

- [32] Giurazza F, Guarnieri G, Murphy KJ, *et al.* Intradiscal O₂O₃: rationale, injection technique, short- and long-term outcomes for the treatment of low back pain due to disc herniation[J]. *Can Assoc Radiol J*, 2017, 68(2):171-177.
- [33] Pachowsky ML, Kleyer A, Wegener L, *et al.* Quantitative T2 mapping shows increased degeneration in adjacent intervertebral discs following kyphoplasty[J]. *Cartilage*, 2020, 11(2):152-159.
- [34] Choi JY, Tanenbaum BS, Milner TE, *et al.* Thermal, mechanical, optical, and morphologic changes in bovine nucleus pulposus induced by Nd:YAG (lambda = 1.32 microm) laser irradiation[J]. *Lasers Surg Med*, 2001, 28(3):248-254.
- [35] Arslan E, Demirci I, Kılınçaslan MO, *et al.* Identification of intervertebral disc regeneration with magnetic resonance imaging after a long-term follow-up in patients treated with percutaneous diode laser nucleoplasty: a retrospective clinical and radiological analysis of 14 patients[J]. *Eur Spine J*, 2014, 23(5):1044-1051.
- [36] Cai F, Wu XT, Xie XH, *et al.* Evaluation of intervertebral disc regeneration with implantation of bone marrow mesenchymal stem cells (BMSCs) using quantitative T2 mapping: a study in rabbits[J]. *Int Orthop*, 2015, 39(1):149-159.
- [37] Ying J, Han Z, Zeng Y, *et al.* Evaluation of intervertebral disc regeneration with injection of mesenchymal stem cells encapsulated in PEGDA-microcryogel delivery system using quantitative T2 mapping: a study in canines[J]. *Am J Transl Res*, 2019, 11(4):2028-2041.
- [38] Capogna EA, Brown E, Walrath E, *et al.* ISSLS prize in bioengineering science 2022: low rate cyclic loading as a therapeutic strategy for intervertebral disc regeneration[J]. *Eur Spine J*, 2022, 31(5):1088-1098.

• 国际译文 •

开放 K_{ATP} 通道预防术后疼痛慢性化的机制

慢性疼痛是临床的常见病，其发病机制不清，治疗效果欠佳。南京医科大学刘文涛教授团队前期工作发现，预防性给予 K_{ATP} 的开放剂（克罗卡林）可以缓解慢性疼痛。该研究从神经炎症的角度，进一步解析 K_{ATP} 的开放剂预防术后疼痛慢性化的机制。主要结果：（1）在鼠脊髓背角，K_{ATP} 的亚基 Kir6.1 与小胶质细胞存在明显共定位，与神经元和星型胶质细胞有少量共定位。（2）在足底术后切口痛的小鼠，脊髓背角 K_{ATP} 的亚基 Kir6.1 含量在术后 3 天明显降低，至术后 7 天逐步恢复。（3）鞘内给予 K_{ATP} 的开放剂克罗卡林，降低 *c-fos* 和 CGRP 等疼痛标志物的表达，并且缓解手术切口引起的机械痛敏。以上结果表明，开放 K_{ATP} 可以缓解手术切口引起的机械痛敏。（4）为了探究 K_{ATP} 通道开放剂的镇痛机制，研究人员用 RNA 测序技术 (RNA-Seq) 检测克罗卡林如何影响脊髓背角的基因表达。开放 K_{ATP} 通道可以上调小胶质细胞中细胞信号转导抑制因子 3 (SOCS3) 的表达。SOCS3 是机体重要的负性调节因子，可通过调节多种信号通路抑制炎症反应。（5）进一步研究证明，克罗卡林通过激活 Gas6/Axl/SOCS3 通路，介导炎症耐受，从而预防术后切口引起的疼痛慢性化。敲除或阻断 Gas6 与 Axl 可以取消克罗卡林上调 SOCS3 及镇痛的作用。结论：开放 K_{ATP} 通道调节天然免疫，可引起炎症耐受并产生镇痛作用。该研究为围手术期的疼痛管理提供新靶点和新策略。

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