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前列腺电切腰麻术后低血压的相关研究进展

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摘　要

本文系统回顾了前列腺电切术(TURP)患者在行腰麻麻醉过程中发生低血压的机制、影响因素及临床管理策略。研究表明，腰麻麻醉引起的交感神经抑制和血管扩张是低血压发生的核心机制，此外，手术过程中血容量变化、患者体位调整、药物使用及个体差异也显著影响血压稳定性。文中分析了血容量不足、视野管理不当及麻醉药物选择等因素对低血压的促进作用，并强调了合理补液、血管收缩药物的及时应用以及血压动态监测的重要性。研究还提出，预防低血压的关键在于术前充分评估患者状态，术中加强血流动力学监测，结合个体化麻醉方案，从而减轻低血压带来的不良影响，提高患者安全性。综述内容为临床麻醉管理提供了理论依据和实用建议。

关键词

前列腺电切术(TURP)，低血压，脊髓麻醉，血流动力学监测，血管活性药物，容量管理，麻醉策略，预防与控制

Progress in Research on Post-Spinal Hypotension during Transurethral Resection of the Prostate (TURP) under Local Anesthesia

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Abstract

This review systematically examines the mechanisms, influencing factors, and clinical management strategies of hypotension in patients undergoing TURP with spinal anesthesia. Studies indicate that sympathetic blockade and vasodilation caused by spinal anesthesia are the core mechanisms leading to hypotension. Additionally, intraoperative changes in blood volume, patient positioning, medication use, and individual patient differences significantly affect blood pressure stability. The review analyzes how hypovolemia, improper field management, and choice of anesthetic agents contribute to hypotension, emphasizing the importance of appropriate fluid therapy, timely administration of vasoconstrictors, and dynamic blood pressure monitoring. It also highlights that preventing hypotension relies on thorough preoperative assessment, enhanced intraoperative hemodynamic monitoring, and personalized anesthesia protocols, which can help reduce adverse effects caused by hypotension and improve patient safety. The insights provided offer valuable guidance for optimizing clinical anesthesia management in TURP procedures.

Keywords

Transurethral Resection of the Prostate (TURP), Hypotension, Spinal Anesthesia, Hemodynamic Monitoring, Vasoactive Drugs, Volume Management, Anesthetic Strategies, Prevention and Control

1. 引言

前列腺电切术(transurethral resection of the prostate, TURP)是治疗良性前列腺增生(benign prostatic hyperplasia, BPH)的金标准手术方法，用于缓解由膀胱出口梗阻引起的下尿路症状[1]。在临床实践中，TURP广泛应用于缓解 BPH 相关的症状，例如尿流率改善和生活质量提升。此外，TURP 也可能用于良性前列腺组织评估后前列腺癌风险的监测，例如在良性组织标本中发现前列腺癌的风险。脊髓麻醉(spinal anesthesia)是前列腺手术的常见麻醉方式，因其操作简便且术后恢复快，但易诱发术后低血压(hypotension)，即血压显著下降[2]。术后低血压的发生率高(估计发生率可达 28.6%)，并与严重术后并发症相关[3]。低血压状态易导致器官灌注不足，增加急性肾损伤(acute kidney injury, AKI)、心肌损伤和死亡率的风险[4] [5]。研究表明，术中或术后低血压事件与不良预后强相关，包括增加卒中、器官功能障碍和远期死亡率[6]。此外，低血压在脊髓麻醉后尤为常见，可延长治疗时间，恶化患者结局。因此，针对 TURP 脊髓麻醉后低血压的管理至关重要，以减少相关危害。

2. TURP 腰麻术后低血压的发生机制

1) 脊髓麻醉的核心机制源于局部麻醉药物阻断脊神经根，导致交感神经纤维被抑制，引起外周血管扩张和心脏输出减少，从而促发低血压，且表现为异质性机制(如终末器官灌注受损) [7]。在临床实践中，这一机制被广泛观察到，尤其在剖宫产手术中更为常见，脊髓硬膜外麻醉在如宫颈癌患者中的应用亦表明神经阻滞会增加血液动力学不稳定性。

