

Assessment of the Pneumatic Ischemia Technique Using the Limb Occlusion Pressure During Upper Limb Surgery

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Purpose: The purpose of our study was to evaluate effective ischemia and its associated complications using the limb occlusion pressure technique versus standard pneumatic ischemia technique.

Design: Single-centered randomized, controlled clinical trial.

Methods: One hundred sixty participants were randomized into two equal and parallel groups: (1) intervention group—LOP technique, and (2) control group—standard pneumatic ischemia technique.

Findings: Anesthetic incidences (need to administer analgesics for pain and/or hypnotics for anxiety) were similar in both groups. Statistically significant differences were observed for pain, hyperemia, and hospitalization, with higher values in the control group. Patients in the intervention group had, at 95% confidence, a 2.9 times greater chance of having optimal ischemia (assessed as 9 on the analog scale) than patients in the control group (odds ratio, 2.9; 95% confidence interval, 1.4 to 6.1).

Conclusions: Intervention group patients had lower indexes of hyperemia, pain, and hospital stay.

Keywords: nursing care, ischemia, tourniquet, pain.

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UPPER LIMB SURGERY has evolved over time, especially due to advances in microsurgery and revascularization. The use of a tourniquet is essential in forelimb surgery¹ and has been used to minimize surgical blood loss and optimize operating conditions for surgeons operating on extremities for years.² There is, however, a controversy over the most appropriate procedure for applying a tourniquet, even questioning the need for its use.³ This is because of the multiple consequences associated with their use⁴; tourniquet use is not absolutely safe, with possible systemic and local, harmful effects.⁵ A recent review indicates that the use of a tourniquet in orthopaedic surgery can lead to serious but rare complications that can be prevented by correct knowledge and use of the device.⁶

A wide variety of local and systemic complications have been associated with tourniquets.⁴ When the blood flow is restored after surgery on the ischemic limb, there is a risk of ischemia and reperfusion injury.⁵ Many studies have suggested that unreasonably high tourniquet pressure and prolonged ischemic time are associated with increased postoperative pain and damage to underlying muscles and nerves.^{4,6} Localized clinical symptoms include pain, prolonged swelling, hypesthesia of peripheral nerves, reactive hyperemia, and necrotic tissues.⁷ The most common complication is tourniquet pain, which may be because of mechanical pressure and the ischemia reperfusion mechanism, documented on more than 66% of patients.⁸ As per the literature, it is recommended to limit the use of a tourniquet to a maximum of 2 hours^{5,6} to minimize such complications. Recent evidence on the pathophysiology of ischemia reperfusion injury shows the participation of oxygen radicals,⁹ the expression of adhesive molecules,¹⁰ activated leukocyte recruitment,¹¹ and the progression of inflammation.⁹⁻¹¹

These surgical-related injuries could condition morbidity, affect the outcome, and prolong hospital stay.¹² Therefore, to reduce such injuries, it is recommended that a pneumatic cuff of the right size, specific pressure, and suitable time be tailored to the patient.¹³ Times to achieve ischemia should be monitored during the whole process, although there is no maximum time period for a safe tourniquet. To achieve ischemia in upper limb surgery, it is recommended to apply a

pressure between 50 and 70 mm Hg greater than the systolic blood pressure, although values higher than necessary are commonly applied, regardless of the arterial pressure of the patient.^{14,15}

When a tourniquet is used in surgery, the surgical staff generally tries to use the lowest tourniquet pressure that, in its judgment, is safely possible.¹⁶ Although research has provided evidence that lower inflation pressures can provide a bloodless field with less risk for the patient, one survey has demonstrated that tourniquet pressures in the range of 300 to 350 mm Hg are frequently used in an effort to maintain a bloodless operative field,¹⁷ and less than 20% of respondents routinely use tourniquet pressures of less than 250 mm Hg in lower extremity surgery.⁵

Parallel to forelimb surgery advances, tourniquet systems have evolved in recent years, attempting to respond to the aforementioned issues and achieve fewer adverse effects.¹³ The minimal tourniquet inflation pressure necessary to provide a bloodless field has been suggested to minimize the risk of complications from excessive inflation pressure. Drolet et al¹⁸ showed that tourniquet pressures of 250 mm Hg or less in adult patients with less than 2 hours of ischemic time appear to be safe, even in the elderly and patients with multiple medical comorbidities. The optimal guideline for setting the pressure of a constant-pressure tourniquet is based on limb occlusion pressure (LOP).¹³ LOP can be defined as the minimum pressure required—at a specific time, on a specific tourniquet cuff, and applied to a specific patient's limb at a specific location—to stop the flow of arterial blood into the limb distal to the cuff.¹³ Liu et al¹⁹ established a mathematical model to predict the upper limb's minimal effective pressure and used this model in a prototype adaptive pneumatic tourniquet, demonstrating that the mean arterial occlusion pressure was 152.3 ± 16.7 mm Hg, obviously less than 250 to 300 mm Hg previously recommended.¹⁹ Ishii et al²⁰ also reported a new pneumatic tourniquet in which the inflation pressure is solely determined by the systolic blood pressure of the patient. Furthermore, Sato et al²¹ reported the usefulness of pneumatic tourniquet systems synchronized with the systolic blood pressure during 120 upper limb surgeries because blood pressure can vary during surgery and conventional systems cannot respond to sharp blood pressure changes.

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