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基于器官功能保护理念的消化外科术式创新

陈力豪[1], 孔祥兴[1], 王健[1], 丁克峰[1,2*]

1. 浙江大学医学院附属第二医院大肠外科(教育部恶性肿瘤预警与干预重点实验室), 杭州 310009
2. 消化系统肿瘤医药基础研究创新中心(教育部), 杭州 310058
* 联系人, E-mail: dingkefeng@zju.edu.cn

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摘要 器官与功能保护是现代消化外科的核心目标, 旨在减少传统根治性手术对器官结构的牺牲, 避免术后功能障碍(如胃切除后的营养不良和直肠癌术后的排便失禁), 从而提高患者的生活质量. 通过微创精准手术、术前影像组学评估和手术理念的革新, 功能保留术式有效减少了组织损伤并促进了功能恢复. 然而, 技术的复杂性、基层推广困难、缺乏长期追踪数据及肿瘤异质性等问题仍然制约临床实践. 未来的研究应重点聚焦三个方向: 通过多中心随机对照试验评估新术式的长期疗效; 通过基础研究探索器官功能保留的创新机制; 对无法保留器官功能的患者进行有效干预, 从而推动"病灶切除"向"功能重建"的转变.

关键词 器官功能保护, 微创手术, 生活质量, 外科技术创新, 机器人手术

现代医学在过去几十年取得了显著发展, 不仅在疾病诊断和治疗技术上取得了巨大突破, 而且在提升患者生活质量方面也做出了许多努力. 这一进步体现在多个方面, 包括技术革新、个性化医疗、综合治疗以及对患者心理和社会需求的关注. 与此同时, 外科医生理念与技术的进步使许多既往手术难题被逐一攻克或简化, 如腹腔镜微创手术、机器人手术、同种异体或自体移植手术, 以及基于基因编辑技术的异种移植技术等. 这些技术在追求用手术治疗疾病的同时, 进一步关注到了患者的生活质量. 外科医生为保留肛门功能, 需耗费数小时精细游离和解剖相关结构, 为的就是在保证生存获益的同时, 尽可能使患者获得更好的生活质量.

随着肿瘤向慢病管理发展, 保护器官功能显得愈加重要. 器官功能保护不仅需保留解剖结构完整性, 更需最大限度减少功能损伤. 例如, 保留胃功能的胃癌手术使得患者营养吸收和生活质量得以改善[1]; 低位直肠癌保肛手术使得患者的排便功能得以保留[2]. 此外, 器官功能保护不仅是生理结构上的保留, 更是对患者心理上的支持. 器官功能保护的需求推动了微创手术技术和精细外科理念的发展和革新, 使手术更加精准和安全. 尽管器官功能保护性手术技术复杂且成本较高, 但其通过降低远期并发症发生率、减少后续治疗需求, 显著提升了整体治疗成本效益.

1 消化外科手术器官保护理念的提出与早期发展历程

19世纪末至20世纪初, 消化外科主要通过切除病变组织来治愈疾病. 无论是胃癌、结直肠癌还是其他消化系统疾病, 外科手术主要关注的是彻底切除病灶而对器官功能保留关注不足. 这一时期的手术创伤大, 术后并发症多, 患者生活质量较差. 以治疗直肠癌的腹会阴联合切除术(肛门丧失)[3]、治疗胃癌的Billroth I手术(幽门丧失)[4]为例, 此类手术不仅直接导致器官结构

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缺失, 更造成消化、排泄等生理功能的永久性丧失, 严重影响患者术后生存质量. 当器官功能完整性遭到破坏时, 临床上不得不采用结肠永久造口、空肠代胃等替代性手术方案, 通过替代器官实现部分功能代偿. 随着麻醉技术、无菌术与抗生素和输血技术的发展, 到了20世纪中叶, 外科医生开始关注手术技术的改进, 以减少手术带来的创伤和并发症. 然而, 尽管技术有所进步, 器官功能的保留仍然不是手术设计中的主要考虑因素.

20世纪初, 腹腔镜技术在临床的首次应用标志着消化外科进入微创时代[5]. 腹腔镜手术与传统开放手术相比, 创伤小、恢复快、住院时间短, 患者术后生活质量显著改善. 例如, 自20世纪末在Mühe医生和Philippe Mouret医生对腹腔镜胆囊切除术首次实施和推广下, 腹腔镜胆囊切除术得到了全球范围的快速普及, 在我国已成为日间病房常规术式, 患者术后4 h下地, 24 h内出院[6]. 然而, 当时微创手术的理念在于减少手术对正常组织的损伤、加速患者康复, 并未直接将概念延伸至器官功能保护. 直到21世纪初, 随着诊治技术和仪器设备的进步, 患者在追求疾病根治的基础上, 对生活质量提出了更高的需求. 此时, 器官功能保护理念逐渐形成并广泛应用于消化外科.

随着患者对生活质量要求的提升, 器官功能保护的理念逐渐得到重视, 并广泛应用于消化外科. 该理念的核心是, 在疾病根治的基础上, 尽量保留器官功能, 减少对正常组织的损伤, 并加速患者术后康复. 这一理念在现代消化外科中, 通过技术进步与创新(如微创手术、精准评估等)得到了有效实践, 并促进了消化外科手术的持续进步.

2 器官功能保护在消化外科的积极探索应用

2.1 胃部手术

传统胃癌根治术需要开腹大范围切除胃组织, 导致术后营养吸收不良等问题. 随着内镜技术的发展和早期胃癌(early gastric cancer, EGC)检出率的提高, EGC治疗逐渐转向内镜、腹腔镜和机器人手术等微创方式, 手术切除范围从全胃或大部分胃缩小为近端胃切除、保留幽门的胃切除等. 这种在确保根治性和系统淋巴结清扫的前提下, 最大限度保留胃正常解剖和生理功能的手术方式, 被称为功能保留性胃切除术(function-preserving gastrectomy, FPG), 极好体现了器官保护功能的理念[7~9]. 保留幽门的胃切除术(pylorus-preserving gastrectomy, PPG)由日本医生Maki在20世纪60年代开创, 而在2001~2010年PPG才逐步走向成熟, 被列为治疗EGC可选手术之一, 主要适用于病灶位于胃中部的临床EGC($CT_1N_0M_0$)的患者[10,11]. 这种手术在有效切除肿瘤的同时, 保留了幽门和(或)贲门的血供和神经, 可较好地维持残胃功能, 还能显著改善患者术后的胃排空功能和营养状态, 使胃肠激素分泌更稳定, 术后早饱、倾倒综合征等并发症显著减少[1,9,12,13]. 此外, 得益于先进的内镜技术, 针对早期非浸润性且直径≤2 cm的肿瘤, 内镜黏膜下剥离术(endoscopic submucosal dissection, ESD)(图1)可以在保证同等治疗效果下降低了手术创伤和并发症, 很好保留了胃部的正常功能, 加快了患者的术后康复[14~16].

