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Hans汉斯

输尿管通道鞘置入成功率影响因素的研究进展

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摘　要

背景与目的：随着泌尿外科腔镜技术的飞速发展，输尿管通道鞘(UAS)已成为逆行肾内手术(RIRS)中不可或缺的辅助装置。其主要功能在于建立从尿道外口至肾盂的连续通道，从而降低肾盂内压、改善术野可视度并提高结石清除效率。然而，在临床实际操作中，UAS置入失败的发生率依然不容忽视，且常伴随输尿管穿孔、撕裂甚至断裂等严重医源性损伤。因此，深入探究影响UAS置入成功的潜在因素，对于优化围手术期管理、降低手术风险具有重要的临床价值。方法：本文对近年来关于UAS置入安全性及成功率的国内外文献进行了系统性梳理，从患者个体特征、解剖病理学基础、术前预处理策略及术中操作技术四个维度进行了综合分析。结果：研究显示，患者年龄、性别、BMI等生理特征，输尿管管径、走行角度及顺应性等解剖因素，以及术前是否预置支架管、药物干预等准备措施，均与UAS的置入结局密切相关。此外，置入力度的控制与新型器械的应用也是决定手术成败的关键。结论：UAS置入是一个涉及多因素的复杂过程。通过术前精准的影像学评估识别高危因素，并制定个体化的预处理方案，是提高置入成功率、减少并发症的核心策略。未来研究应致力于开发基于人工智能的预测模型及具备力反馈功能的智能置入装置。

关键词

输尿管通道鞘，逆行肾内手术，危险因素

Factors Affecting the Success Rate of Ureteral Access Sheath Placement: A Systematic Review and Future Perspectives

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Abstract

Background: The Ureteral Access Sheath (UAS) has evolved into a standard ancillary tool in modern Retrograde Intrarenal Surgery (RIRS). It functions to establish a stable conduit from the urethral meatus to the renal pelvis, thereby reducing intrarenal pressure, improving visualization, and facilitating efficient stone fragment retrieval. However, failure in UAS placement remains a clinical challenge, often associated with severe iatrogenic injuries ranging from mucosal tears to ureteral avulsion. Consequently, a comprehensive investigation into the factors influencing placement success is critical for optimizing perioperative management and mitigating surgical risks. Methods: This article presents a systematic review of recent literature concerning the safety and efficacy of UAS placement. We critically analyzed factors across four dimensions: patient demographics, anatomical and pathological characteristics, preoperative intervention strategies, and intraoperative techniques. Results: Evidence suggests that patient physiological traits (age, gender, BMI), anatomical factors (ureteral diameter, angulation, compliance), and preparatory measures (pre-stenting, pharmacotherapy) are intimately linked to UAS placement outcomes. Furthermore, the control of insertion force and the utilization of novel device technologies play pivotal roles. Conclusion: Successful UAS placement is multifactorial. Preoperative identification of high-risk factors via precise imaging, coupled with individualized pretreatment protocols, constitutes the core strategy for enhancing success rates and minimizing complications. Future research should focus on developing AI-based predictive models and intelligent insertion devices with force-feedback mechanisms.

Keywords

Ureteral Access Sheath, Retrograde Intrarenal Surgery, Risk Factors

1. 引言

随着激光碎石技术和光纤成像技术的革新，逆行肾内手术(RIRS)已逐渐取代体外冲击波碎石术(ESWL)，成为直径 ≤ 2 cm 肾结石及部分输尿管上段结石的首选微创治疗方案[1]。在此类手术中，输尿管通道鞘(UAS)的应用被视为里程碑式的进步[2]。从流体力学角度来看，UAS 在输尿管软镜与输尿管壁之间构建了一个同轴的“流出通道”，这不仅允许以更低的注水压力维持手术视野的清晰度，还能有效将术中肾盂内压维持在安全阈值以下，从而显著降低液体反流导致的菌血症及尿源性脓毒血症风险[3]。此外，UAS 允许术者在不损伤输尿管黏膜的前提下多次进出输尿管软镜，极大提升了取石效率，并减少了软镜本身因反复摩擦而损坏的概率[4]。

