saddle frame was positioned subclavicularly, it is likely that her axillary vasculature was compressed between the securing tape and the frame support.

For radial arterial catheter insertion, a patient's hand is routinely hyperextended. Excessive extension of the hand has been shown to occlude the transpalmar arch resulting in a blanched hand.[16]

Excessive retraction of the sternum during internal mammary artery dissection is known to produce neurovascular compromise.[17] Use of a chest wall retractor probably caused excessive traction on the axillary neurovascular bundle, which was detected by pulse oximetry and direct arterial pressure recording. It is likewise possible that the retractor support compressed the arm.

In patients requiring an arterial catheter as well as routine pulse oximetry, placement of the monitors on opposite upper extremities greatly increases the effectiveness of monitoring for vascular compromise. For patients in the lateral decubitus position, insertion of the arterial catheter or pulse oximeter on the dependent or nondependent upper extremity remains controversial.[12]

The eight patients presented here emphasize the importance of patient positioning on the operating table. In most instances, simple intermittent palpation of the radial artery will detect vascular compromise in the upper extremity. Likewise, a frequent manual check of thoracoabdominal excursions in the patient placed in the prone position will usually prevent respiratory compromise. These precautionary maneuvers remain an absolute necessity. If a pulse oximeter is able to detect a pulse, it could be assumed that blood flow to that extremity has not been significantly compromised. Pulse oximetry is a welcome and valuable additional safeguard, particularly because it provides a continuous, rather than intermittent, check of proper patient positioning.

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REFERENCES

1. Freisen RH: Pulse oximetry during pulmonary artery surgery. Anesth Analg 64:376, 1985
2. Skeen JT, Backus WW, Hovagim AR, Poppers PJ: Intraoperative pulse oximetry in peripheral revascularization in an infant. J Clin Monit 4:272–273, 1988
3. Hovagim AR, Katz RI, Poppers PJ: Pulse oximetry for evaluation of radial and ulnar arterial blood flow. J Cardiothoracic Anes 3:27–30, 1989
4. Hershman ZJ, Levy MI, Frost EA, Goliner PL: Pulse oximetry during shoulder arthroscopy (letter to the editor). ANESTHESIOLOGY 65:565, 1986
5. Gibbs N, Handal J, Nentwig MK: Pulse oximetry during shoulder arthroscopy. ANESTHESIOLOGY 67:150–151, 1987
6. Wright IS: The neurovascular syndrome produced by hyperabduction of the arms. Am Heart J 29:1–19, 1945
7. Adson AW: Surgical treatment for symptoms produced by cervical ribs and the scalenius anticus muscle. Surg Gynecol Obstet 85: 687, 1947
8. Falconer MA, Weddell G: Costoclavicular compression of the subclavian artery and vein: Relation to the scalenus anticus syndrome. Lancet 2:539, 1943
9. Schein CJ, Haimovici H, Young H: Arterial thrombosis associated with cervical ribs: Surgical considerations: Report of a case and review of the literature. Surgery 40:428, 1956
10. Clausen EG: Postoperative ("anesthetic") paralysis of the brachial plexus. Surgery 12:933–942, 1942
11. Prentice JA, Martin JT: The Trendelenburg position, anesthesiologic considerations, Positioning in Anesthesia and Surgery. Edited by Martin JT. Philadelphia, WB Saunders, 1987, pp 127–145
12. Lawson NW: The lateral decubitus position, anesthesiologic considerations, Positioning in Anesthesia and Surgery. Edited by Martin JT. Philadelphia, WB Saunders, 1987, pp 155–179
13. Lincoln JR, Sawyer HP: Complications related to body positions during surgical procedures. ANESTHESIOLOGY 22:800–809, 1961
14. Britt BA, Gordon RA: Peripheral nerve injuries associated with anesthesia. Can Anaesth Soc J 11:514–535, 1964
15. Rehder K, Knopp TJ, Sessler AD: Regional intrapulmonary gas distribution in awake and anesthetized-paralyzed prone man. J Appl Physiol 45:528–535, 1978
16. Greenhow DE: Incorrect performance of Allen's test-ulnar-artery flow erroneously presumed inadequate. ANESTHESIOLOGY 37: 356–357, 1972
17. Kinzer JB, Lichtenthal PR, Wade LD: Loss of radial artery pressure trace during internal mammary artery dissection for coronary artery bypass graft surgery. Anesth Analg 64:1134–1136, 1985