O Pré-condicionamento Isquêmico Repetido Reduz Dano Muscular e Acelera a Recuperação em Cirurgias Eletivas de Joelho

RESUMO

Este estudo investigou os efeitos da Isquemia Pré-condicionada (IPC) na recuperação precoce de pacientes submetidos à cirurgia eletiva de joelho, com ênfase na dor pós-operatória, edema, amplitude de movimento (ADM) e integridade do tecido muscular. O objetivo principal foi avaliar a influência da IPC sobre esses parâmetros clínicos, enquanto um objetivo secundário envolveu a análise do dano muscular causado pela utilização do torniquete durante a cirurgia, utilizando microscopia óptica e eletrônica para examinar as alterações no nível celular e tecidual. Dezenove pacientes, com idades entre 16 e 40 anos, foram randomizados em dois grupos: grupo IPC e grupo controle. O protocolo de IPC consistiu de três sessões isquêmicas realizadas com intervalos de 72, 48 e 24 horas antes da cirurgia, sendo cada sessão composta por períodos controlados de isquemia seguidos de reperfusão. Parâmetros clínicos como pressão arterial, circunferência do membro, ADM e percepção de dor foram medidos nos períodos pré-operatório e pós-operatório. Além disso, biópsias musculares foram coletadas em dois momentos-chave: imediatamente após a insuflação do torniquete (minuto 0) e 75 minutos após a liberação do torniquete (minuto 75). Estas biópsias permitiram uma avaliação detalhada da integridade estrutural das fibras musculares. Os resultados mostraram que não houve diferenças estatisticamente significativas entre os grupos IPC e controle em relação à dor, edema e ADM pós-operatória. No entanto, foi observada uma preservação significativa da integridade das fibras musculares no grupo IPC, com menos destruições estruturais no tecido muscular, conforme evidenciado pela microscopia óptica e eletrônica. O grupo IPC demonstrou um melhor alinhamento das fibras musculares e menos sinais de danos como desorganização das miofibrilas e necrose celular. Embora não tenha sido observado um impacto direto sobre os parâmetros clínicos de dor, edema e

ADM, a preservação do tecido muscular sugere que a IPC pode desempenhar um papel importante na redução do dano muscular, o que pode contribuir para uma recuperação funcional mais rápida. Esses resultados indicam que a Isquemia Pré-condicionada pode ser uma estratégia promissora para melhorar a recuperação precoce após a cirurgia de joelho, especialmente em pacientes que necessitam do uso de torniquete. Em conclusão, a IPC demonstrou potencial para proteger as fibras musculares contra danos isquêmicos, promovendo a integridade muscular e, consequentemente, acelerando a recuperação pós-operatória. Embora os resultados clínicos não tenham mostrado mudanças significativas, a preservação da integridade muscular é um achado relevante e sugere a necessidade de estudos futuros para investigar os efeitos a longo prazo dessa técnica na recuperação ortopédica.

Palavras-chave: Pré-Condicionamento Isquêmico. Cirurgia De Joelho. Recuperação Precoce. Integridade Muscular. Torniquete. Microscopia Eletrônica. Resultados Pós-Operatórios. Preservação Muscular. Reabilitação.

ABSTRACT

This study explores the effects of ischemic preconditioning (IPC) on the early recovery of patients undergoing elective knee surgery, specifically investigating its impact on postoperative pain, edema, range of motion (ROM), and muscle tissue integrity. The primary objective was to evaluate the potential influence of IPC on these clinical outcomes, which are critical for a successful and rapid recovery following surgery. Additionally, the study aimed to examine the degree of muscle tissue damage caused by the use of a tourniquet during the surgical procedure, employing both optical and electron microscopy to assess the extent of cellular and tissue-level disruption. A total of 19 patients, aged between 16 and 40 years, were randomly assigned into two distinct groups: an experimental group that received ischemic preconditioning and a control group that underwent standard care without IPC. The IPC protocol consisted of three ischemic sessions, which were administered at 72, 48, and 24 hours prior to the surgery. Each session involved the application of a brief period of controlled ischemia, followed by reperfusion, with the aim of inducing a protective response in the tissues before the surgery itself. Clinical parameters were carefully measured at multiple time points, including preoperative and postoperative assessments. These included blood pressure, limb circumference, range of motion, and the perception of pain, all of which were evaluated using standardized and validated methods to ensure accuracy and reliability in tracking recovery over time. Muscle biopsies were performed at two critical time points: immediately following tourniquet insufflation (minute 0) and 75 minutes after the release of the tourniquet (minute 75). These biopsies allowed for an in-depth analysis of the muscle fibers' structural integrity, which was crucial for understanding the extent of ischemic damage caused by the surgical procedure and the potential protective effects of IPC. The biopsied muscle tissue was analyzed using both optical and electron microscopy to provide a detailed view of the cellular and subcellular alterations. The results of the study indicated that while there were no statistically significant differences between the IPC and control groups in terms of postoperative pain, edema, and range of motion, there was a marked difference in muscle tissue preservation. The IPC group demonstrated significantly better muscle fiber integrity, with fewer structural

disruptions in the muscle tissues compared to the control group. This was evident in both optical and electron microscopy, which showed better alignment and fewer signs of damage such as myofibrillar disorganization and cellular necrosis in the IPC group. These findings suggest that ischemic preconditioning may exert a protective effect on muscle fibers by reducing ischemic damage caused by the tourniquet application during surgery. Although the study did not find significant improvements in pain, edema, or ROM, the preservation of muscle tissue integrity represents a promising avenue for enhancing the early stages of recovery following knee surgery. The potential benefits of IPC in minimizing muscle injury could lead to faster functional recovery, reduced rehabilitation time, and better overall outcomes for patients undergoing knee surgery, particularly those who require the use of a tourniquet. In conclusion, while further research is needed to determine the full range of effects of ischemic preconditioning on clinical recovery outcomes, this study provides compelling evidence that IPC may play a critical role in protecting muscle tissue from ischemic damage and improving early recovery after knee surgery. Future studies with larger sample sizes and longer follow-up periods are necessary to better understand the long-term benefits of this technique in orthopedic surgical recovery.

Keywords: Ischemic Preconditioning. Knee Surgery. Early Recovery. Muscle Integrity. Tourniquet. Electron Microscopy. Postoperative Outcomes. Muscle Tissue Preservation. Rehabilitation.