

· 综述 ·

## 联合肝脏离断和门静脉结扎二步肝切除术的应用进展

陈一帆, 黄 博, 卢杏生\*

南京医科大学附属苏州医院肝胆外科, 江苏 苏州 215002

**[摘要]** 肝脏肿瘤早期诊断率低, 大部分患者初诊即失去手术机会。剩余肝脏体积(future liver remnant, FLR)不足是无法手术的主要原因, 这已成为制约肝脏外科发展的瓶颈。联合肝脏离断和门静脉结扎二步肝切除术(associating liver partition and portal vein ligation for staged hepatectomy, ALPPS)能够促进剩余肝脏快速增生, 进而接受手术切除, 显著改善了无法手术患者的预后。但这项技术开展之初, 因其安全性问题争议较大, 现已得到明显改善。文章通过总结 ALPPS 相关文献来阐述其临床应用方面的进展。

**[关键词]** 肝脏肿瘤; 联合肝脏离断和门静脉结扎二步肝切除术; 剩余肝脏体积; 肝切除术; 切除后肝功能衰竭

**[中图分类号]** R657.3

**[文献标志码]** A

**[文章编号]** 1007-4368(2022)06-891-06

**doi:** 10.7655/NYDXBNS20220621

### Progress in the application of associating liver partition and portal vein ligation for staged hepatectomy

CHEN Yifan, HUANG Bo, LU Xingsheng\*

Department of Hepatobiliary Surgery, the Affiliated Suzhou Hospital of Nanjing Medical University, Suzhou 215002, China

**[Abstract]** The early diagnostic rate of liver cancer is low. Most patients lose the opportunity for surgical resection when they are first diagnosed. It is not eligible for patients to achieve operations mainly due to deficient future liver remnant (FLR) which obstacles the development of liver surgery. Associating liver partition and portal vein ligation for staged hepatectomy (ALPPS) enables patients undergo radical excision by rapid liver hypertrophy, which significantly improves the prognosis of patients. Now ALPPS has substantially gained improvement, which was remarkably controversial for its safety issue in the early stage of practice. This review will elaborate the progress of clinical applications by synthesizing the articles concerning ALPPS.

**[Key words]** liver cancer; associating liver partition and portal vein ligation for staged hepatectomy; future liver remnant; liver resection; post-hepatectomy liver failure

[J Nanjing Med Univ, 2022, 42(06): 891-896]

尽管近年来免疫及靶向药物在肝胆肿瘤领域取得了较大进展, 使许多中晚期患者成功实现转化治疗, 但可行手术者仅占 15%~30%<sup>[1]</sup>, 根治性切除仍是实现长期生存的重要手段<sup>[2]</sup>。无法手术的主要原因是剩余肝脏体积(future liver remnant, FLR)不足, 这部分患者生存期短, 预后极差。如何使剩余

肝脏增生成为肝脏外科医师最为关注的问题。联合肝脏离断和门静脉结扎二步肝切除术(associating liver partition and portal vein ligation for staged hepatectomy, ALPPS)可使 FLR 在短时间内迅速增长以满足手术要求, 进而提高肿瘤切除率, 改善患者预后。但在开展之初, 较高的并发症发生率及早期病死率使 ALPPS 在手术安全性方面受到了极大质疑<sup>[3]</sup>。由于技术的不断改良, 临床应用逐渐增多, 其并发症率及病死率已较前明显下降<sup>[4]</sup>, ALPPS 也在慢慢走向成熟。

