Case Report

Negative-pressure pulmonary oedema in a patient undergoing shoulder arthroscopy

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ABSTRACT

An 18-year-old ASA-I patient who underwent elective left shoulder arthroscopy developed severe airway obstruction post-extubation due to fluid extravasation from the shoulder joint into the neck and airway tissue. Re-intubation for relief of obstruction resulted in negative-pressure pulmonary oedema. The patient was electively ventilated in the intensive care unit and recovered uneventfully. A high index of suspicion along with monitoring of neck circumference can prevent this kind of complication.

Key words: Fluid extravasation, negative-pressure pulmonary oedema, shoulder arthroscopy, subacromial space

INTRODUCTION

Shoulder arthroscopy is a commonly used technique for dealing with pathologies of the shoulder joint, like rotator cuff tears, recurrent dislocations and other subacromial lesions. Arthroscopy of the joint can be performed under general or regional anaesthetic techniques, and the joint space is visualized with the help of irrigating fluid infused at desired pressures. Shoulder arthroscopy is a fairly safe procedure with limited complications. We report a case of a rare but life-threatening complication occurring because of fluid extravasation following shoulder arthroscopy.

CASE REPORT

An 18-year-old boy with a height of 150 cm and weight of 50 kg with history of recurrent shoulder dislocation was scheduled for elective shoulder arthroscopy and accepted for anaesthesia under ASA Grade I.

The anaesthetic technique employed was general anaesthesia with endotracheal intubation and controlled ventilation. In the operation theatre, after placing standard monitors [electrocardiogram (ECG), pulse oximeter, capnometer, non-invasive blood pressure) and securing intra-venous access, the patient was pre-medicated with injection diclofenac 75 mg intramuscular (i.m.) and injection fentanyl 100 μgm intravenous (i.v.). General anaesthesia was induced with propofol 100 mg i.v. and injection rocuronium 25 mg i.v. followed by direct laryngoscopy (Cormack Lehane view: Grade One) and intubation of trachea with a cuffed orotracheal tube of 8 mm internal diameter. The patient was put on intermittent positive-pressure ventilation (IPPV) using the Ohmeda ventilator with tidal volume equal to 500 ml, respiratory rate of 10/min and inspiriratory: Expiratory ratio = 1:2, and then turned to the right lateral position for performing arthroscopy on the left shoulder joint. General anaesthesia was maintained with oxygen (33%), nitrous oxide (66%) and isoflurane (titrated to mean arterial pressure of 60–65 mmHg). Muscle relaxation was achieved with rocuronium at the rate of 20 mg/h. Intra-operative monitoring was within normal limit [heart rate of 65–85/min, end tidal carbon dioxide ($EtCO_2$) was 30–34

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mmHg, oxygen saturation was (SpO_2) was 98–100%]. The surgical procedure lasted for 3 h, during which the patient received approximately 1500 ml of balanced ringer lactate solution. The shoulder joint was irrigated using approximately 36 L of normal saline with epinephrine in a concentration of one in three million employing a Stryker infusion pump at a pressure of 100–150 cm water. Fifteen to 20 min before the end of surgery, rocuronium infusion and isoflurane were switched off. The patient was made supine. At the onset of adequate respiratory efforts, neuromuscular blockade was reversed using injection neostigmine 2.5 mg i.v. and injection glycopyrrolate 0.4 mg i.v. N_2O was switched off and, after ensuring adequate reversal (head lift for more than 5 s, tongue protrusion present), the trachea was extubated.

Post extubation, the patient started having obstructed breathing that progressed to complete airway obstruction as evidenced by obstructed abdominal movements, no movements of reservoir bag when switched from controlled system to manual, lack of waveform on capnograph and decreasing SpO_2 (up to 70%). The capnograph sampling tube was confirmed not to be kinked. Also, a quick blow into the capnograph sampling tube by the anesthesiologist's assistant obtained a graph ensuring that the line was clear and not blocked by moisture. Haemodynamically, the patient remained stable. Massive swelling extending to the neck and chest was also observed. Considering the threat of airway obstruction, the trachea was immediately intubated after direct laryngoscopy (view was now Cormack Lehane grade 2b) with orotracheal tube of 7 mm internal diameter and IPPV with 100% oxygen was given till SpO_2 increased to 95%. Pinkish froth was observed in the endotracheal tube. On further examination, auscultation of the chest revealed bilateral crepts, and neck circumference was measured as 52 cm. Based on the above findings, a diagnosis of post-obstructive non-cardiogenic pulmonary oedema was made. The patient received injection morphine 3 mg i.v., injection furosemide 40 mg i.v., injection midazolam 1 mg i.v. and injection rocuronium 25 mg i.v., and was shifted to the Intensive Care Unit (ICU) for elective ventilation and further management.