尽管 UAS 优势显著，但其临床应用并非毫无风险。据 Traxer 等人的经典研究统计，UAS 置入相关的输尿管壁损伤发生率可能高达 46.5%，其中严重损伤(如平滑肌层撕裂)虽然少见，但后果严重[5]。置入失败不仅迫使手术中断或转为分期手术，增加了患者的经济负担和心理压力，还可能因反复尝试暴力置入而导致灾难性的输尿管全层撕裂或断裂[6]。因此，如何通过科学的方法在术前识别“困难输尿管”，并采取针对性的干预措施，已成为泌尿外科医师关注的焦点。本文旨在系统整合现有证据，深入剖析影响 UAS 置入成功率的多维因素，为临床决策提供理论依据。

2. 影响 UAS 置入成功的关键因素分析

2.1. 患者相关因素：生理特征与个体差异

患者的基线特征是评估 UAS 置入难度的第一道关卡。

年龄与组织弹性：

年龄是目前研究中争议较少且影响显著的因素之一。多项大样本回顾性研究一致指出，年轻是 UAS 置入困难的独立危险因素[7]-[9]。其组织学机制可能与细胞外基质的改变有关：年轻患者的输尿管平滑肌层致密，胶原蛋白与弹性蛋白比例维持在较高水平，导致输尿管壁张力高、被动扩张能力差；而随着年龄增长，输尿管壁发生退行性改变，肌肉层萎缩、结缔组织松弛，顺应性显著增加，从而降低了置入时的机械阻力。

性别差异与解剖微环境：

关于性别对 UAS 置入的影响，现有文献尚未达成共识。部分学者认为男性是置入失败及发生高级别输尿管损伤的危险因素[7] [10]-[13]。解剖学上，男性输尿管在跨越髂血管处通常受到更发达的腰大肌挤压，且男性骨盆较深狭，输尿管下段走行更为迂曲，这可能增加了置入难度。然而，也有研究指出女性是困难输尿管通路的预测因子(OR: 2.859, P = 0.005) [9]。此外，亦有数据表明女性在首次 UAS 置入中更有优势(OR: 1.5, P = 0.008) [14]，或者性别本身无显著统计学差异[15]。这种结果的异质性提示，性别可能不是单一的决定因素，而是与盆腔解剖变异、激素水平等因素共同发挥作用。

肥胖与体质指数(BMI)：

高 BMI 已被多项研究证实为 UAS 置入失败的独立预测因子(OR: 1.12, P < 0.001) [7]。肥胖患者往往伴有腹内压升高，且腹膜后脂肪组织堆积，这不仅使得输尿管受压、活动度降低，还增加了输尿管下段与膀胱壁的角度，使得导丝和鞘管难以顺应输尿管的自然走行。此外，肥胖患者在截石位下的体位限制，也可能影响术者的操作手感和力传导。

既往病史与全身状态：

患者的既往泌尿系病史提供了重要的预判信息。同侧输尿管镜手术史或支架置入史通过“被动扩张”效应，常预示着 UAS 置入的高成功率[16]。相反，无结石手术史的初治患者风险较高。值得注意的是，关于感染的影响存在有趣的悖论：虽然既往反复尿路感染可能导致输尿管狭窄或纤维化，增加置入难度[9]；但术前存在的菌尿症(无症状性)有时却与大尺寸 UAS 的成功置入呈正相关，这可能归因于慢性炎症介导的输尿管壁水肿和张力下降(类似于炎症后的松弛)。在全身指标方面，最新的研究开始关注炎症标志物，如低血小板计数和血小板–淋巴细胞比率(PLR)被发现与 UAS 置入失败有关[11]，这提示全身免疫状态可能通过微血管环境影响输尿管的局部顺应性。