**[基金项目]** 苏州市医学重点学科项目(SZXX201808)

\*通信作者(Corresponding author), E-mail: luxingsheng88@sina.com

## 1 ALPPS的优势

在ALPPS问世之前,门静脉栓塞(portal vein embolization, PVE)及门静脉结扎(portal vein ligation, PVL)是FLR不足患者的首选治疗方法。其主要缺点在于肝脏增生缓慢,通常需要4~6周才能达到接受再次手术的要求,在等待过程中约有20%的患者因肿瘤持续进展或增生不足,从而丧失了二期手术的机会<sup>[5]</sup>。此外,单纯PVE也不适用于伴有门静脉癌栓(portal vein tumor thrombosis, PVTT)的患者。经动脉化疗栓塞(trans-arterial chemoembolization, TACE)联合PVE是有效的治疗手段,TACE可控制肿瘤进展,同时PVE诱导剩余肝脏增生,荟萃分析显示联合治疗的转化成功率显著高于单纯PVE(90% vs. 75%,  $P < 0.01$ )<sup>[6]</sup>,但并未提升增生速率。肝静脉系统栓堵术(liver venous deprivation, LVD)则是Guiu等<sup>[7]</sup>于2016年提出的术式,通过介入手段同时进行肝静脉栓塞(hepatic vein embolization, HVE)与PVE,以实现FLR的快速增长,报道称此法可将具有肝硬化背景肝癌患者的二期手术等待时间缩短至25 d<sup>[8]</sup>,但目前仍缺乏大宗的临床数据。ALPPS的优势则在于能在短期内促进FLR大幅度增长(47%~192%),且二期肝切除术(two-staged hepatectomy, TSH)的完成率更高(95%~100%)<sup>[9-10]</sup>。Robles-Campos等<sup>[11]</sup>应用倾向性评分匹配法比较了ALPPS与TSH,两种手术并发症率相近,前者间隔时间更短(15 d vs. 45 d,  $P < 0.001$ ),促肝增生效果更优。亦有研究表明ALPPS能使具有肝病背景的剩余肝脏增长<sup>[12]</sup>。对于第1步行PVE失败的病例,ALPPS可作为后续治疗方法,被称为“挽救性ALPPS”,也可在短期内使FLR增生61.8%~88.0%<sup>[13]</sup>。根据国际ALPPS注册中心的最新数据显示,总体术后90 d死亡率为7%,并发症率为39%,二期手术完成率达到了98%<sup>[14]</sup>,这表明ALPPS的安全性及有效性较前已有长足进步。

## 2 ALPPS促肝增生的机制

### 2.1 血流动力学改变

ALPPS使未结扎的门静脉血流量明显增多,压力也显著增高,流向剩余肝脏的营养因子增加,使之呈高灌注状态,故能够迅速进行增生<sup>[15-16]</sup>。ALPPS一方面通过结扎门静脉减少了流入肿瘤一侧肝脏的血流量;另一方面原位离断肝实质,阻断了肝脏之间的侧支循环,使门静脉血流全部流入剩

余肝脏。研究表明,增生速度与侧支循环的数目成反比,侧支循环建立的数量越少,剩余肝脏增生速度越快<sup>[16]</sup>,这也是ALPPS促进肝脏增生的速度与程度显著优于单纯PVE/PVL的原因。

### 2.2 体液炎症因子

Schlegel等<sup>[17]</sup>通过建立动物实验模型进行研究,分别设置了ALPPS组、单纯PVL组、单纯肝脏离断组和额外脏器损伤组(行肾、脾或肺消融及PVL),发现ALPPS组的剩余肝脏增长率为单纯PVL/单纯肝脏离断组的2倍,而额外脏器损伤组的增长率与ALPPS组无明显差异。研究人员将ALPPS组小鼠的血浆注射入单纯PVL组后发现,两组的剩余肝脏增长率类似,差异并无统计学意义。通过进一步的实验验证,发现ALPPS组术后血浆和剩余肝脏中的炎症因子,如白介素6(interleukin-6, IL-6)及肿瘤坏死因子 $\alpha$ (tumor necrosis factor- $\alpha$ , TNF- $\alpha$ ),表达明显上调,提示肝脏增生的肝细胞生长因子(hepatic growth factor, HGF)浓度约为单纯PVL组的10倍。另外创伤相关的体液因子如高迁移率族蛋白B1、晚期糖基化终产物受体和Toll样受体4等蛋白表达也显著上调,这些实验结果提示ALPPS诱导剩余肝脏增生的机制可能与手术创伤所产生的炎症反应有关。

## 3 ALPPS的临床应用进展

ALPPS主要适用于肝脏肿瘤过大或多发,无法行一期肝切除或既往行PVE或PVL后剩余肝脏增生不足者。ALPPS早期多用于治疗结直肠癌肝转移(colorectal cancer liver metastasis, CRLM),后手术适应证不断扩大,逐渐应用于肝细胞癌(hepatocellular carcinoma, HCC)等其他肝脏肿瘤。根据国际ALPPS注册中心统计的数据显示,在437例ALPPS手术病例中,CRLM的比例由53%上升至77%,胆道肿瘤下降至9%,HCC的比例则逐渐升高<sup>[4,18]</sup>。