2.2 肝胆胰手术

肝胆手术往往涉及复杂的血管和胆道结构, 传统的手术方式对肝脏功能损害较大. 随着解剖性肝切除术和肝段切除术的应用, 外科医生能够更精确地切除病变组织, 同时最大限度地保留健康的肝脏组织. 世界上首例离体肝切除术联合自体肝移植术(*ex-vivo* liver resection and autotransplantation, ELRA)由Pichlmayr等人在1988年实施并报道. 手术示意见(图2)[18]. 1991年, Hannoun等人[19]在ELRA基础上创新了半离体肝切除和自体肝移植术, 相较于ELRA, 该术式保留了第一肝门, 减少了术后并发症. 1996年, 董家鸿团队[20]完成了我国首例半离体肝切除和自体肝移植术, 治疗了一例中央型巨大肝癌患者. 2005年, 温浩团队[21]在一例肝内胆管细胞癌患者上成功实施了我国首例ELRA手术, 标志着我国肝脏移植技术进入新阶段. 此类技术的突破显著提升了健康肝组织的保留率, 推动了肝胆外科的精细化发展.

2.3 肠道手术

直肠癌的外科治疗中, 在保证肿瘤根治的前提上保留肛门功能从而改善患者的术后生活质量, 一直是该领域的重难点. 在早期, 低位直肠癌采用的是腹会阴联合切除术(abdomenperineal resection, APR), 即Miles术(图3(a)), 通过腹部和会阴部联合切口, 切除直肠、肛门和周围组织, 并进行永久性的结肠造口, 严重影响患者的生活质量[3]. 随着外科技术的不断进步, 低位直肠的保肛手术诞生并得到大范围推广——通过低位或超

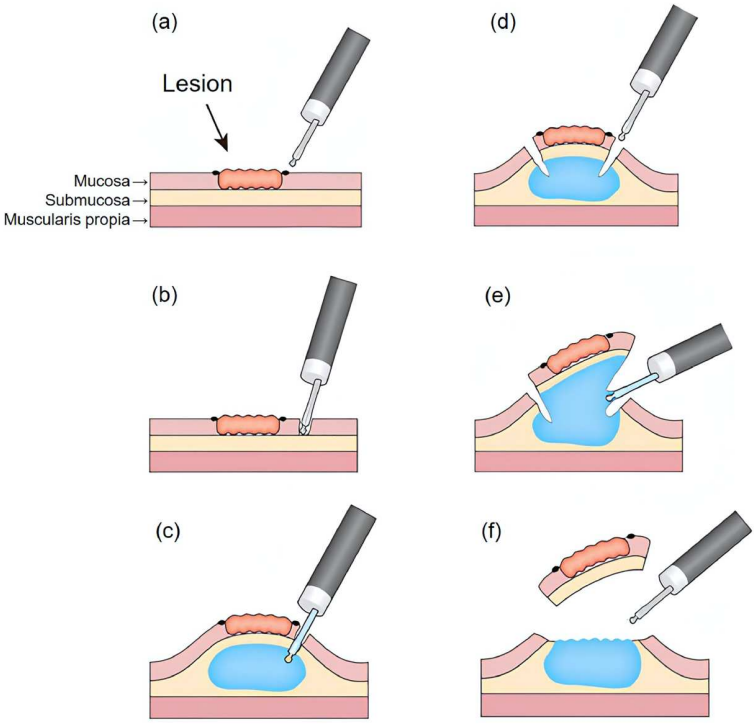

图 1 (网络版彩色)内镜黏膜下剥离术示意图. (a) 标记; (b) 预切开; (c) 注射; (d) 黏膜切开; (e) 追加注射; (f) 黏膜下剥离. 改自文献[17]
Figure 1 (Color online) Schematic illustration of endoscopic submucosal dissection (ESD). (a) Marking; (b) pre-cut; (c) injection; (d) mucosal incision; (e) additional injection; (f) submucosal dissection. Reproduced from Ref. [17]

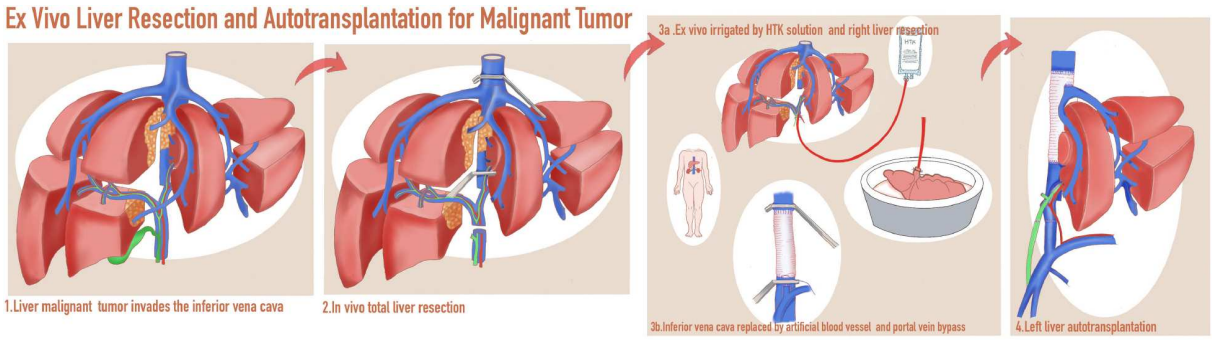

图 2 (网络版彩色)离体肝切除术加自体肝移植术示意图. 改自文献[22]
Figure 2 (Color online) Schematic illustration of *ex-vivo* liver resection and autotransplantation (ELAR). Reproduced from Ref. [22]

低位吻合保留肛门功能, 大幅改善了一部分直肠癌患者的生活质量. 其中最经典、使用最多的术式是低位前切除术(low anterior resection, LAR), 即Dixon术(图3(b)), 保留了肛门括约肌及肛管的完整结构和排便功能[23,24]. 此外, 还有经肛门结肠肛管吻合术(Parks术)[25]和改良肛管结肠拖出切除术(Bacon术)[26], 应用于直肠残端过短而难以完成低位或超低位吻合的病例. 但是, 上述手术的缺陷也显而易见: 改良Bacon术需要待结肠与肛管完全愈合牢固后再二期切除肛门外多余结肠, 术后肛门括约肌功能不甚满意, 控便功能差, 也有部分病人会出现肠管回缩、吻合口狭窄的现象[27,28]; Parks术后容易导致粪便存储功能锐减, 造成早期排便功能控制欠佳, 并且由于术后吻合口漏发生率较高, 通常需行预防性回肠造口术[29,30]. 括约肌间切除术(intersphincteric resection, ISR)是一种在括约肌间进行切除的手术方式, 适用于更低位的直肠癌. 在保留肛门括约

