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Please cite this article as https://doi.org/10.4097/kja.23655
Intraoperative tourniquet-induced hyperthermia in a pediatric patient: a forgotten association

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Running title: Tourniquet-induced hyperthermia

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Previous presentation in conferences: not applicable

Conflict of interest: No potential conflict of interest relevant to this article was reported

Funding: not applicable

Acknowledgements:
We extend our sincere thanks to Dr. Hazim Abdulkafi Kassas (Senior Consultant) for providing clinical insights during the case.

MRC ID (equivalent to IRB): 04-23-566

Clinical Trial Registration number: Not applicable

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Abstract

Background

The intraoperative use of tourniquets is associated with several complications, including hyperthermia. We present the first documented case of tourniquet-induced hyperthermia in a pediatric patient at our institution.

Case

A 5-year-old female with no past medical history underwent tendon release surgery for congenital talipes equinovarus under general anesthesia. Following inflation of a pneumatic tourniquet to a pressure of 250 mmHg on her left thigh, the patient experienced a gradual increase in body temperature. Despite the implementation of cooling measures, the temperature continued to increase until it plateaued. The hyperthermia gradually resolved upon deflation of the tourniquet.

Conclusions

Tourniquet-induced hyperthermia should be considered as a potential cause of intraoperative hyperthermia, particularly in the absence of typical signs of malignant hyperthermia. Early recognition and appropriate management, including deflation of the tourniquet and implementation of cooling measures, are crucial for preventing potential complications associated with hyperthermia.

Keywords: Hyperthermia; Intraoperative; Local complication; Management; Systemic complication; Tourniquet.
Tourniquet-induced hyperthermia is a rare phenomenon that has not been reported previously at our institution. This case report aims to raise awareness about tourniquet-induced hyperthermia as a possible cause of intraoperative temperature elevation and emphasizes the importance of differentiating it from malignant hyperthermia, particularly in the pediatric population. Although this association has been described previously in the literature, it is often not considered in practice [1-3]. Here, we present a comprehensive case description, including patient demographics, anesthesia induction and surgical procedure details, physiological changes and systemic effects of tourniquet use, along with insights into tourniquet-induced hyperthermia.

Case Report

This case report was approved by the Medical Research Center of Hamad Medical Corporation (ID MRC-04-23-566). Written informed consent was obtained from the patient’s family for publication of this case report.

A previously healthy 5-year-old female weighing 18 kg presented for left foot tendon release surgery for congenital talipes equinovarus. Using standard American Society of Anesthesiologists (ASA) monitors, vital signs were assessed, revealing a blood pressure of 87/57 mmHg, heart rate (HR) of 97 beats per minute, and peripheral oxygen saturation (SPO2) of 100% on room air. General anesthesia was induced at 08:05 with 100 mg of propofol, 10 mg of ketamine, and 10 mg of rocuronium. A size
4.5 Endotracheal tube was successfully inserted using direct laryngoscopy on the first attempt. After appropriate positioning, a caudal block with 15 ml of 0.125% levobupivacaine was administered. Anesthesia was maintained using sevoflurane inhalation and remifentanil infusion.

Before tourniquet inflation, the patient received 555 mg cefazolin as prophylaxis. Vital signs recorded immediately before the application of the pneumatic tourniquet on the left thigh at 08:58 showed a blood pressure of 82/59 mmHg, HR of 97 beats per minute, and SPO2 of 100%. The patient's body temperature measured via an oropharyngeal temperature probe was 36.2 °C. The tourniquet was inflated to 250 mmHg by the surgeon at 08:59. The surgical plan included left forefoot deformity correction by open lateral calcaneal osteotomy, tibialis anterior tendon release and transfer, and cuboidal osteotomy.

At 09:10, shortly after the start of the surgery, the patient's measured body temperature increased to 37.5°C. All active warming devices, including the Bair Hugger and fluid warmer, were immediately stopped. However, the temperature continued to rise, reaching 38.2°C at 09:30. Concerned about the possibility of malignant hyperthermia, anesthesia maintenance was switched from sevoflurane to a propofol infusion although no signs of malignant hyperthermia were present, and end-tidal CO2 remained within normal limits.

Despite these interventions, the temperature increased to 39.2°C at 09:50. To further facilitate cooling, 20 ml of cold normal saline was administered. The temperature remained elevated at 39.0°C until 10:20 and then plateaued at 38.5°C. At 10:50, the tourniquet on the left thigh was deflated, and the patient's temperature gradually began to decrease. The surgery was completed at 11:00. By 11:20, the patient's measured body temperature had decreased to 37.2°C, and anesthesia was discontinued. Once the
patient regained full consciousness, she was extubated, and transferred to the post-anesthesia care unit (PACU) for postoperative monitoring and recovery (Fig. 1).

During the postoperative period, the patient's vital signs and laboratory parameters were monitored regularly to ensure continued recovery. In the PACU, the patient maintained stable vital signs within normal limits, including a temperature of 36.5°C. Additionally, laboratory findings remained within normal limits, with hemoglobin levels at 13.2 g/dl, platelet counts at 375 x 10^9/L, urea levels at 1.6 mmol/L, creatinine levels at 24 µmol/L, bicarbonate levels at 20 mmol/L, alanine aminotransferase (ALT) levels at 0.17 µkat/L, aspartate aminotransferase (AST) levels at 0.34 µkat/L, and glucose levels at 5.7 mmol/L. These findings indicated that no significant abnormalities or complications were present.