In the ICU, the patient was put on a Puritan Benett 7200 ventilator with pressure control ventilation with positive end expiratory pressure (PEEP) of 10 cm H_2O. Sedation was maintained with morphine and midazolam infusions. Routine blood investigations (haemogram, kidney function test, serum electrolytes, blood sugar and liver function test) and ECG were within normal limits. Chest X-ray revealed marked left chest wall oedema and resolving pulmonary oedema with a normal cardiothoracic ratio [Figure 1]. After 24 h of IPPV, the neck circumference had reduced to 38 cm (from 52 cm) and chest X-ray had also became normal. The patient was now weaned off the ventilatory support and trachea was extubated. Post extubation, the patient maintained his airway and vitals. He was shifted to the ward and finally discharged from the hospital 2 days later.

DISCUSSION

Shoulder arthroscopy requires visualization of two main areas: Glenohumeral joint and subacromial area. The glenohumeral joint is almost completely encapsulated. Proper visualization of the glenohumeral joint requires expansion of the joint space by irrigating fluid from a capacity of 3–4 ml to 60 ml. The subacromial area on the other hand is an unencapsulated area and communicates well via various anatomical planes to the soft tissues of the neck and chest. This space requires higher pressures for proper visualization and poses risk of fluid escape into the neck and chest, leading to airway swelling and further to respiratory compromise. Amount of fluid extravasation will depend on the amount and pressure of the irrigating fluid used and duration of surgery. Lateral position (usual surgical position) and obesity also predispose to fluid accumulation. This fluid extravasation is not just a mere inconvenience as large amounts of fluid escaping into the neck and chest can accumulate and cause external compression on the laryngeal and tracheal tissues as well as swelling of

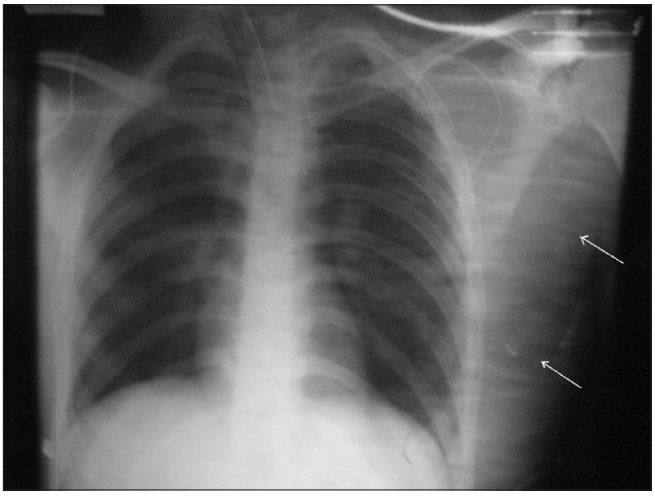

Figure 1: Post-operative chest radiograph showing oedema of the left chest wall (arrows)

these structures, leading to airway obstruction (partial or complete) that can be life-threatening.[1-4] Thus, measures that decrease fluid extravasation play a very important role in shoulder arthroscopy.

Pumps used to deliver the irrigating fluid can be gravity-dependent pumps or mechanical pumps. Gravity-dependent pumps consist of bags of normal saline of 2–3 L capacity hung at different heights, which will determine the pressure delivered. These are thus less-accurate as the exact pressure cannot be determined. Mechanical pumps are more accurate, allowing better control of pressure, but can be associated with pressure surges.

Minimizing bleeding into the joint cavity is of utmost importance to aid clear vision to the surgeons. A clear field will help minimize the duration of surgery and hence decrease the total amount of irrigating fluid used. This is achieved by use of epinephrine in irrigating solutions (1 in 3,000,000), cauterization of large vessels and tamponade effect of the irrigating fluid.[5] Induced hypotension plays a vital role as it not only decreases bleeding (thereby limiting the surgical duration) but consequentially also decreases the amount and pressure of fluid required for tamponade effect.

