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· 文献综述 ·

超微创腹腔镜手术：技术革新与临床研究进展

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摘要

随着微创外科理念的不断演进, 手术方式正逐步从“最小损伤”向“无痕化”方向迈进。超微创腹腔镜手术(SMLS)是在传统腹腔镜技术基础上, 对操作要素进行革新及再组配, 从而实现更小创伤、更高美观度手术目标的一种新术式。SMLS以脐部皮肤褶皱为瘢痕隐匿区, 通过设立不超过2个核心操作通道(最大直径 ≤ 15 mm)并辅以直径 ≤ 2 mm的腹部辅助操作孔, 结合创新型分离式手术器械及高清视觉系统, 实现对通道瘢痕遗留等关键问题的系统性解决。本文综述了SMLS的发展、技术创新、临床应用现状及其在微创手术美学化进程中的潜在价值, 旨在为该术式的推广与技术迭代提供理论依据与研究参考。

关键词

最小侵入性外科手术; 胆囊切除术, 腹腔镜; 超微创腹腔镜手术; 综述
中图分类号: R656

Super-minimally invasive laparoscopic surgery: technical innovations and clinical research progress

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Abstract

With the continuous evolution of minimally invasive surgical concepts, operative techniques are progressively advancing from "minimal injury" toward "scarless" approaches. Super-minimally laparoscopic surgery (SMLS) is a novel surgical modality developed on the basis of conventional laparoscopic techniques through the innovation and recombination of operative elements, aiming to achieve smaller trauma and improved cosmetic outcomes. Utilizing the umbilical skin fold as a natural scar-concealing site, SMLS establishes no more than two primary operating channels (maximum diameter ≤ 15 mm), supplemented by auxiliary ports ≤ 2 mm in diameter on the abdominal wall. Combined with innovative separable surgical instruments and high-definition visualization systems, this approach provides a systematic solution to key issues such as residual access-site scarring. This review

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summarizes the development, technical innovations, current clinical applications, and potential aesthetic value of SMLS in the evolution of minimally invasive surgery, aiming to offer theoretical insights and research reference for its future promotion and technical refinement.

Key words

Minimally Invasive Surgical Procedures; Cholecystectomy, Laparoscopic; Super-minimally Invasive Laparoscopic Surgery; Review

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腹腔镜技术自20世纪60年代诊断性腹腔镜检查技术发展以来便已存在^[1-2],在20世纪80年代初将其从诊断性操作发展为外科手术手段^[3],此后该技术便成为多个学科的常用方法。腹腔镜手术在减轻术后疼痛、缩短恢复周期及降低并发症发生率方面的优势已得到广泛证实^[1,4-6]。然而,传统多孔腹腔镜手术仍难以实现真正的“无痕”目标。超微创腹腔镜手术(super-minimally invasive laparoscopic surgery, SMLS)作为一项技术革新,通过限定切口参数(脐部切口 ≤ 2 个,最大直径 ≤ 15 mm;辅助孔直径 ≤ 2 mm)并结合分离式器械设计,旨在推动微创外科向“超微创”与“无痕化”转型。SMLS不仅体现了外科手术精准化、个体化的发展趋势,也为提升患者术后生活质量提供了新路径。本文综述SMLS的发展历程、技术创新、临床应用现状及其在微创外科领域的潜在价值,旨在为该术式的规范化推广与技术迭代提供理论参考。

1 SMLS的演进与发展

腹腔镜胆囊切除术(laparoscopic cholecystectomy, LC)自1985年德国Mühe教授完成世界上第1例以来^[7],已成为治疗胆囊良性疾病的金标准^[8-12]。相较于传统开腹手术,腹腔镜手术因其切口小、出血少、术后疼痛轻及恢复快等优点,显著改善了临床疗效^[13-16]。为追求更微创化与美容效果,技术不断演进^[17]。例如,郑民华等^[18-19]较早开展针孔腹腔镜手术,借助直径 < 3 mm的腔镜及操作器械显著减小腹壁创伤;周明等^[20]通过将1个10 mm Trocar与2个5 mm Trocar置入脐部凹陷区域,开发出“隐瘢痕”腹腔镜技术;胡海等^[21-22]自制3 mm多功能针辅助操作,进一步实现术后瘢痕最小化。然而,专家们似乎并未对超微创的概念进行明确总结。