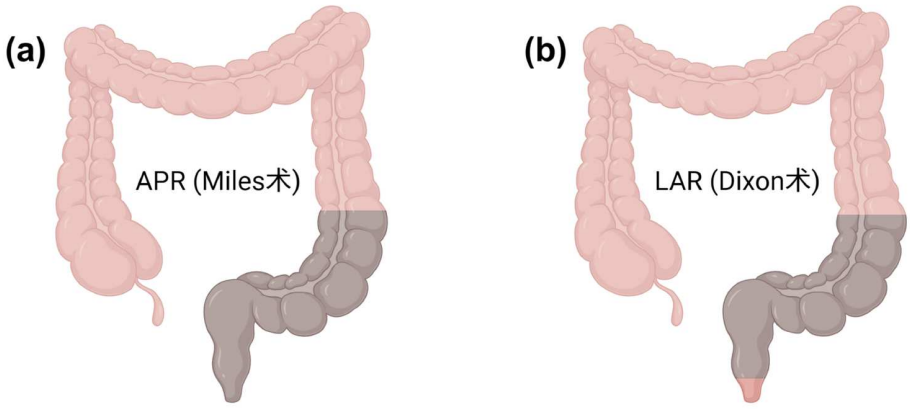

图 3 (网络版彩色)两种结肠切除术示意图. (a) 腹会阴联合切除术示意图; (b) 低位前切除术示意图. 图片使用Biorender制作
Figure 3 (Color online) Schematic illustration of two types of colectomy. (a) APR; (b) LAR. Created by BioRender

肌的前提下, 通过肛门和腹部联合入路, 切除直肠及其系膜, 并进行结肠-肛门吻合[31]. 据Chen等人[32]的一项Meta分析显示, 与传统开腹ISR相比, 腹腔镜ISR术后术中出血量更少、住院时间更短、术后复发率更低. 然而, ISR术后复发率增加[33]、严重肠道功能障碍及尿失禁亦有报道[34].

值得注意的是, 直肠癌手术的功能保护不仅涉及肛门括约肌系统, 术中精细化的神经解剖技术对于保护盆腔自主神经(pelvic autonomic nerves, PANs)也至关重要, 可显著降低术后泌尿功能障碍(如尿潴留)和性功能障碍的发生率[35~37].

保肛手术尚未找到最优解, 各种手术仍有较大改进空间, 相关的临床验证也有待完善.

3 革新与突破: 器官功能保护在消化外科的创新实践与升华

传统消化外科手术并未重视器官功能保护, 常采用“一刀切”的治疗理念, 虽然可以达到完全切除病灶的目的, 但对病人长期的生存质量造成了显著影响. 随着精准治疗理念的推广和重视, 业界对外科手术的治疗效果从单纯的“切干净”逐步过渡到了既要“切干净”又要“保功能”. 这种新的要求也促进基于器官功能保护理念的消化外科术式革新.

3.1 胃相关手术革新

对于胃中部1/3早期胃癌(earlygastriccancer, EGC), 功能保留手术的革新体现在两个方面: 胃解剖结构保留和抗反流技术改进. 在结构保留方面, 保留幽门胃切除术(pylorus-preserving gastrectomy, PPG)通过保留部分胃部结构和迷走神经分支, 显著改善术后生活质量[11,14,38]. Kim等人[39]的随机对照研究显示, PPG组通过保留幽门, 在术后12个月的腹泻症状发生率(2.30% vs. 9.60%, P<0.05)和食欲减退患者增长比例(–6.2% vs 4.5%, P<0.05)均显著低于传统手术, 证实其改善消化道功能的长期获益. 多项研究发现, 通过保留迷走腹腔支可显著降低术后倾倒综合征、胆汁反流、胆结石的发生率, 并可减少胰岛素分泌障碍, 与饥饿激素的调控产生协同作用, 共同控制血糖的平衡[40~44]. 目前, PPG在国内作为一种尚未普遍开展的手术方式, 仍需要初学的手术医师克服学习曲线, 持续开展并达到熟练应用. 在抗反流技术方面, 针对近端胃切除术后的反流症状, 双通道吻合(double tract reconstruction, DTR)(图4)技术通过构建Roux-en-Y空肠旁路, 可使反流性食管炎发生率从传统吻合的60%降至4.6%[45,46], 同时相较于全胃切除, DTR可显著提高患者术后对维生素B12和铁等微量元素的吸收[47].

在微创技术方面, 近年来减孔和单孔腹腔镜手术逐渐应用于胃部肿瘤治疗. Kunisaki等人[48,49]报道减孔腹腔镜胃癌根治术的安全性及疗效与传统腹腔镜手术相当. 此外, 我国的研究也指出, 单孔腹腔镜手术具有术后恢复更快、切口更小、并发症发生率更低、术后疼痛更轻、住院时间更短、美观性更好的优势[50~52]. 然而, 与传统手术相比, 单孔腹腔镜手术的操作难度更大, 目前的适应证主要集中在早期胃癌, 对于进展期胃癌的应用尚在探索阶段. 机器人手术则凭借三维视野和高自由度器械提高了外科医生操作的精细度, 降低

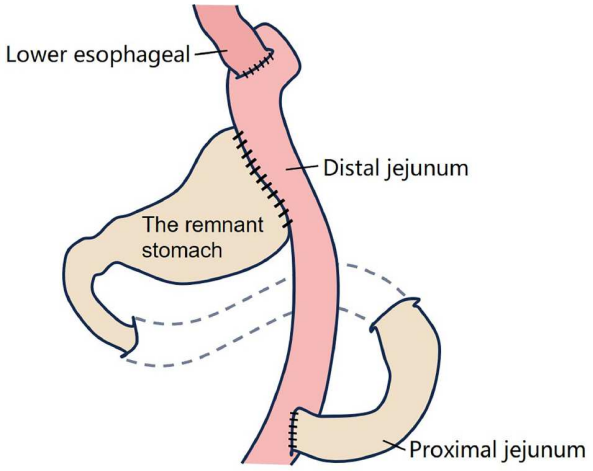

图 4 (网络版彩色)双通道吻合示意图
Figure 4 (Color online) Schematic illustration of DTR

了操作难度，从而减少邻近器官的损伤和术后并发症[53]，例如使用机器人进行Kamikawa吻合，降低操作难度的同时可降低近端胃切除术后反流性食管炎、吻合口狭窄等并发症的发生率[54]. 在近期疗效方面, 国内首个机器人胃癌手术的多中心回顾性队列研究[55]结果显示，机器人手术具有术中出血量少、淋巴结清扫数目多、手术总体并发症发生率低的优势；在远期疗效方面，机器人手术与腹腔镜手术相比，5年总体生存率的差异无统计学意义. 总而言之, 机器人手术精细的操作有助于胃的器官保护和术后恢复, 应用前景光明, 目前普及的主要难点在于高昂的购置成本和较长的培训周期.

