Appendectomy at world's highest altitude operation theatre in a remote set-up: A rare anaesthetic scenario and a short literature review

Sir,

Approximately 140 million people worldwide live permanently at altitudes greater than 9,000 feet and many of them might require surgical care. We describe a case of an emergency open appendectomy in a high-altitude environment in an underground dug-in forward surgical centre in an austere environment.

A 27-year-old male patient residing at an altitude of 16,000 feet was posted for emergency open appendectomy. The nearest tertiary care hospital was 1,000 km by road and the weather was not conducive for air evacuation. The patient was well acclimatised, residing there for the last 4 months, with an oxygen saturation of 98% on room air. He was taken up for surgery under spinal anaesthesia (SA). A spinal dermatomal blockade up to T6-T8 level

was achieved with 3.0 mL (15 mg) bupivacaine (hyperbaric). SA was later supplemented with general (GA), as the appendix was subhepatic, with intravenous (IV) midazolam 75 μg/kg, fentanyl 100 μg, propofol 5 mg/kg, and ketamine 3 mg/kg in incremental doses as the appendix was subhepatic. Controlled mechanical ventilation was delivered via a mechanical ventilator (Neptune) and using i-gel size 4. The oxygen saturation was maintained at 100%. The duration of surgery was 4.5 h and the FiO_2 was maintained at 100% throughout. The patient was haemodynamically stable. Post-operative oxygen supplementation was given via a face mask at 5 L/min for 4 h and IV paracetamol 1 gm was given 8 hourly. Oxygen saturation remained at 99% and the postoperative recovery was uneventful.

The physiological effects of high altitude exposure are mainly a reduction in the inspired partial pressure of oxygen (PaO_2), ambient pressure, and gas density.[1] Long-term residents may have higher haematocrit and pulmonary hypertension, lower partial pressure of carbon dioxide, and bicarbonate concentrations.[2] Because of the reduced PaO_2, the risk of perioperative hypoxia is likely to be increased, particularly in persons who have recently ascended to such an altitude. Nevertheless, delayed awakening, bladder and bowel distension, and postanaesthetic headache with nausea have been reported after GA due to perioperative hypoxia at high altitude.[3] Literature reveals that the delivered percentage of volatile anaesthetic increases with ascending altitude; however, its partial pressure remains constant and the floating bobbin under-reads the actual gas flow rates in the flowmeter.[4] A hypoxic mixture may, therefore, be delivered to the patient; hence, a concentration of 100% oxygen should be administered in the perioperative period. At high altitudes, PaO_2 is normally increased by hyperventilation, induced by the hypoxic ventilatory drive. Anaesthetic agents and narcotic analgesics can blunt the hypoxic ventilatory drive and precipitate hypoxia. Hence, agents that are least likely to suppress ventilation should be chosen. Furthermore, due to low temperatures, all intravenous fluids and blood products should be warmed to body temperature and care should be taken to prevent fluid overload keeping in mind the risk of pulmonary oedema. Nevertheless, a total of 3,000 mL of warmed Ringer's lactate was infused intraoperatively in our patient.

The physiology of spinal anaesthesia at high altitudes is not well understood and evidence on this has to build up. Lower pH of the cerebrospinal fluid has been reported in high-altitude natives.[5] Also, the duration of motor block and sensory block time with intrathecal hyperbaric bupivacaine have been found to be higher at sea level compared with that at moderate high altitude, thus, pointing toward the need for an increase in the dose of intrathecal hyperbaric bupivacaine at high altitudes.[6] The incidence of post-dural puncture headache (PDPH) is higher than that at sea level and is attributed to intracranial pressure changes that take place. Nevertheless, we used a 25-gauge Quincke spinal needle and PDPH did not occur in our patient.

As the risk of infection was high, we got the dug-in operation theatre (OT) in tent cleaned, fumigated, and made airtight by placing rocks around the tent. The outside temperatures were sub-zero (−15 to −20°C) along with the associated wind chill factor. The OT was maintained at ambient temperature with the help of kerosene heaters that were placed away from the oxygen source. Electricity was supplied with a generator. The floor inside the tents was uneven, and the operation table, lights, and monitoring equipment needed frequent adjustments. Limited manpower in an unfamiliar environment made the surgery even more challenging.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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