Following the PACU stay for approximately 90 min, the patient was transferred to the regular pediatric ward for continued monitoring and care. On postoperative day 1 the patient was discharged from the ward with normal vital signs, stable laboratory parameters, and no evidence of complications.

Discussion

Pneumatic tourniquets are commonly used in both upper and lower-limb surgeries to minimize bleeding, optimize the view of the surgical field, and expedite surgical procedures. Despite recent technological advances, using surgical tourniquets can result in tissue damage, ischemia/reperfusion injury, and systemic complications [4,5]. These complications significantly affect patient outcomes, including the length of hospital stay. Therefore, anesthesiologists must recognize these potential complications and manage them in a timely manner.
Complications associated with pneumatic tourniquets vary in severity, ranging from minor and self-limiting to severe and potentially fatal. Systemic effects typically manifest upon deflation of the tourniquet cuff. Local effects and complications may result from direct pressure on the underlying tissues or from ischemia in tissues distal to the tourniquet.

Following 1-2 h of ischemia, anaerobic metabolism occurs in the affected limb. These changes include a moderate increase in PaCO2, lactic acid, and potassium levels, and a decrease in PaO2 and pH levels [5-7]. Upon tourniquet deflation, metabolites are released into the circulation, which can result in secondary effects on different-body systems. Tourniquet inflation typically results in a temporary increase in the blood volume by approximately 15% and systemic vascular resistance by up to 20%.

Consequently, blood pressure and venous return increase; however, these effects typically diminish within 5 min. The vasodilatory effect of metabolites following tourniquet deflation results in decreased blood pressure and central venous pressure, and increased HR. Some metabolites have a direct effect on the heart as myocardial depressants, leading to reduced cardiac output. Such changes are more pronounced with prolonged use of bilateral tourniquets. The release of metabolites upon tourniquet deflation also affects the respiratory system, resulting in an elevation in the end-tidal carbon dioxide tension by approximately 0.1 to 2.4 kPa. However, this increase typically resolves and returns to baseline levels within 10-13 min. Additionally, a rapid rise in PaCO2 leads to increased cerebral blood flow and intracranial pressure, particularly in polytrauma patients with traumatic brain injury.

Tourniquet use has also been associated with coagulopathy [6,7].

Edmond Bloch was the first to describe the association between tourniquet use and increased body temperature in pediatric patients [1]. He observed an increase in the body temperature of pediatric patients undergoing orthopedic procedures. In some patients, increase in body temperature was
dramatic, raising concerns for malignant hyperthermia. To investigate this phenomenon, a retrospective analysis of 56 pediatric patients who had undergone orthopedic surgery was conducted. The findings provided support for an association between tourniquet use and an increase in body temperature, and subsequent studies further confirmed this association [8,9]. This phenomenon is attributed to reduced metabolic heat transfer between the central and peripheral compartments, as well as decreased heat loss from the limb distal to the tourniquet. This effect is more pronounced in cases involving bilateral tourniquets. The main precipitating factor for the increase in core temperature appears to be the duration of tourniquet inflation. Upon tourniquet deflation, a transient decrease in the core temperature occurs resulting from the redistribution of body heat and the return of hypothermic venous blood from the previously constricted limb to the systemic circulation. The thermoregulatory vasodilation process can thus potentially be arrested, causing a drop in both the central and peripheral temperatures. In general, intraoperative hypo- and hyperthermia are associated with a high risk of adverse events, including coagulopathy. Therefore, maintaining the body temperature is the primary goal. Current evidence on the treatment and management of tourniquet-induced hyperthermia is limited. However, management strategies should employ careful monitoring of the temperature; adjustments in tourniquet inflation times; avoidance of extra layers of drapes, active warming devices or fluid warmers; and a reduction in the surgical time [8-11]. Local complications associated with tourniquet use include tissue damage or edema, rhabdomyolysis, thrombosis, digital ischemia, tourniquet-induced neuropathy, compartment syndrome, and post-tourniquet syndrome [5,7].

Our patient exhibited a gradual increase in temperature after tourniquet inflation. Despite the patient's hemodynamic stability and isolated temperature increase, malignant hyperthermia was suspected. As a precautionary measure, sevoflurane administration was halted and propofol infusion was initiated. The
implementation of cooling measures did not significantly decrease the patient's temperature. The patient's hemodynamic status remained stable, the surgery was continued. Upon tourniquet deflation, the body temperature gradually decreased, raising suspicion that hyperthermia was tourniquet-related. The onset of malignant hyperthermia is not always immediate; sometimes, it is insidious. Thus, malignant hyperthermia must always be considered when the body temperature rises during the course of anesthesia. However, other possibilities should also be considered in such situations, including sepsis, metabolic syndrome, adverse drug reactions, central nervous system disturbances, transfusion-related issues, or heatstroke [12].

In conclusion, although rare, tourniquet-induced hyperthermia should be considered in cases of intraoperative temperature elevation after tourniquet use, particularly in pediatric patients. Aggressive warming methods are not advised in pediatric patients who require intraoperative tourniquets. Anesthesiologists should consider the possibility of tourniquet-induced hyperthermia, particularly in cases involving bilateral tourniquets. Prompt identification and differentiation between tourniquet-induced and malignant hyperthermia is crucial for guiding management decisions and preventing unnecessary interventions.
References


Paediatr Anaesth 2013; 23: 842-50
Tourniquet Induced Hyperthermia

Fig. 1 Perioperative temperature change in our patient associated with Tourniquet use