综上所述，从传统手术到减孔、单孔腹腔镜技术，再到机器人辅助手术，胃癌的手术方式正在朝着更加微创、精准和安全的方向发展. 这些技术的不断进步不仅拓展了手术的适应证，还显著改善了患者的术后生活质量. 随着技术的进一步成熟和外科医师操作经验的积累，未来这些创新技术有望为更多的胃癌患者带来更优质的治疗选择.

3.2 肝胆胰相关手术革新

3.2.1 肝胆手术

由于肝脏结构十分复杂，传统的肝切除术已经不能满足精准外科理念的需求. 而利用计算机辅助对肝切除术患者进行术前的三维可视化重建可以清晰地展现肝脏组织的各个结构，有助于准确识别病变位置并估计肝脏体积，为精准的肝脏切除策略提供指导[56]. Lamadé等人[57]研究发现，与二维计算机断层扫描相比，三维重建可将肿瘤定位精度提高了37%, 切除区域的准确性提高了31%, 进一步说明了三维重建在术前评估中的价值. 在肝细胞癌(hepatocellular carcinoma, HCC)的手术治疗中，三维图像相较于二维图像表现出显著优势. 方驰华团队的研究指出, 通过三维可视化图像可以显著降低中央型HCC的手术时间，并降低肝脏流入阻塞率, 同时减少了术后并发症和腹水的发生率[58]. 不仅如此，三维重建技术在肝内胆管癌手术中同样表现优异, 有效提高了术中切缘的阴性率[59]. 这些研究充分表明，三维重建技术在原发性肝癌外科手术中起到了关键作用, 能够最大限度地保留健康肝脏组织, 提升患者的术后生活质量.

除了肝癌的精准切除，三维重建技术在活体肝移植术中也展现出重要作用. 活体肝移植术要求供、受者肝脏的大小和结构相匹配，以保证手术成功并确保供者的安全. 三维重建联合3D打印技术可辅助医生在术前对供者和移植者肝脏的解剖结构进行精准模拟，掌握移植物的大小、厚度以及血管分布，从而缩短手术时间，进一步提高手术的成功率[60,61]. 该技术的应用, 不仅加速了手术进程, 也提高了移植成功率, 为临床手术提供了新的手段.

在复杂肝癌的治疗中，特别是对于肿瘤侵犯范围较大且未来残余肝体积(future liver remnant, FLR)不足的患者，联合肝脏离断及门脉结扎的分次肝切除术(associating liver partition and portal vein ligation for staged hepatectomy, ALPPS)(图5)提供了新的根治选择[62]. ALPPS手术分为两期: 一期通过肝脏离断和患侧门静脉结扎来促进健侧肝脏的代偿性增生；待健侧达到足够体积后, 再行二期手术彻底切除患侧肝脏. 这一创新性手术为难以治愈的肝占位患者提供了新的生存机会. 然而, ALPPS的围手术期并发症和病死率较高, 尽管其3年生存率优于经导管动脉栓塞化疗(transcatheter arterial chemoembolization, TACE), 但5年生存率与门静脉栓塞(portal vein embolization, PVE)后的二步肝切除术相当[63].

目前，针对中晚期的HCC患者，临床逐步推崇“双转化”治疗策略，即以肿瘤降期或生物学转化为先，后进行FLR转化. 在FLR转化上，PVE或其改进技术末梢门静脉栓塞术(terminal branches portal vein embolization, TBPVE)仍为首选，而ALPPS和肝移植则作为最后

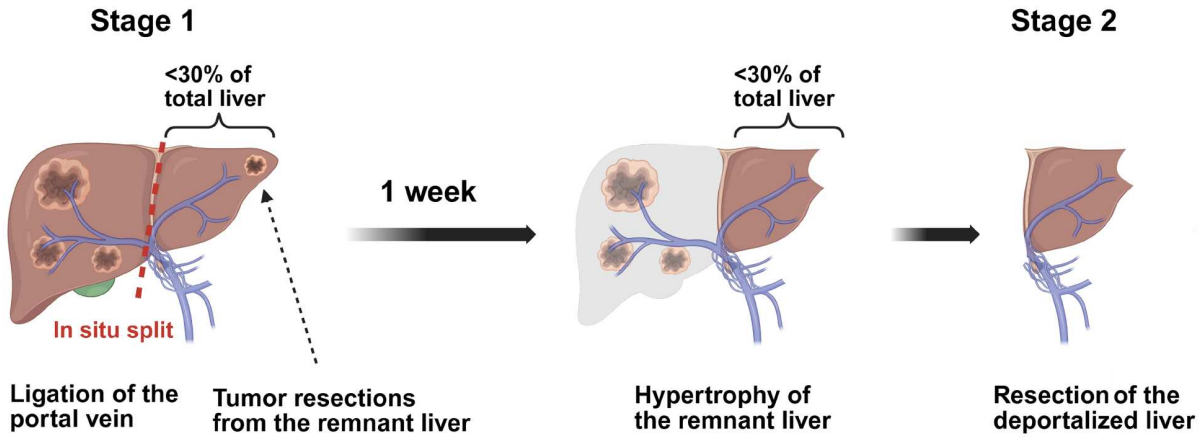

图 5 (网络版彩色)联合肝脏离断及门脉结扎的分次肝切除术示意图. 图片使用BioRender制作

Figure 5 (Color online) Schematic illustration of associating liver partition and portal vein ligation for staged hepatectomy (ALPPS). Created by BioRender

的治疗选择[63]. 这一策略不仅优化了肝脏功能恢复和手术安全性, 也为患者的生存带来了希望和可能.

3.2.2 胰腺手术

保留幽门的胰十二指肠切除术(pylorus-preserving pancreatoduodenectomy, PPPD)(图6(a))是传统Whipple手术的重要改良术式, 其核心在于保留幽门及近端2~3 cm十二指肠段, 从而最大限度维持了胃-十二指肠连续性的解剖结构及胃排空功能[64]. 该手术主要用于治疗胰腺头部和十二指肠的良性或恶性肿瘤. 相较于传统的胰十二指肠切除术对幽门及十二指肠的完全切除, PPPD保留了幽门括约肌和部分十二指肠, 从而减少了胃排空障碍和倾倒综合征的发生率, 显著改善了患者术后的营养吸收和生活质量[65]. PPPD的应用体现了外科医生在肿瘤根治与功能保留间的精准权衡. 在处理胰腺体部和尾部病变时, 胰体尾切除术是首选. 在传统手术中, 脾脏通常也被切除, 但近年来, 为减少免疫和代谢影响, 保留脾脏的手术技术得到了发展. 通过保留脾动脉和脾静脉(Warshaw技术)或保留脾门血管, 外科医生可以在清除病变的同时降低术后并发症风险[66]. 对于胰腺中央部的良性或低度恶性肿瘤, 中央胰腺切除术(central pancreatectomy, CP)(图6(b))提供了一种胰腺功能保留的选择. 手术仅切除胰腺中央部分, 保留胰腺头部和尾部, 并对胰腺残端进行吻合[67]. 与全胰尾切除术相比, CP术保留了更多胰腺组织, 从而减少了内、外分泌功能的丧失风险, 患者术后糖尿病和消化不良的发生率较低, 生活质量显著提高[39,40].