### 3.1 ALPPS治疗CRLM

CRLM患者大多无肝炎及肝硬化病史,剩余肝脏的增生能力尚可,ALPPS一期手术后等待9~15 d即可达到要求[FLR/标准肝体积(standard liver volume, SLV) > 30%或FLR/体重 > 0.5%]。现今积累的临床数据表明应用ALPPS技术治疗CRLM相对成熟,患者近期生存获益良好,1、2、3年总体生存率可达78%、59%~63%、50%,1至3年无瘤生存率分别为59%~67%、40%~41%、13%<sup>[19-21]</sup>。CRLM的术后并发症率已下降至与大范围肝切除术相近,明显低于非CRLM者<sup>[22]</sup>。欧洲开展的LIGRO临床研究亦显示了

ALPPS治疗CRLM的优越性<sup>[13]</sup>。此项研究总共纳入97例患者,其中48例行ALPPS,49例行PVE,ALPPS的切除率明显高(92% vs. 57%,  $P < 0.001$ ),且12例PVE失败患者均通过挽救性ALPPS治疗成功,中位生存时间达到46个月<sup>[23]</sup>。这些数据均说明ALPPS用于CRLM患者的效果得到肯定,已有指南将ALPPS作为CRLM的一种可选治疗手段进行推荐<sup>[24]</sup>。

### 3.2 ALPPS治疗胆道肿瘤

虽然首例ALPPS用于治疗肝门部胆管癌(perihilar cholangiocarcinoma, PHC),但极高的并发症率及病死率表明PHC并不是ALPPS的良好适应证。因胆汁流出受阻、局部胆汁淤积和健侧肝脏内胆管树发育不成熟<sup>[25]</sup>,PHC患者术前常伴有胆红素上升、肝功能损害及胆管炎<sup>[26]</sup>。ALPPS一期手术后需要较长时间等待FLR充分增生,且术后发生胆漏、腹腔感染、肝功能衰竭、脓毒血症的比例较高(尤其是行胆道重建者)<sup>[27]</sup>。2017年国际ALPPS协作组比较了29例应用ALPPS以及257例行肝门部胆管癌根治术的病例,ALPPS组90 d病死率竟然达到48%,为对照组(24%)的2倍;且中位生存时间明显短于对照组(6个月 vs. 29个月,  $P < 0.05$ )<sup>[28]</sup>。故目前多数专家仍推荐PVE作为治疗FLR不足的PHC患者的首选方法。肝内胆管癌、胆囊癌应用ALPPS亦见少量报道,但仍缺乏大宗的病例研究<sup>[29-30]</sup>。ALPPS治疗胆道肿瘤日趋减少,需综合评估患者全身状态后审慎开展。

### 3.3 ALPPS治疗HCC

ALPPS用于治疗初始无法切除的HCC尚存较大争议,由于此类患者具有慢性肝病背景,肝脏增生速率较CRLM明显减缓<sup>[31]</sup>,常伴有不同程度的肝功能损害,二期手术的条件更为严苛,必须满足FLR/SLV $>40\%$ 或FLR/体重 $>0.8\%$ 。D'Haese等<sup>[12]</sup>的研究结果显示,西方人群HCC患者ALPPS术后90 d病死率(31.4% vs. 6.7%,  $P < 0.01$ )约为CRLM的5倍,剩余肝脏增生率也显著低于CRLM患者(47% vs. 76%,  $P < 0.01$ )。Schadde等<sup>[22]</sup>甚至认为HCC本身即为ALPPS的独立危险因素。但也有部分学者持不同意见,认为HCC患者同样可通过ALPPS获益。我国周俭教授团队继完成亚洲首例ALPPS后,选择了45例HCC患者行标准ALPPS,其中41例(91.1%)完成了第二步手术,FLR中位增长率为56.8%,90 d病死率为11.1%,1年、3年总生存率达到64.2%和60.2%<sup>[32]</sup>。Vennarecci等<sup>[33]</sup>对17例行ALPPS的HCC患者进行回顾性分析,2年生存率为38.5%,无病生

