CASE REPORT

Acute pulmonary edema following inflation of arterial tourniquet

M.C.B. Santhosh a,*, R.B. Pai b, R.P. Rao a

a Department of Anesthesiology, SDM College of Medical Sciences and Hospital, Dharwad, Karnataka, India
b Department of Anesthesiology, Goa Medical College, Goa, India

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Abstract Arterial tourniquets are used as one of the methods for reducing blood loss and for allowing blood free surgical field. A 20-year-old, 45 kg healthy female with a sphere shaped pendunculated hemangioma in the popliteal fossa of her left lower limb was applied with arterial tourniquet after exsanguination. The procedure was performed under general anesthesia. Soon after exsanguination and tourniquet inflation, the patient developed pulmonary edema which subsided after deflating the tourniquet. The clinical evolution, treatment and pathophysiology of this complication are described.

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Introduction

Arterial tourniquets are used as one of the methods for reducing blood loss from the surgical site in extremity surgeries. It has also been used for intravenous regional
anesthesia, intravenous regional sympathectomy in the management of complex regional pain syndromes and for isolated limb perfusion in the management of localized malignancies. There are reports of pulmonary edema and severe hemodynamic derangement following deflation of arterial tourniquet.\textsuperscript{1,2} We report an unusual case of pulmonary edema following inflation of an arterial tourniquet.

**Case report**

A 20-year-old, 45 kg female, with a sphere shaped pendunculated hemangioma in the popliteal fossa of her left lower limb measuring approximately 12 cm in diameter was scheduled for surgical excision. She did not have any coexisting disease and cardiorespiratory parameters were within normal limits. Routine preoperative investigations were also within normal limits. General anesthesia was planned as the patient did not give consent for regional anesthesia. With all standard noninvasive monitoring, general anesthesia was induced intravenously with fentanyl 150 μg, and propofol 100 mg. The trachea was intubated after achieving neuromuscular blockade with 6 mg of intravenous vecuronium. Anesthesia was maintained with morphine (8 mg, intravenous), oxygen, nitrous oxide and isoflurane (1.5–2%) with positive pressure ventilation. Patient's cardiorespiratory parameters were within normal limits. The left lower limb was exsanguinated using a Esmarch's bandage and a pneumatic tourniquet in the upper thigh was inflated to a pressure of 250 mmHg. After exsanguination, the hemangioma size decreased to a diameter of 8 cm. One minute after tourniquet inflation, an increase in the heart rate from 70/min to 136/min, blood pressure from 110/70 mmHg to 176/110 mmHg, peak airway pressure from 12 cmH\textsubscript{2}O to 28 cmH\textsubscript{2}O and a fall in SPO\textsubscript{2} from 99% to 85% were noticed. There was no significant change in the ETCO\textsubscript{2} number but there was slight prolongation of expiratory upstroke in the capnography curves. On auscultation of the chest, there were extensive crepitations in all the lung fields. Electrocardiogram (ECG) did not show any significant changes except sinus tachycardia. Only 300 ml of crystalloids was infused to the patient till that time. A central venous line was secured through right subclavian vein and central venous pressure was measured which was 20–22 mmHg. Emergency echocardiography (TEE) done was normal. So, a provisional diagnosis of pulmonary edema because of circulatory overload following tourniquet inflation was made. Immediately the tourniquet was deflated, ventilation with 100% oxygen and positive end expiratory pressure (PEEP) of 8 cmH\textsubscript{2}O was continued in propped up position and 5 mg of additional morphine, and 40 mg furosemide were given intravenously. Within 5 minutes the clinical situation started improving and 15 minutes later, the patient had a heart rate of 90/min, blood pressure of 120/72 mmHg, peak airway pressure of 14 cmH\textsubscript{2}O and SPO\textsubscript{2} of 96% with 40% oxygen but fine lung crepitations were still present on auscultation of chest but were significantly less. The surgery was abandoned. Immediately chest roentgenogram was taken which showed Kerley B lines and bat wing pattern shadowing in the parahilar region of the lungs. Patient was electively mechanically ventilated in the intensive care unit with adequate sedation and muscle paralysis for 4 h. Trachea was extubated after reversal of neuromuscular blockade. The patient was monitored in the intensive care unit (ICU) for next 24 h and the stay was uneventful. A TTE and a chest roentgenogram taken 24 h later were normal. A week later the hemangioma was excised uneventfully without tourniquet with prior identification of feeding blood vessel.