2) 高位麻醉(如涉及胸部或更高节段的麻醉)可扩大交感神经阻滞范围，加剧低血压风险，具体表现为血管张力丧失和心率下降。研究显示，连续脊髓麻醉比全身麻醉更易引发术中低血压(定义为平均动脉

压下降 30%)，而硬膜外麻醉的低血压发生率显著高于腰麻，表明阻滞水平是关键影响因素[8]。此外，脊髓麻醉后 30 分钟内低血压事件的严重程度与交感神经抑制程度密切相关。

3) TURP (经尿道前列腺切除术)手术中，循环容量变化(如吸水中毒导致的容量负荷增加或术中出血引起的容量减少)与腰麻协同作用诱发低血压，构成所谓的 TURP 综合征。大型研究指出，TURP 患者输血率高达 8.8%且 ICU 入院率为 1.7% (较激光技术组更高)，突显术中容量损失问题与术后低血压风险增加的关联[9]。围手术期出血和容量不稳定已被证实加剧低血压事件。

4) 手术体位变动(例如采用膀胱截石位或快速体位变换)通过影响静脉回流和心脏前负荷，加剧腰麻诱导的低血压[10]。血流动力学不稳定在脊髓麻醉中更明显，尤其是在体位变化时引发平均动脉压下降 30%或收缩压低于 80 mmHg 的事件，而硬膜外麻醉则因广泛交感阻滞加剧此风险。体位相关静脉瘀滞也被强调需术中监测管理。其他潜在机制包括迷走神经过度刺激引起的自主神经失衡(如血管迷走反应)，可能在心室心动过速事件中伴发反应失败(迷走神经过度抑制相关) [11]。背根神经节刺激可降低交感活动、改变血流动力学参数(如平均动脉压下降)，年龄相关的自主神经失平衡(即交感活性增强、迷走活动减少)亦增加术后风险[12]。

3. TURP 腰麻术后低血压的预防与干预策略

1) 预防 TURP 腰麻术后低血压需采取综合策略。其处理与干预依赖于个体化风险因素评估、早期识别和及时措施[13]。早期识别的关键在于设定监测指标和阈值，例如收缩压低于 80 mmHg 被定义为低血压的紧急干预点[14]，同时评估如年龄、术前血压基线等独立风险因素。在麻醉前的评估与准备阶段，构建风险评估模型是关键，通过对患者基础疾病史(如心血管功能)及实验室指标的综合分析，可建立预测低血压风险的列线图(Nomogram)模型，其中高龄、术前低血压倾向等因素被识别为独立风险因素，该模型同样适用于 TURP 患者评估[15]。个体化筛查需特别关注既往神经功能异常史(如类似脊髓炎症状)，因其可能增加腰麻后严重并发症风险。

2) 非药物干预策略首推静脉补液，旨在维持血容量并优化血流动力学稳定性，尤其适用于高危患者如老年人或术前低血容量状态[16]。这类措施可在麻醉诱导前实施以缓解血压下降。术前、术中液体管理需谨慎规划，液体预负荷策略(尤其是胶体液)对血流动力学稳定的优化效果仍存争议[17]，但多项研究支持限制性液体策略(优先使用血管活性药)，其在降低死亡风险方面具有优势，尤其适用于合并慢性肾病(CKD)或脓毒症低血压患者[18]。对于血容量评估复杂人群如肝硬化患者，可能需要更大剂量液体复苏。动态容量监测技术(如基于机器学习的低血压预测指数 HPI)的应用能指导精准补液，有效减少低血压发生[19]，同时，早期脓毒症休克患者中限制性液体策略(较少液体 + 早期升压药)相比开放性策略降低病死率的原则[18]，可延伸至 TURP 术中管理以优化循环稳定性。