存率(disease free survival, DFS)可达60%。我国周伟平教授团队也在美国临床肿瘤协会(American Society of Clinical Oncology, ASCO)2020年度会议上首次报告了ALPPS与PVE二步切除术治疗HCC的随机对照研究(randomized controlled trial, RCT)数据,ALPPS的3年生存率高(65.8% vs. 42.1%,  $P < 0.05$ ),但术后严重并发症率达到了54.1%,PVE仅为20.0%<sup>[34]</sup>。虽然以上数据显示HCC应用ALPPS生存获益良好,但短期风险较大,需严格把握手术适应证,选择年龄 $<60$ 岁、肝纤维化程度低、基本状况良好的患者施行手术,肝功能严重受损(Child-Pugh分级B或C级)或合并肝硬化及门静脉高压应视作其禁忌证。同时ALPPS可作为PVE治疗失败HCC患者的后续方案,有学者建议术前FLR/SLV $<30\%$ 时行ALPPS,30%~40%则行PVE;术后1个月FLR不足可行挽救性ALPPS<sup>[35]</sup>。目前国际ALPPS协作组对于HCC的大规模RCT尚未完成,治疗效果有待后续数据进一步论证。

## 4 ALPPS的技术改进

### 4.1 并发症防治技术的改进

ALPPS开展初期,手术相关并发症发生率为68%(Clavien-Dindo III级以上占44%),III b级以上的严重并发症患者病死率达到27%<sup>[36]</sup>。肝脏断面出现胆漏,进而引起严重的腹腔感染及脓毒血症是患者死亡的主要原因。Alvarez等<sup>[19]</sup>提出在一期手术中使用塑料袋包裹含有肿瘤的一侧肝脏,用于预防或减少胆漏,以控制腹腔内感染。Ardiles等<sup>[37]</sup>则持相反意见,认为放置塑料袋会导致门静脉粘连,且并不能降低腹腔感染的风险。

Oldhafer等<sup>[27]</sup>研究后指出可在术中经胆管行造影检查以发现胆漏,并改用生物防粘连材料预防局部感染,使ALPPS术后胆漏及腹腔感染的发生率明显降低。

随着精准外科的理念越来越普及,许多新技术使ALPPS进一步优化。术前运用三维可视化技术可精确计算FLR,同时模拟手术过程,减小手术创伤<sup>[38]</sup>。Dodan等<sup>[39]</sup>首次在ALPPS中引入ORBEYE手术显微镜,该设备融合了内镜与显微镜的特点,具有3D视觉效果并配备4K显示器,还可借助吲哚菁绿(indocyanine green, ICG)染色精准识别肿瘤所在位置。该病例是1例右肝9 cm巨大肿瘤的患者,术者首先在显微镜下游离右肝周围韧带并精细解剖肝门部,结扎门静脉右支后临时阻断肝右动脉(right hepatic

artery, RHA),再通过外周静脉注射 ICG,根据荧光显像下产生的缺血线标记左右肝界限,进行精准的肝实质离断,患者术后未出现任何并发症,并于 17 d 后顺利完成二期手术。

## 4.2 相关改良术式

### 4.2.1 部分 ALPPS(partial-ALPPS, p-ALPPS)

是指根据肿瘤在肝脏内的位置,一期手术仅离断 50%~80% 肝组织,离断时需注意保留肝静脉,二期手术时再行肝脏的完全离断,据报道,这种方法与标准 ALPPS 相比,剩余肝脏增长的比例类似,且并发症率更低<sup>[40]</sup>。另一项研究数据显示标准 ALPPS 并发症率超过 90%,而在 p-ALPPS 中有 37% 未出现并发症,两种手术方式引起剩余肝脏增长的效果相近<sup>[41]</sup>。已有 2 项荟萃分析的研究结果证明,对于合并肝硬化的病例,p-ALPPS 促肝增生的效果更佳<sup>[42-43]</sup>。

### 4.2.2 射频/微波消融 ALPPS(radio-frequency/microwave ablation assisted liver partition with portal vein ligation for staged hepatectomy, RALPP/MALPP)