2.2. 解剖与病理因素：物理屏障的量化评估

输尿管的解剖形态是决定 UAS 能否通过的物理基础。

管径测量与影像学评估：

基于非增强 CT 的术前评估是预测 UAS 置入难度的一个重要指标。输尿管管径，尤其是生理狭窄处(如跨髂血管处、输尿管膀胱连接处 UVJ)的直径，与置入成功率呈显著正相关[17]。近年来，利用三维重建技术测量输尿管体积和截面积的研究进一步精确了预测阈值，为术前筛选提供了量化工具。

走行角度与孔口形态：

除管径外，输尿管的空间构型至关重要。输尿管在 UVJ 处的入膀胱角度、以及跨越髂血管时的弯曲角度若过于锐利，会显著增加 UAS 尖端与管壁的摩擦力。有研究指出，膀胱出口与下段输尿管最外侧点

的连线角度过大，或远端输尿管存在明显的侧向偏斜，均提示置入困难[18] [19]。术中观察到的输尿管口形态也是重要的即时指标：导丝置入后，若 UO 呈现“帐篷状”扩张，通常预示着输尿管壁具有良好的弹性和顺应性，置入成功率高[20]。

肾积水与结石特征的复杂影响：

肾积水对 UAS 置入的影响具有双重性。急性结石梗阻引起的肾积水常伴随输尿管壁的炎性水肿和痉挛，这种急性炎症状态增加了管壁脆性和摩擦系数，导致置入失败率升高[11]。然而，长期慢性梗阻导致的肾积水往往伴随着输尿管的代偿性扩张和延长，这种“慢性被动扩张”反而为 UAS 提供了宽敞的通道，提高了首次尝试的成功率[14]。

关于结石本身，一个反直觉的发现是：较小的输尿管结石反而可能是 UAS 置入失败的危险因素(OR: 0.23, $P < 0.001$) [7]。其机制可能在于，大结石在输尿管内停留时间较长，产生类似于支架管的扩张作用；而小结石往往移动迅速，未能引起输尿管壁的适应性扩张，且常诱发强烈的局部痉挛。

周围解剖环境：

输尿管并非孤立存在。同侧髂总动脉的直径、是否存在盆腔占位性病变等周围环境因素也不容忽视。

2.3. 术前干预与准备：主动规避风险的策略

面对上述不可控的患者及解剖因素，积极的术前干预是临床医师可控的变量，也是提升成功率的关键。

术前预置双 J 管：

这是目前证据等级最高的干预措施。大量循证医学证据证实，术前留置双 J 管可以诱导输尿管发生被动扩张，显著降低输尿管壁张力。这一措施不仅能将 UAS 置入成功率提高，还能大幅降低输尿管穿孔、撕裂等高级别损伤的风险[16] [21]-[25]。对于初次手术失败或 CT 提示输尿管极细的患者，分期手术(先留置双 J 管，二期行 RIRS)已成为标准推荐流程。

药物辅助治疗：

作为有创操作的替代方案，药物扩张备受关注。α-肾上腺素能受体阻滞剂通过阻断分布在输尿管下段特别是 UVJ 处的 α1 受体，松弛平滑肌，解除痉挛。多项研究分析显示，术前服用 α-受体阻滞剂可显著提高 UAS 置入成功率，减少置入所需的机械力[26]-[30]。例如，Nam 等人开展的一项双盲随机对照试验指出，术前 1 周服用坦索罗辛(0.4 mg/d)可将 12/14 Fr UAS 的置入成功率从安慰剂组的 75.3%显著提升至 88.0% ($P = 0.038$) [28]。这种方法对于不愿意接受分期手术的临界困难患者尤其适用。