随着技术的发展, 针对胰腺远端的恶性肿瘤, Appleby术式(即联合腹腔干切除的胰体尾癌根治术)成为一种新的选择. 该术式最早在1953年由加拿大外科医师Appleby[68]应用于局部进展期胃癌, 手术切除范围包括全胃、胰体尾、脾脏和腹腔干. 1976年Nimura等人[69]将Appleby手术首先用于胰体尾癌的扩大根治术, 进行了彻底的后腹膜区域清扫. 为了进一步改善患者的生活质量和术后营养状态, Appleby手术进一步发展为联合腹腔干切除的胰体尾癌根治术(distal pancreatectomy with en bloc celiac axis resection, DP-CAR)(图6(c))[70]. 这种改良术式在切除病灶的同时保留了全胃, 保持消化道的完整性, 提供了较高的R0可切除率, 改善了患者的术后生活质量[71,72]. 然而, 由于该术式操作复杂, 尤其是血管操作的高难度, 使得其适应证严格, 目前尚未在临床上广泛应用.

此外, 胰腺全切除术联合自体胰岛移植(total pancreatectomy and islet autotransplantation, TPIAT)(图6(d))自David Sutherland首次报道以来[73], 经过技术的不断发展, 相较于传统的胰腺全切除术, 让胰腺功能得以保留, 不仅能够有效治疗胰腺疾病, 还能显著减少术后内分泌和外分泌功能的缺失[74~76]. 值得关注的是, 近年来中国科研团队在胰岛移植领域取得突破性进展, 上海长征医院殷浩团队和中国科学院程新团队利用患者血液外周血单个核细胞(peripheral blood mononuclear cells, PBMCs)将其重新编程为自体诱导多能干细胞(induced pluripotent stem cells, iPSCs), 然后将其转化为

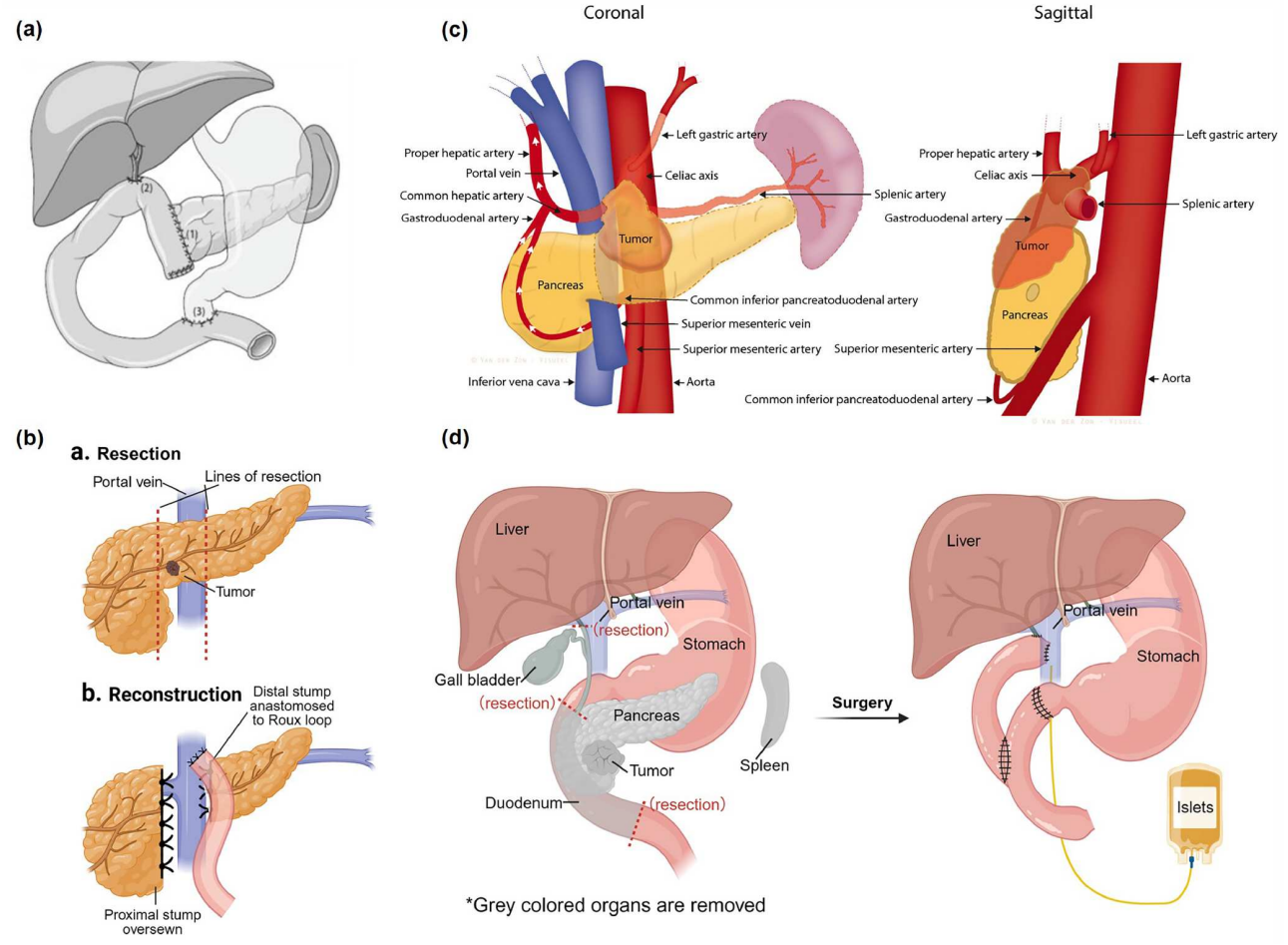

图 6 (网络版彩色)胰腺手术示意图. (a) 保留幽门的胰十二指肠切除术(PPPD), 转载自文献[78]; (b) 中央胰腺切除术(CP), 图片使用BioRender制作; (c) 联合腹腔干切除的胰体尾癌根治术(DP-CAR), 转载自文献[79]; (d) 胰腺全切除术联合自体胰岛移植(TPIAT), 图片使用BioRender制作

Figure 6 (Color online) Schematic illustration of pancreatic surgery. (a) Schematic illustration of pylorus-preserving pancreatoduodenectomy (PPPD), Reproduced from Ref. [78]. (b) Schematic illustration of central pancreatectomy (CP), created by BioRender. (c) Schematic illustration of distal pancreatectomy with en bloc celiac axis resection (DP-CAR), Reproduced from Ref. [79]. (d) Schematic diagram of total pancreatectomy and islet autotransplantation (TPIAT), created by BioRender

"种子细胞", 即内胚层干细胞(endodermal stem cells, EnSCs), 成功实现了胰岛组织的体外重建, 该技术成功实现了终末期糖尿病肾病患者的胰岛功能重建, 成为全球首例胰腺全切后功能性治愈案例, 为未来的胰岛移植治疗提供了新希望[77].