3) 麻醉平面控制与药物预防策略发挥核心作用，血管活性药物的合理应用至关重要。药物治疗适用于中到重度低血压，包括血管收缩剂如去甲肾上腺素和肾上腺素。预防性输注肾上腺素(剂量 0.01~0.03 μg/kg/min)显著降低剖宫产腰麻低血压发生率[20]，而去甲肾上腺素持续输注较麻黄碱单次推注能更稳定维持血压[8]。此外，复合给药方案表明，硬膜外麻醉中添加肾上腺素(2~5 μg/mL 至罗哌卡因中)可显著减少术中低血压[21]，这为局麻药复合血管收缩剂在 TURP 腰麻中的应用提供依据。这类药物需监控潜在副作用(如心悸)，但总体上安全有效，尤其在老年患者中[22]。新方案如术前口服咖啡因 200 mg 可显著减少腰麻后 1 小时内低血压(15.3% vs 42.5%)并降低麻黄碱需求[23]。严重低血压需立即启动抢救流程，针对阈值如收缩压 < 80 mmHg 或平均动脉压 < 50 mmHg 实施快速响应[24]。关键措施包括优先使用去甲肾上腺素等血管收缩剂并持续监测生命体征，目标是 5~10 分钟内完成以避免不良结局。注意强调设定个体化危害阈值(基于年龄或并存疾病)，并优化治疗方案如优选去甲肾上腺素而非麻黄碱[25]，同时监控血

压恢复以防反弹效应。

4) 改善体位与下肢加压的机械性干预措施同样重要，其中充气式腿部加压装置显著降低机器人辅助前列腺切除术老年患者的诱导后低血压($P < 0.001$)，其机制可能通过增加静脉回流实现[22] [26]。体位优化(如采用左倾位)能缓解下腔静脉(IVC)压迫，预测并减少低血压发生[27]，类似原理可适用于 TURP 手术中优化静脉回流以维持血流动力学。

4. TURP 腰麻术后低血压存在的问题与争议

在经尿道前列腺切除术(TURP)中，脊髓麻醉术后低血压是一种常见并发症，其发生率高达 28.6~49% (如硬膜外麻醉后) [14]。然而，相关研究存在显著争议，主要源于观察性方法的局限性、患者异质性及治疗效果的未确定性。

1) TURP 腰麻术后低血压研究中，不同结果差异的主要表现包括发生率、关联性及治疗效果的不一致。例如，TURP 与其他前列腺手术(如光选择汽化术)的治疗失败率差异不显著(HR 1.07, 95% CI 0.93~1.22)，但内镜剜除术的失败率显著低于 TURP (HR: 0.24, 95% CI 0.06~0.97) [28]，表明手术方法可能是影响因素。同时，低血压定义阈值不一致(如收缩压 < 80 mmHg 或 MAP 下降 30%) [29] [30]，导致报告发生率存在较大范围。这些差异可归因于多个因素：首先，研究设计缺乏均质性，因多数证据来源是回顾性观察性研究，仅能揭示关联性而非明确因果(如术中低血压与术后发病率)，这与随机对照试验(RCT)结论相反，后者显示低血压深度而非持续时间更关键的关联心肌损伤和死亡风险[31]，暗示观察性方法可能夸大风险。其次，患者基线异质性显著，TURP 人群多为老年群体(中位年龄 69 岁) [28]，合并症(如良性前列腺增生)和术前状态(如收缩压基线)影响低血压风险，宫颈癌患者研究开发的 nomogram 模型虽识别了个体风险因素(如年龄)，但未针对 TURP 人群验证[15]，导致可外推性受限。此外，低血压测量的不一致性问题突出，如持续低血压对比短暂事件更易导致并发症[24]，但 TURP 研究中缺乏术后低血压的统一时序定义(如 30 分钟内 vs.术中) [8]，放大了结果变异。综上，观察性偏倚、定义标准缺失及患者群体多样性是核心分歧源头。

2) 标准化研究设计和多中心大样本项目的需求日益紧迫。观察性研究(如数据库分析)虽能评估真实失败率(TURP 组达 15.3%)，却无法确立因果机制，且样本代表性有限[28]。多篇文献呼吁未来研究应聚焦三点：第一，建立标准化的定义和阈值，如统一采用 MAP 下降 30%或收缩压 < 90 mmHg 等衡量指标[29] [30]，并明确器官特异性伤害阈值(如心肌损伤风险) [25]，以消除当前定义的客观模糊性；第二，推动多中心大样本队列建设，因为单中心研究统计效能不足，未能充分控制混杂因素(麻醉技术或手术时长)，而 meta 分析[32]强调多中心协作可增强炎症干预效果(如血管升压药的预防作用)，并支持个体化策略开发，类似机器人辅助前列腺切除术的大样本研究($n = 4945$) [33]；第三，推广随机对照试验(RCT)，鉴于关联性未必代表因果，未来应优先设计 RCT 对比不同管理策略(如允许性 vs.目标性血压管理) [31]，并结合文献，导向优化监控策略(如早期检测)和干预(血管升压药选择)。简而言之，高质量 RCT 缺失和标准化定义缺乏亟需多中心大样本支撑。