膀胱状态的管理：

一个常被忽视的细节是术中膀胱的充盈度。研究表明，在置入 UAS 前排空膀胱，可以缩短 UVJ 的壁内段长度，减小输尿管与膀胱壁的角度，从而降低置入阻力[31]。

2.4. 术中技术与设备因素：操作层面的优化

器械选择与物理特性：

UAS 的规格直接决定了置入难度。一般而言，在能满足进水和出水需求的前提下，应优先选择管径较细的 UAS (如 9.5/11.5 Fr 或 10/12 Fr)。研究数据表明，10/12 Fr UAS 的置入成功率显著高于 12/14 Fr，且造成的输尿管缺血性损伤更轻[32]。此外，不同品牌 UAS 的物理特性差异巨大，包括亲水涂层的润滑度、鞘体的径向支撑力(抗折性)、尖端的锥度设计以及扩张芯的柔韧性。优质的亲水涂层能显著降低摩擦系数，是减少黏膜损伤的关键。

辅助置入技术：

当常规置入遇到阻力时，盲目暴力推进是禁忌。此时，多种辅助技术可供选择：

直视下置入法：将半硬性输尿管镜置入 UAS 内，在直视导丝和管腔的情况下引导置入，可直观避开黏膜皱襞和狭窄环，安全性极高[33]。

序贯扩张法：使用球囊扩张器或半硬性输尿管镜先行扩张输尿管口及狭窄段，再行 UAS 置入。

加压灌注法：利用液压泵适度扩张输尿管管腔，减少管壁贴壁造成的摩擦。

旋转推进法：相较于单纯的轴向推力，轻微的旋转运动有助于分散摩擦力，使鞘管更容易通过狭窄处。

置入力度的量化与安全阈值：

近年来，关于“安全置入力”的研究成为热点。过大的推力是导致输尿管全层撕裂的直接原因。通过力传感器进行的体内外实验建议，将置入力控制在 6 牛顿(N)以内是预防高级别损伤的安全界限[34]；而在动物模型中，当力量超过 8.1 N 时，输尿管壁的完整性将受到不可逆破坏。然而，令人担忧的是，外科医生的主观手感往往不可靠。研究发现，即便是有经验的术者，在模拟操作中施加的力量也常超出安全阈值，且资深医生倾向于使用更大的力量来克服阻力。这凸显了仅凭“手感”的局限性，也呼唤着具备实时力反馈功能的新型器械的问世。

3. 讨论

本综述系统分析了影响 UAS 置入成功率的多维因素，结果显示这并非单一因素作用的结果，而是患者生理特征、解剖条件及围术期处理共同作用的复杂过程。

3.1. 解剖与生理因素的临床意义

研究一致认为，年轻患者及未受结石长期刺激的输尿管具有更强的肌层张力，是置入困难的主要人群。这解释了为何在处理小结石或无梗阻性结石时，UAS 置入往往更具挑战性。此外，组织顺应性差导致的生理性阻力，往往需要药物或支架管的长期干预才能改善。

3.2. 预处理策略的选择

术前预置双 J 管虽然能极大提高成功率，但考虑到患者的生活质量和医疗成本，不应作为常规手段。我们的分析支持一种分级干预策略：对于 CT 显示输尿管管径细小或存在明显解剖变异的高危患者，推荐分期手术；而对于临界患者，术前短期应用 α-受体阻滞剂可能是一种高性价比的替代方案，尽管其确切疗效仍需更高质量的 RCT 研究证实。为了更直观地指导临床决策，我们制定了临床评估与决策流程(图 1)，以供临床参考。

3.3. 器械与技术的进步

器械的选择对成功率有着直接影响。亲水涂层的质量和鞘管的抗折性是关键参数。值得注意的是，虽然大通道鞘能降低肾内压并提高取石效率，但其造成的输尿管壁缺血损伤风险也随之增加。因此，术者应遵循“最小够用”原则，根据结石负荷和输尿管条件选择最细的适用型号，而非盲目追求大通道。