3.3 小肠相关手术革新

小肠移植自1967年由Lillehei等人[80]首次在临床报道以来, 因缺乏强效的免疫抑制剂和较大的手术难度一直未能得到良好的治疗效果. 20世纪70年代以后, 随着免疫抑制剂的发展和外科技术的成熟, 小肠移植技术不断发展, 移植肠存活时间不断延长, 小肠移植的应用范畴也不断拓宽. 浙江大学医学院附属第一医院梁廷波、吴国生团队近期报道, 采用自体小肠移植技术(autointestinal transplantation)成功治疗了10例累及肠系膜上动脉(superior mesenteric artery, SMA)的局部晚期或复发性结肠癌患者. 该团队通过扩展切除联合小肠自体移植手术, 3年无复发生存率达68%, 总体生存率达80%. 这一技术不仅提高了肿瘤切除的彻底性, 还显著延长了患者的生存期, 展示了在复杂肿瘤手术中的巨大潜力[81]. 此外, 他们利用该技术联合新辅助治疗完成了36例局部晚期胰腺导管腺癌(advanced pancreatic ductal adenocarcinoma, PDAC)的根治性切除, 突破性解决了以往PDAC累及SMA而不可切除的难题, 手术

成功率达94.4%, 术后无复发生存期中位数为13.6个月, 总体生存期中位数为21.4个月. 小肠自体移植显著提高了PDAC切除的彻底性, 展示了在特定高选择性患者中的安全性和临床益处[82].

3.4 结直肠相关手术革新

随着结直肠癌发病率的增加和年轻化趋势, 患者的保肛需求也越加普遍和迫切. 由此近几十年来低位直肠的保肛手术得到了创新性发展. 2008年Williams等人[83]提出的经前会阴超低位直肠切除术(anterior perineal planE for ultra-low anterior resection, APPEAR)通过会阴途径实现超低位直肠癌切除, 其核心价值在于通过保留肛提肌复合体显著改善肛门功能. 14名患者中, 均保证了良好的肛门功能, 术后Wexner失禁评分肿瘤/外伤患者中位5分(范围0~8, n=6), 溃疡性结肠炎患者中位数2分(范围0~6, n=3), 术后SF-36生活质量评分维持基线水平, 性功能障碍发生率21.4%(3/14); 值得注意的是, 会阴伤口感染和瘘的发生率高达50%[84]. 后续的研究也证实了APPEAR术结合腹腔镜TME手术在治疗低位直肠癌方面的有效性和可行性, 但是由于手术的复杂性和后续发现的15.4%~60%的会阴伤口并发症[85], 并未在我国广泛开展.

在APPEAR术式的基础上, 2010年Atallah等人[86]提出经肛门微创手术(transanal minimally invasive surgery, TAMIS), 通过单孔通道实现肿瘤精准切除. 随后McLemore等人[87]利用经肛门内镜显微外科手术(transanal endoscopic microsurgery, TEM)平台进行了"自下而上"的独特解剖视角的经肛门全直肠系膜切除术(transanal total mesorectal excision, taTME). 值得注意的是, 中山六院康亮教授主导的多中心随机对照试验(randomized controlled trial, RCT)的初期结果显示, taTME相较于腹腔镜全直肠系膜切除术(laparoscopic-assisted total mesorectal excision, laTME)可以减少手术切口要求, 提供更早的术后恢复, 缩短术后首次排气、首次进食和行走的时间[88]. 该团队进一步通过TaLaR-01多中心Ⅲ期RCT提供了远期肿瘤学证据, 3年随访数据显示taTME与laTME的3年无病生存率(82.1% vs 79.4%; HR=0.86, 97.5%CI 0.63~1.18)及总生存率(89.3% vs 87.6%; HR=0.91, 95%CI 0.72~1.15)均达到非劣效性终点(P<0.001 for non-inferiority)[89]. 在排粪功能方面, Bjoern等人[90]研究发现, taTME患者在控粪能力(P=0.017)及排粪急迫感(P=0.032)方面较laTME患者有所劣势, 但是两组在低位前切除综合征(low anterior resection syndrome, LARS)评分上差异无统计学意义(26.18 vs 20.61, P=0.054). 一项2019年Meta分析综合14项研究证实, 两组在严重LARS评分方面无显著差异[91]. 在排尿功能、性功能及生活质量方面, Bjoern等人[90]研究表明, taTME与laTME患者术后性功能相当, 但taTME患者在排尿功能及生活质量方面满意度更高. Pontallier等人[92]的研究认为, taTME在性功能保护方面可能具备潜在优势, 而在排粪功能上与laTME差异无显著性. Keller等人[93]的随访研究显示, taTME患者术后排尿功能及生活质量优于laTME组. 法国GRECCAR2 III期研究[94]显示, 新辅助治疗后局部切除术(LE)与taTME的5年生存率差异无统计学意义(OS 84% vs 82%, P=0.85; DFS 70% vs 72%, P=0.68), 5年局部复发率无统计学差异(7% vs 7%, P=0.60), 为功能保留提供了高级别循证证据, 为那些希望保留直肠功能的患者提供了新的治疗选择. 总体而言, taTME能更好地保护神经, 它在排尿功能及性功能保护上可能具有潜在优势, 且患者的术后生活质量较高; 相较于传统的术式在治疗困难的低位直肠癌病例中更具优势, 可显著缩短手术时间、减少手术创伤、加速术后康复[95]. 目前, taTME仍处于发展阶段, 在开展过程中会出现尿道损伤和二氧化碳栓塞等并发症, 而这些问题与该术式学习周期长密切相关, 外科医生需要较多病例数(≥50例次)度过学习曲线[95]. 未来, 随着单孔机器人技术的普及, taTME的学习难度有望降低, 使其优势能惠及更多患者.