首次出现“超微创”(super-microinvasive)概念最早可追溯至章建全^[23]在其文章《关于术语

ultrasonology 和 supermicroinvasive》中提出的观点。他指出,超声穿刺使用的针具及治疗器械通常较为纤细,无论是皮肤穿刺点、穿刺路径,还是治疗野(相当于手术野)的组织损伤均极为轻微,皮肤切口多 < 2 mm。在多模态超声成像的实时引导下,术中可有效避开重要解剖结构,显著降低副损伤风险,最大限度维护患者体内环境的稳定性。因此,若将腔镜手术定义为“微创手术”(microinvasive),则超声等影像引导下的经皮穿刺操作可界定为“超微创”(supermicroinvasive)。基于上述论述,笔者认为,术语“超微创”在此语境下更宜译为“ultra-microinvasive”,专指超声引导下经皮完成的超微小创伤操作。

随着微创器械和治疗手段的不断进步,令狐恩强^[24]首次提出“超微创手术”(super-microinvasive surgery, SMIS)理念,并将其定义为:“在实现疾病治愈的同时,尽可能保持器官解剖结构的完整性”。SMIS强调在不破坏器官结构与功能的前提下进行有效治疗,兼顾患者的术后生存质量和长期预后。本文所讨论的“超微创”正是相对于传统“微创手术”而言,强调创伤进一步缩小,技术理念亦与令狐恩强所提出的SMIS保持一致。

本研究团队基于SMLS理念,自主研发了超微创器械,并对其操作要素进行再组配,建立了新术式,已成功应用于胆囊、肝脏、脾脏等手术^[25-26]。其技术优势体现在:(1)瘢痕隐蔽性:脐部切口可被自然褶皱遮盖,其余 < 2 mm切口愈合后几乎无瘢痕;(2)器械创新:团队自主研发的“超微创器械”采用10 mm钳头与2 mm操作杆分离设计,突破传统腹腔镜器械等径限制;(3)安全性:2 mm切口相关并发症未见报道,且器械力臂优化增强了承力能力,各项功能接近常规器械。其核心定义除脐部切口外,其余腹部切口直径均 < 2 mm,脐部切口数量不超过两个且最大直径不超过15 mm。未将脐部切口定义为 < 2 mm,主要基于两点原因:

(1) <2 mm 的腹腔镜尚未普及, 且清晰度不足, 影响手术安全^[27]; (2) 手术标本取出常需更大切口。相较于针孔器械, 超微创器械钳头直径可达 10 mm, 功能与常规器械相同, 大幅度提高了其在隐痕手术的应用范围, 且针孔腹腔镜器械缺乏明确定义不能直接与超微创概念相关联。

2 SMLS 的临床验证与优势分析

为验证 SMLS 的有效性, 团队开展了一项回顾性研究, 对比分析了自愿接受 SMLS、传统三孔法 LC 及经脐单孔 LC 的各 100 例患者资料。对比手术时间、术中出血量、术后疼痛评分、术后住院时间及住院费用的差异。超微创 LC 的适应证与禁忌证与单孔腹腔镜手术基本相同 (表 1)^[28]。SMLS 组关键步骤如下: (1) 脐部建立双通道 (10 mm+5 mm 穿刺器) (图 1A); (2) 剑突下经 18 号针头破皮置入 1.98 mm 操作杆 (图 1B); (3) 腹腔镜监视下于脐部通道引出操作杆 (图 1C); (4) 在体外组装 10 mm 钳头并测试功能后退入腹腔 (图 1D), 之后体外组装手柄; (5) 解剖出胆囊动脉、胆囊管、胆总管 (图 1E); (6) 三管关系明确后离断, 剥离胆囊 (图 1F), 检查术区, 取出标本及拆卸器械; (7) 缝合脐部切口 (图 1G)。单孔组和三孔组则按常规方法完成。结果表明: (1) SMLS 组与单孔组相比, 手术时间更短