3) 治疗指南和共识制定现状严重依赖于一般麻醉模型，缺乏针对 TURP 腰麻术后低血压的专门框架。现有指南主要源于系统评价(如 Cochrane 综述)，覆盖预防策略如液体输注、血管升压药(如去甲肾上腺素)和物理干预[16]；例如，RCT 证据支持肾上腺素输注降低低血压发生率(不同剂量比较研究) [20]，或使用压缩装置减少老年患者诱导后风险[26]。然而，这类证据多基于剖宫产场景(如脊髓麻醉后) [16] [20]，而非 TURP 特定背景，导致实用性受限。术后管理尤其缺位：血管升压药虽然常用，但其益处并未通过系统评价充分确认[34]，现有指南未提供术后低血压的详细方案[35]；研究强调术后事件(如未识别或持续低血压)较术中更高危，但动态监控策略(如血压检测频率)缺乏标准化[25] [34]。指南现状亟需填补术后管理

空白并强化 TURP 特殊性，未来共识应基于多中心数据弥合理论与实践差距。

5. TURP 腰麻术后低血压的未来研究方向

1) 个性化麻醉风险预测模型，构建针对 TURP 患者的个性化风险预测模型是关键方向。此类模型需整合患者年龄、术前生命体征及合并症等因素，通过 Nomogram 实现精准风险分层与早期干预。现有研究表明，基于脊髓麻醉的多变量逻辑回归模型能有效识别持续性低血压等独立风险因素(如基线血压及波动特征)，显著提升预测效能[15] [24]。未来需在 TURP 人群中验证此类模型，重点探索脑/肾等器官灌注损害的临界阈值，明确低血压的器官特异性影响，指导个体化预防方案[25]。当前宫颈癌手术中的成功模型可作为重要参照。

2) 实时监测系统，实时监测技术将成为防控核心。研究亟需开发连续血流动力学监测策略，智能识别收缩压下降 ＞20%等事件并生成实时预警[25]。麻醉控制塔(ACT)系统已证实其价值：通过整合电子健康记录与数据分析软件，实现对多手术室远程监测及实时报警，优化麻醉管理并弥补传统监测滞后性。未来应将该模式应用于 TURP 手术，实时追踪血压波动与麻醉深度，加速低血压的干预响应。

3) 新型麻醉药物及辅助装置的临床试验针对新型血管活性药物及辅助装置的临床试验是突破重点。随机对照试验需验证去甲肾上腺素等药物方案对低血压的防治效果，现有证据表明其防治腰麻低血压优于麻黄碱[8]。辅助技术如添加肾上腺素的罗哌卡因可延缓血压下降[21]。当前血管加压素应用证据尚不充分，未来试验应聚焦血管扩张等病理机制，优化药物选择策略[34]。所有新型干预措施均需在 TURP 人群中验证安全性及有效性。

6. 总结与展望

随着对 TURP 术中低血压发生机制的持续研究和临床实践的不断积累，未来的研究方向主要集中在以下几个方面：第一，建立科学、统一的低血压评估标准，开展多中心、多样本的临床研究，以验证各种预防和治疗策略的有效性和适用性；第二，结合现代血流动力学监测技术，如动态血压监测、血流量测定等，实现对血压变化的早期预警和精准干预，提升管理效果；第三，探索新型血管收缩药物和麻醉药物，优化药物组合，为不同风险水平的患者制定个性化的麻醉方案。此外，随着微创技术的不断发展，如何最大程度减少血液流失，维持血压稳定，也成为未来重点研究领域。更深入的机制研究，尤其是对低血压相关器官(如心脏、肾脏、脑部)供血不足的影响及其长远影响，也需引起关注，以优化患者预后、减少并发症。综上所述，未来在低血压预防与管理方面，需要多学科交叉合作、技术创新和个性化策略的共同推进，以实现更安全、更高效的麻醉管理目标。

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