3.4. 局限性

本综述也存在一定局限性。纳入的文献多为回顾性分析，且各研究中使用的 UAS 品牌、型号及术者经验水平不一，可能导致结果存在偏差。此外，关于输尿管损伤的长期随访数据(如术后远期狭窄率)相对匮乏，这应是未来研究关注的重点。

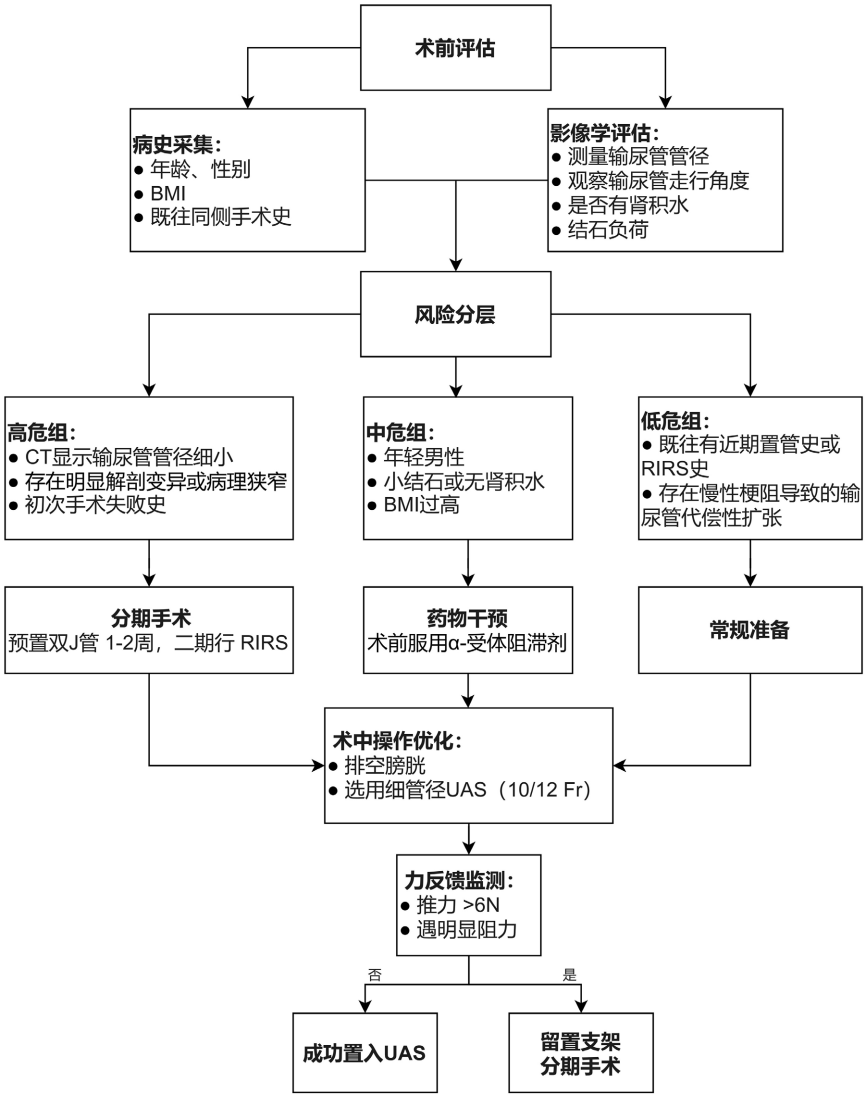

Figure 1. Flowchart for the prediction and management of difficult Ureteral Access Sheath (UAS) placement
图 1. 困难输尿管通道鞘(UAS)置入的预判与处理流程图

4. 结论

输尿管通道鞘的成功置入并非单一技术动作，而是贯穿于术前评估、预处理及术中精细操作的系统工程。目前，年轻患者及特定的解剖狭窄是公认的核心风险因素。通过影像学手段精确识别高危个体，并灵活运用预置支架、药物扩张及辅助置入技术，是保障手术安全的关键。

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