[50.0 (42.0~60.0) min vs. 55.0 (45.0~65.0) min, $P=0.038$]、术后疼痛评分更低 [2.0 (1.0~3.0) vs. 2.0 (2.0~3.7), $P=0.011$]、住院费用更少 [13 617.6 (12 789.7~14 425.8) 元 vs. 14 560.1 (13 769.2~15 541.1) 元, $P<0.001$], 而术后住院时间、术中出血量差异无统计学意义 (均 $P>0.05$)。 (2) SMLS 组与三孔法组相比, 术后住院时间更短 [18.0 (15.0~21.0) h vs. 20.0 (18.0~23.0) h, $P=0.008$]、疼痛更轻 [2.0 (1.0~3.0) vs. 3.0 (3.0~4.0), $P<0.001$], 而手术时间、术中出血量、住院费用无明显差异 (均 $P>0.05$)。该初步研究表明, SMLS 兼具传统腹腔镜的操作灵活性与单孔的瘢痕隐匿优势 (图 1H), 并能有效减少术后疼痛, 促进快速康复。目前, SMLS 已在肝胆、胃肠、泌尿及妇科等领域展现出应用潜力。

表 1 超微创 LC 的适应证与禁忌证
Table 1 Indications and contraindications of cholecystectomy using super-minimally invasive laparoscopic surgery

分类	具体内容
适应证	胆囊良性疾病, 主要包括: 胆囊结石、胆囊息肉、慢性胆囊炎、胆囊功能障碍
绝对禁忌证	怀疑胆囊恶性肿瘤; 胆总管梗阻; 重要器官 (心、肺、肾) 功能严重不全; 严重的肝硬化及门静脉高压症; 脐部存在感染、湿疹等皮肤病
相对禁忌证	既往有腹部手术史; BMI≥35 kg/m ² ; 萎缩性胆囊炎; 麻醉评估 ASA 分级≥3 级

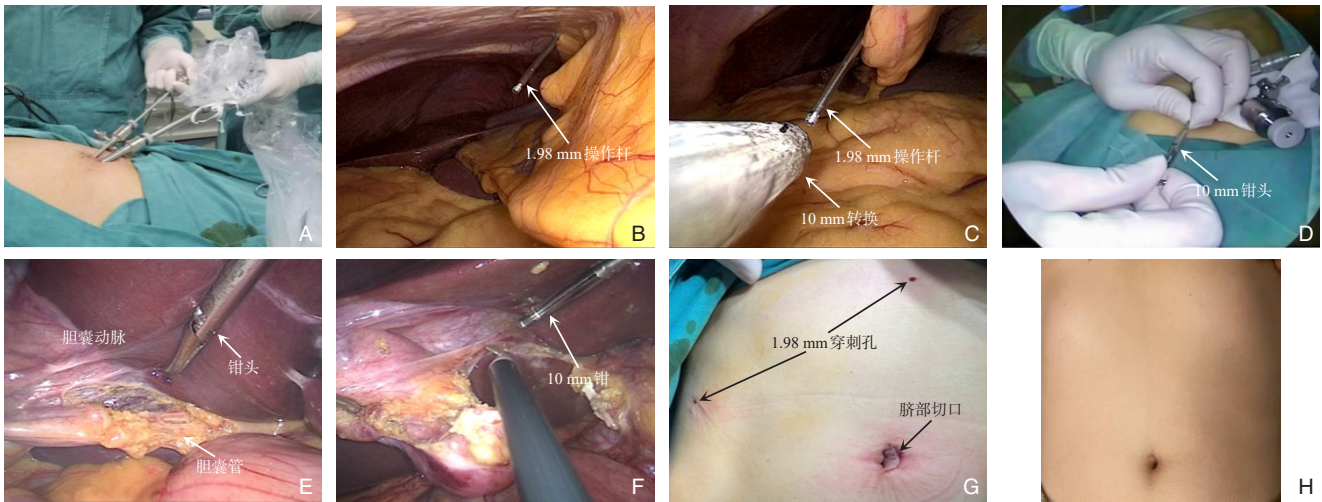


图 1 超微创 LC A: 脐部 2 个 Trocar; B: 1.98 mm 操作杆置入腹腔; C: 转换器引接操作杆; D: 组装 10 mm 钳头; E: 显露胆囊三角结构; F: 分离胆囊; G: 术后腹壁切口; H: 术后半年随访无瘢痕