**Discussion**

The possible causes for the clinical event in our patient are congestive cardiac failure because of acute myocardial infarction, anaphylaxis to anesthetic agents, light plane of anesthesia, pulmonary thromboembolism, pulmonary aspiration, endobronchial intubation, acute bronchospastic episode, circulatory overload either due to over transfusion of intravenous fluid or fluid shift because of exsanguination of the limb and tourniquet application.

Myocardial infarction was an unlikely cause considering patient's age and was proved by insignificant changes in the ECG and echocardiography. Anaphylaxis was an unlikely cause as the event occurred 10–15 min after the start of use of anesthetic agents. There was tachycardia and hypertension in our patient unlike hypotension and tachycardia as seen in anaphylaxis.\textsuperscript{3,4} Light plane of anesthesia was a least possible cause as adequate depth of anesthesia was maintained throughout. Pulmonary thromboembolism is one of the fatal complications following exsanguination of the limb and inflation of the tourniquet.\textsuperscript{5,6} So it was one of the possible causes for the above clinical event but it was ruled out by chest roentgenogram, echocardiography findings. In pulmonary embolism, echocardiography will show dilated right atrium and ventricle, elevated pulmonary artery pressure derived from tricuspid regurgitation and leftward bulging of interatrial and/or interventricular septum.\textsuperscript{9} These findings were not found in our patient which ruled out the possibility of pulmonary embolism as the cause of the event.

Pulmonary aspiration was an unlikely cause as patient was administered general anesthesia with a cuffed endotracheal tube and was ruled out by chest roentgenogram findings. Endobronchial intubation was also an unlikely cause as there was no reason for a properly placed endotracheal tube to become endobronchial and was confirmed by presence of bilateral equal air entry during the clinical event. Acute bronchospastic episode was one of the most possible causes for the clinical event but was ruled out by the presence bilateral equal air entry and absence of rhonchi on chest auscultation.

So the circulatory overload was the most possible cause in our patient for the clinical event. But circulatory overload due to over transfusion of fluid was an unlikely cause as patient had received only 300 ml of fluid till that time. So the circulatory load due to fluid shift because of exsanguination of the lower limb and tourniquet application was the cause of the clinical event which was confirmed by improvement in clinical condition after release of tourniquet. When a limb is exsanguinated and tourniquet inflated, there will be shift of blood from that limb to the central blood volume and an increase in systemic vascular resistance.\textsuperscript{7} This results in an increase in central venous pressure and systolic blood pressure. But such an increase in central venous pressure and systolic blood pressure
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will be usually transient in a healthy patient so well tolerated by them but not so in a patient with poor cardiac reserve who can develop cardiac failure and arrest from it. Exsanguination and tourniquet inflation of both lower limbs simultaneously can increase the effective circulating blood volume by up to 15% (800 ml in an adult). Such a large increase in circulating blood volume may cause large and sustained increases in central venous pressure and circulatory overload even in healthy individuals. Cardiac failure and cardiac arrest have been reported after the application of bilateral thigh tourniquets in healthy individuals.

Hemangioma is a benign, localized tumor of the blood vessels filled with blood. Any pressure on the hemangioma will displace the blood contained in it and will lead to reduction in its size. In our patient hemangioma was approximately 12 cm in diameter which might have contained approximately 400 ml of blood. After exsanguination and tourniquet inflation of the limb, size of the hemangioma reduced to 8 cm diameter. So blood in the hemangioma was displaced to the systemic circulation along with blood in rest of the lower limb. This might have suddenly added 750–800 ml of blood to circulating blood volume, thus producing circulatory overload and consequent pulmonary edema.

In spite of being a healthy young adult, with good cardiac reserve, our patient developed acute pulmonary edema following exsanguination and tourniquet inflation of only one lower limb possibly because of sudden massive increase in the circulating blood volume due to exsanguination of hemangioma along with rest of the lower limb shifting a volume of blood almost equal to blood shifted by simultaneous exsanguination and tourniquet application of both the lower limbs.

Patients with good cardiac reserve will tolerate exsanguination and tourniquet inflation of one lower limb well. But anesthesiologist should bear in mind the possibility of acute circulatory overload even in a patient with good cardiac reserve during exsanguination and tourniquet inflation of a lower limb in the presence of large vascular blood containing lesion which might increase the circulating blood volume to a larger extent.

**Conflict of interest**

The authors declare no conflicts of interest.

**References**