近年来, 直肠癌的治疗不仅在手术技术上不断革新, 还在综合治疗策略上取得了显著进展, 特别是在针对dMMR(微卫星不稳定)肠癌的免疫治疗领域[96,97]. 直肠癌豁免手术(watch-and-wait策略)作为一种创新性治疗方案, 逐渐在临床实践中受到关注. 对于那些对新辅助治疗反应良好的患者, 尤其是dMMR肠癌患者, 豁免手术为许多患者提供了避免切除术的机会[98].

与此同时, 对于右半结肠癌的手术方法也在不断革新. 传统的右半结肠癌根治术(traditional right hemicolectomy, TRH)(图7)切除了末端回肠、回盲部、升结肠及部分横结肠, 并进行回肠-结肠吻合. 术后可能出现反复腹痛、腹泻及营养吸收不良等肠道恢复功能受损的问题[99]. 笔者团队针对这个问题, 提出并开展了腹腔镜下保留回盲部的右半结肠癌切除术(laparoscopic ileocecal-sparing right hemicolectomy, LISH)(图7)[100],

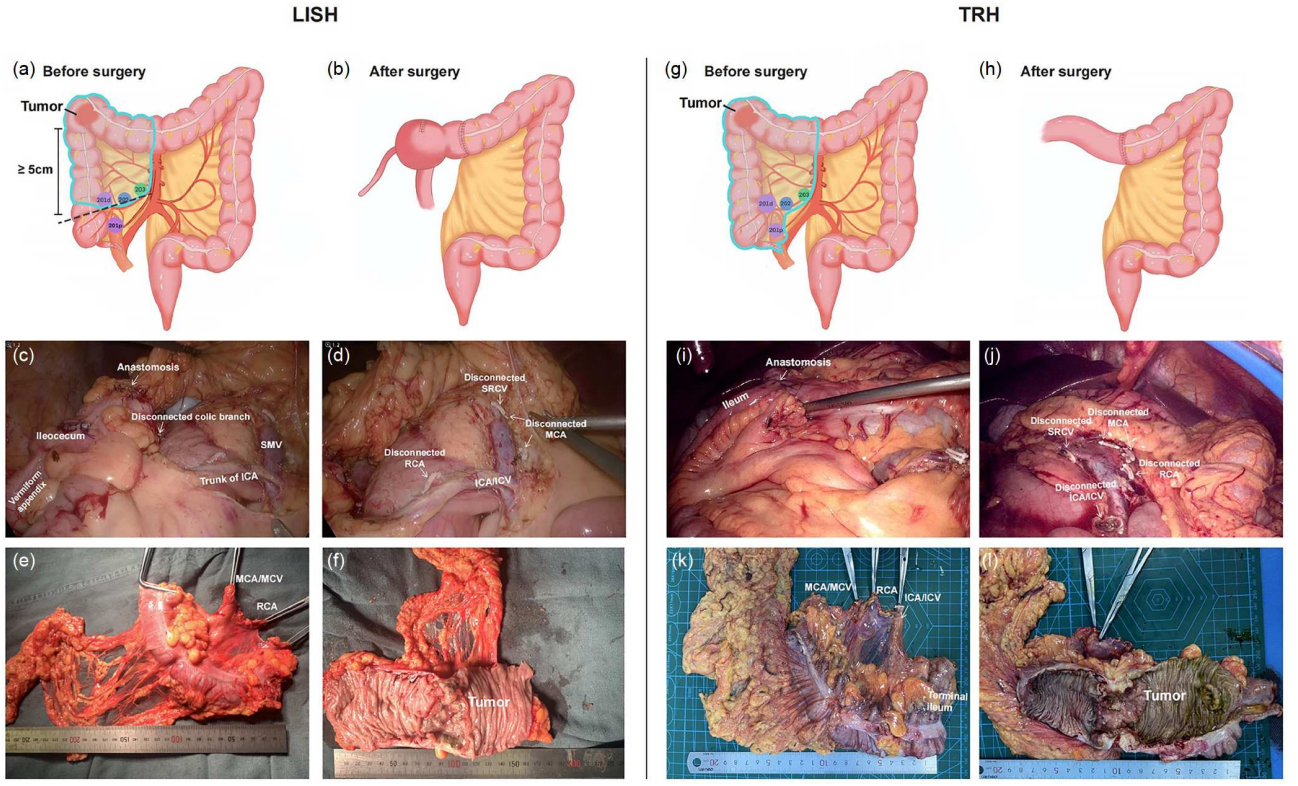

图 7 (网络版彩色)回盲部的右半结肠癌切除术(LISH)及传统右半结肠癌切除术(TRH)示意图, 改自文献[100]. (a, b) LISH手术示意图, 标记了201p、201d、202、203淋巴结; (c, d) LISH 术中吻合口与离断血管图像; (e, f) LISH切除标本; (g, h) TRH手术示意图; (i, j) TRH术中吻合口与离断血管图像; (k, l) TRH切除标本. SMV, 肠系膜上静脉; ICA, 回结肠动脉; ICV, 回结肠静脉; MCA, 结肠中动脉; MCV, 结肠中静脉; RCA, 右结肠动脉; SRCV, 右结肠上静脉

Figure 7 (Color online) Schematic illustration of laparoscopic ileocecal-sparing right hemicolectomy (LISH) and traditional right hemicolectomy (TRH), Reproduced from Ref. [100]. (a, b) Schematics of the LISH procedure. The 201p, 201d, 202, and 203 lymph nodes were marked; (c, d) intraoperative images of anastomosis and disconnected vessels during the LISH procedure; (e, f) specimens removed during LISH; (g, h) schematic of the TRH procedure; (i, j) intraoperative images of anastomosis and disconnected vessels during the TRH procedure; (k, l) specimens removed during the TRH procedure. SMV, superior mesenteric vein; ICA, ileocolic artery; ICV, ileocolic vein; MCA, middle colic artery; MCV, middle colic vein; RCA, right colic artery; SRCV, superior right colic vein

主要适用于位于结肠肝曲或近端横结肠的肠道肿瘤, 骨骼化分离回结肠动脉(ileocolic Artery, ICA)并选择性结扎结肠支从而保留了回盲部这个重要的生理结构, 在保留手术安全性和肿瘤学安全性的前提下加快了患者术后的恢复时间、缩短了患者的住院时间, 显著降低了患者术后腹泻发生率[101]. 目前, LISH的III期全国多中心临床研究(NCT05923255)由笔者所在团队牵头, 正在全国30家多分中心广泛开展中. 通过这一研究, 将有望进一步规范论证LISH术式的外科学与肿瘤学安全性, 同时对其促进右半结肠癌患者术后康复的效果进行探究.