Figure 1 Super-minimally invasive LC A: Two trocars placed at the umbilicus; B: Insertion of a 1.98-mm operating shaft into the abdominal cavity; C: Connection of the operating shaft via the converter; D: Assembly of the 10-mm jaw head; E: Exposure of the Calot's triangle; F: Dissection of the gallbladder; G: Postoperative abdominal wall incision; H: No visible scar at 6-month follow-up

3 SMLS的临床价值与优缺点

SMLS的核心临床价值在于显著减小创伤。研究^[29-30]表明,切口对腹壁的损伤体积与半径平方成正比,10 mm切口的理论损伤体积是2 mm切口的25倍。创伤减小直接带来术后疼痛减轻、恢复加快及住院时间缩短,从而降低整体医疗成本。

目前,单孔腹腔镜手术(laparoendoscopic single-site surgery, LESS)^[31]、经自然腔道内镜手术(natural orifice transluminal endoscopic surgery, NOTES)^[32]、针孔腹腔镜手术(needlescopic surgery, NS)^[33]及机器人手术(robotic surgery, RS)^[34]已成为微创领域的代表性技术。例如,Navarra等^[35]于1997年首次报道LESS胆囊切除术,强调其单一切口美学优势;自然腔道手术评估和研究联盟(NOSCAR)发表了一份白皮书^[36],打造了“无瘢痕”手术新范式;Krpata等^[37]则通过NS将切口缩小至3 mm以下;随着科技的进步,RS不仅弥补了腹腔镜手术的“筷子效应”,还为“跨时空手术”(across space time surgery)^[38-40]提供了可能。然而,LESS受制于器械干扰与操作难度^[41-43];NOTES存在入路相关感染与痿的风险^[44-45];NS因器械功能有限难以复杂操作;RS则因高昂成本制约其普及^[46-49]。相比之下,SMLS通过脐部双通道(≤ 15 mm)与2 mm辅助孔的混合设计,结合分离式器械,展现出了明显优势。SMLS相较于LESS,拥有LESS“隐瘢痕”效果的同时,克服了LESS的“筷子效应”,明显缩短手术时间。并且SMLS可以做到更小的脐部切口,更有利于瘢痕隐藏。这是因为SMLS仅需要脐部通道同时进入2个器械工作,而LESS必须满足3个器械同时进入。SMLS相较于NS,克服NS操作局限的同时还可以经过脐部切口取出标本。SMLS与NOTES相比较,SMLS不经过阴道、消化道等自然腔道,降低了术后感染、痿管形成的风险。SMLS相较于RS最明显的优势就是在费用上,不管是器材购置费用还是患者手术费用都明显低于RS。

不可否认的是SMLS也有其局限性。首先,SMLS的超微创器械位置、种类相对固定,术中调整和更换不便。其次,细操作杆(1.98 mm)在操作时比常规器械容易弯曲,在深部操作时更加明显。虽通过外部力臂设计增强了承载力^[25-26],但此物理局限无法完全避免。

国际上,如Sapalidis等^[50]对Percutance等经皮器械系统的探索,与SMLS技术思路不谋而合,预示着柔性器械与微型化操作是未来微创外科的发展方向之一。

4 结 语

SMLS通过器械与术式创新,在传统腹腔镜的基础上实现了创伤更小、美容效果更佳的突破,展现出良好的临床转化潜力。现有证据表明其安全、有效,且在减轻疼痛、加速康复和降低成本方面具有优势。然而,其长期疗效仍需更多大样本、多中心的前瞻性研究加以验证。未来研究应聚焦于器械的优化迭代、规范化培训体系的建立以及手术适应证的精确拓展,以推动SMLS的成熟与广泛应用。

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