Shoulder arthroscopy can be performed under general anaesthesia or regional anaesthesia (interscalene block). The main advantage of general anaesthesia is that the airway is secured and induced hypotension can be used to decrease the irrigating fluid requirements. Merits of regional anaesthesia are that it avoids multipharmacy, provides for post-operative analgesia, promotes early ambulation and, if direct communication is maintained with the patient (by use of measured amount of sedatives), then the patient can aid in early recognition of airway obstruction by complaining of ominous signs like difficulty in swallowing or a throat sensation.[1] However, if regional anaesthesia is used as the sole anaesthetic technique, then, in the first place, the airway is not secured and, also, if intra-operative airway obstruction develops, then bringing the patient to the supine position can cause delay in ultimately securing the airway. Also, neck swelling once present may limit neck mobility as well as visualization of the glottis, making laryngoscopy and intubation difficult to impossible. Glottic swelling itself can significantly decrease the size of its aperture and hence impede the passage of an adequate-sized endotracheal tube. Attempting endotracheal intubation after development of airway obstruction in such a scenario can thus be tedious and time consuming. Cricothyrotomy can be a life-saving procedure in this situation.[1] However, external swelling on the neck can prevent proper identification of the necessary landmarks, and may not be possible in all cases. Still, an external superficial incision on the anterior side of the neck can relieve external compression on the trachea, thereby improving ventilation and also facilitating re-intubation.[1] Fibreoptic evaluation of the airway for laryngopharyngeal oedema and glottic visualization followed by intubation of the trachea with an appropriate-sized endotracheal tube (glottic aperture may be reduced) may have to be resorted to.

Arthroscopic shoulder surgery has several advantages over open procedures like reduced post-operative pain, reduced hospital stay and early ambulation. It is considered to be a fairly safe procedure with limited complications:[6-9] Traction neuropraxia of brachial plexus (most commonly musculocutaneous nerves), cervical neuropraxia (if beach chair position is used), haemorrhage, infection, complex regional pain syndrome type-II, rhabdomyolysis, compartment syndrome, instrumentation-induced cartilage injury, fluid extravasation, airway obstruction and respiratory compromise. Anaesthesia-related complications include mainly those due to interscalene block and use of hypotensive anaesthesia.[9] In our case, the patient developed post-obstructive negative-pressure pulmonary oedema.

Post-obstructive negative-pressure pulmonary oedema is a transudative oedema arising from the large negative intrathoracic pressure generated on inspiration against an obstructed airway. Large negative intrathoracic pressure increases venous return to the right atrium and increases pulmonary artery pressure. Hypoxia due to airway obstruction along with increased myocardial wall stress and systemic vascular resistance due to the large negative intrathoracic pressure lead to a depression of cardiac output. This decrease in cardiac output proceeds as increased end diastolic left ventricular pressure followed by increased left atrial pressure and, finally, increased pulmonary venous and pulmonary microvascular pressure. Thus, increased hydrostatic pressure in the pulmonary circulation disturbs the balance of Starling's forces between pulmonary vasculature and pulmonary interstial tissue, causing shift of fluid into the pulmonary interstitium manifesting as negative-pressure pulmonary oedema.

Fluid extravasation leading to airway obstruction is a rare but potentially life-threatening complication of shoulder arthroscopy. We recommend the use of balanced anaesthesia using general anaesthesia with endotracheal intubation and controlled ventilation supplemented with interscalene block as the anaesthetic technique of choice. Insertion of supraglottic devices is not advised.[3] Monitoring of neck circumference and airway pressures can forewarn about the amount of fluid extravasation. Because intra-operative measurement of neck circumference is not possible as the neck is covered under drapes and also in obese patients as increase in neck circumference may not be apparent, the difference between the pre- and the post-operative values can be calculated (up to 5 cm increase in the neck circumference can be considered insignificant).[10] If post-operative airway obstruction is anticipated, then tube exchanger or Aintree catheter can be used while extubation. Aintree catheter can aid ventilation as well as fibreoptic assessment of the airway for laryngopharyngeal oedema and glottis aperture. If airway obstruction does occur, then these devices will also aid in quick restoration of the airway. It is advocated to reduce the amount of fluid used for joint irrigation. An experienced surgical team to limit operative time along with proper patient positioning, use of lower pump pressures and induced hypotension will help in decreasing the irrigating fluid requirements and hence the risk of airway obstruction from fluid extravasation.[1] Use of minimal number of portals with adequate lengths and water-tight seals by the surgeon and creation of least number of rents in the native capsule to preserve its integrity can also be useful.[1]

CONCLUSION

By reporting this case, we highlight the indispensable role of an anaesthesiologist in prevention, anticipation and management of airway obstruction resulting from fluid extravasation during shoulder arthroscopy. Use of general anaesthesia with endotracheal intubation not only helps by securing the airway pre-emptively but also provides the option of employing induced hypotension to minimize irrigating fluid requirements. Pre- and post-operative measurement of neck circumference can help anticipate dangerous levels of fluid extravasation. If a sign of airway obstruction is present, the trachea should not be extubated immediately post-operatively and elective ventilation should be continued till the airway oedema has subsided.

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