此外, 达·芬奇机器人系统在结直肠手术中的应用也日渐广泛. 自2001年Weber等人[102]首次成功应用机器人进行乙状结肠和右半结肠的手术以来, 越来越多的研究显示, 与传统腹腔镜手术相比, 机器人手术在降低中转开腹率、提升肿瘤切除质量等方面具有优势[102~104]. 例如, 复旦大学许剑民团队的多中心、随机、对照、优越性试验比较了机器人和传统腹腔镜手术在中低位直肠癌患者中的手术质量和长期肿瘤学结果, 结果表明机器人手术具有更好的肿瘤切除质量, 手术创伤更小, 术后恢复更好[105].

器官功能保护理念不仅体现在手术技术的改进上, 还包括综合治疗策略的应用. 例如, 术前新辅助治疗(如放疗、化疗)的应用可以缩小肿瘤体积, 从而使得手术切除范围减少, 保留更多正常组织. 与此同时, 多学科团队(multidisciplinary team, MDT)的协作在治疗策略的制定中也起到了重要作用, 使得手术与治疗方案能够更加个性化, 从而更好地保护患者的器官功能. 这

些多层次的努力共同推动了结直肠癌治疗的进展，使患者在得到有效治疗的同时，能够保有更高的生活质量.

4 总结和未来发展方向及展望

器官功能保护的实现得益于手术技术的成熟、手术设备的进步和手术理念的革新. 手术技术的成熟为器官功能保护提供了坚实的基础. 随着微创手术技术的发展，医生能够通过更小的切口和更少的创伤下完成复杂的手术操作. 这不仅减少了术后的恢复时间, 还显著减少了手术对器官的损伤[106]. 手术设备的进步是实现器官功能保护的关键因素之一，如手术机器人和高分辨率成像系统, 使得手术过程更加精确和可控. 最后, 手术理念的革新也在推动器官功能保护的发展. 从过去注重病变组织的彻底切除，到现在更加注重如何在切除病变的同时保护器官的功能，这种理念的转变使得外科医生在制定手术计划时更加关注对器官功能的保留.

消化外科领域的器官功能保护不仅是无数患者的迫切需求, 也是当前时代的发展趋势. 消化外科今后需要进一步采用规范的RCT研究论证新术式的安全性与可推广性，采用高水平的基础研究探明器官功能保留的机制，从而对无法保留器官功能的患者提前进行干预. 同时, 我们需要继续整合人工智能(artificial intelligence，AI)等先进技术，以增强术前规划、术中导航和术后护理. 此外, 对消化疾病分子和遗传基础的持续研究有望带来靶向治疗，与手术治疗结合，提高患者治愈率.

消化外科的器官功能保护领域正经历重大转变, 主要由技术创新和对疾病生物学的深入理解推动. 这些进步不仅提高了手术的精确性和安全性，也改善了接受消化外科手术患者的整体生活质量. 随着研究和技术的不断发展，我们可以期待在消化外科领域的进一步突破.

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Summary for “基于器官功能保护理念的消化外科术式创新”

Innovation in digestive surgery techniques based on the concept of organ function preservation

Lihao Chen[1], Xiangxing Kong[1], Jian Wang[1] & Kefeng Ding[1,2*]

[1] *Department of Colorectal Surgery and Oncology (Key Laboratory of Cancer Prevention and Intervention, China National Ministry of Education), The Second Affiliated Hospital, Zhejiang University School of Medicine, Hangzhou 310009, China*
[2] *Center for Medical Research and Innovation in Digestive System Tumors, Ministry of Education, Hangzhou 310058, China*
* Corresponding author, E-mail: dingkefeng@zju.edu.cn

This review focuses on the field of digestive surgery and systematically explores surgical innovations driven by the concept of organ function preservation and their clinical practice, aiming to improve patients’ postoperative quality of life by preserving organ structure and function.

Through a comprehensive review of literature and clinical cases, the study traces the conceptual evolution of digestive surgery from “lesion excision” to “functional reconstruction”: early surgical approaches prioritized radical tumor removal, often resulting in irreversible organ dysfunction (e.g., pylorus loss in Billroth I gastrectomy for gastric cancer, anal sphincter loss in the Miles procedure for rectal cancer); by the early 2000s, advancements in minimally invasive technologies (such as laparoscopy and robotic surgery) and precise diagnostic tools (including radiomics and three-dimensional reconstruction) facilitated the formation of the organ function preservation concept, spurring the development of innovative surgical methodologies.

In gastric surgery, pylorus-preserving gastrectomy (PPG) improves postoperative gastric motility and nutrient assimilation while decreasing the prevalence of dumping syndrome via the preservation of the pyloric sphincter and vagal nerve branches. Similarly, endoscopic submucosal dissection (ESD) enables minimally invasive functional preservation in early-stage gastric cancer by selectively removing lesions while maintaining gastric integrity. For hepatobiliary-pancreatic surgeries, ex-vivo liver resection and autotransplantation (ELRA) and ALPPS (associating liver partition and portal vein ligation for staged hepatectomy) enhance treatment efficacy in complex hepatocellular carcinoma by enabling precise hepatic segmentectomy and functional reconstruction. Additionally, pylorus-preserving pancreatoduodenectomy (PPPD) and central pancreatectomy (CP) balance oncological radicality with the preservation of gastrointestinal continuity and pancreatic endocrine/exocrine functions. In colorectal surgery, transanal total mesorectal excision (taTME) enhances anal sphincter preservation in low rectal cancer via a “bottom-up” approach, safeguarding pelvic autonomic nerves to minimize urogenital and sexual function impairments. Laparoscopic ileocecal-sparing right hemicolectomy (LISH) decreases postoperative diarrhea and promotes faster convalescence by preserving the ileocecal valve, a critical anatomical structure for intestinal transit.

While these innovations demonstrate efficacy in minimizing tissue trauma and optimizing functional retention, significant challenges persist, including procedural complexity, limited adoption in primary care settings, and insufficient long-term outcome data. Technical advancements such as single-incision laparoscopy and robot-assisted platforms partially address these barriers but require further validation.

Theoretically, the review reinforces the centrality of organ function preservation in contemporary digestive surgery, expanding the theoretical paradigm to integrate “radical resection” and “functional preservation” as dual treatment objectives; clinically, multicenter RCTs (e.g., the TaLaR-01 trial) have provided robust evidence for the safety and long-term outcomes of novel procedures, enabling clinicians to tailor surgical choices to individual patient needs.

Future research must prioritize three areas: assessing the long-term outcomes of innovative procedures through standardized randomized controlled trials, investigating the biological mechanisms underlying organ function preservation via basic science research, and designing interventions for irreversible organ dysfunction, with the aim of driving digestive surgery toward a paradigm shift from “tumor removal” to “functional reconstruction” and achieving synergistic improvements in oncological control and patient quality of life.

organ function preservation, minimally invasive surgery, quality of life, surgical innovation, robot-assisted surgery

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