Gall 等<sup>[44]</sup>报告了首例使用术中射频消融技术的 ALPPS(RALPP),术中首先结扎肿瘤一侧的门静脉,再沿缺血线使用消融针烧灼形成缺血带,以阻隔两侧肝脏的侧支循环。Gringeri 等<sup>[45]</sup>在 1 例腹腔镜 ALPPS 手术中引入了微波消融(microwave ablation, MVA),使用方法与 RALPP 类似,消融所产生的缺血面积更大,术中花费的时间更短,且具有良好的止血效果。消融技术的加入极大地简化了手术步骤,操作更加简便,缩短了手术时间,较标准 ALPPS 创伤小,不易产生胆漏及腹腔感染等并发症,还可减轻一期手术后腹腔粘连,降低二期手术难度。但至今应用这项技术的病例较少,其安全性和可行性有待进一步探索。

### 4.2.3 绕肝止血带 ALPPS(associating liver tourniquet and portal vein ligation for staged hepatectomy, ALTPS)

该方法的特点是使用止血带取代肝脏离断,手术中首先解剖肝门结构,结扎肿瘤侧门静脉,再于两侧肝脏之间切开深约 1 cm 的间隔,成功建立肝后隧道之后使用止血带牢牢捆绑肝脏组织<sup>[46]</sup>。再使用术中超声(intra-operative ultrasound, IOUS)确认两侧是否存在侧支循环,待增生体积合格后行二期手术。ALTPS 操作便捷,无需大量离断肝实质,有效降低了胆漏及腹腔感染等并发症。Cai 等<sup>[47]</sup>报道了国际上第 1 例完全腹腔镜下 ALTPS,使该项技术更加微创,极大程度地减轻了对机体的损伤。

### 4.2.4 混合 ALPPS(hybrid-ALPPS)

该法是指在使用 PVE 代替一期术中 PVL, Li 等<sup>[29]</sup>首次在 2 例胆囊癌患者中应用,与标准 ALPPS 相比,对伴有门静脉侵犯的病例更加安全有效。这项技术无需对肝门部位进行解剖,降低了手术风险和难度,同时避免了对肿瘤及周围组织的过多操作。其主要缺点在于术后需要较长时间等待剩余肝脏增生,开展例数也较少,尚无大规模应用的报道。

### 4.2.5 微创 ALPPS

腹腔镜手术者能够在离断肝实质时清晰观察到其中的脉管结构,有利于术中对门静脉及胆道系统的操作,使手术更加安全,且两期手术均能在腹腔镜下完成<sup>[48]</sup>。腹腔镜不仅简化了手术操作,创伤也较传统开腹 ALPPS 小。1 项荟萃分析结果表明,微创 ALPPS 的并发症率及短期病死率较开腹 ALPPS 明显降低( $P < 0.01$ )<sup>[49]</sup>。Vicente 等<sup>[50]</sup>报道了国际第 1 例使用 Da-Vinci 机器人手术系统的微创 ALPPS 手术,其放大视野可令术者能够观察到更加细微的解剖结构,操作也较腹腔镜更加灵便。

## 5 总结与展望

ALPPS 是本世纪以来肝脏外科领域一项具有里程碑意义的创新技术,为原本无法手术的肝脏肿瘤患者创造了手术机会,虽然在开展初期饱受争议,但通过手术技术的改良以及手术经验的积累,这项技术现已逐渐被接受和认可。与传统的 PVE/PVL 两步肝切除相比,ALPPS 在肿瘤切除率及患者生存获益方面更优,但其并发症率和病死率不可忽视,应当选择合适的病例施行手术。近年来新型抗肿瘤药物层出不穷,综合治疗手段也不断丰富,越来越多的中晚期患者能够实现肿瘤降期从而接受手术。未来 ALPPS 与免疫及靶向药物进行联合治疗,有望进一步提高切除率,造福更多的肝脏肿瘤患者。

### [参考文献]

- [1] 周 俭,彭远飞,王 征. 余肝不足肝癌手术治疗争议与共识[J]. 中国实用外科杂志, 2018, 38(2): 126-132
- [2] TONG Y F, MENG N, CHEN M Q, et al. Maturity of associating liver partition and portal vein ligation for staged hepatectomy-derived liver regeneration in a rat model[J]. World J Gastroenterol, 2018, 24(10): 1107-1119
- [3] OLTHOF P B, SCHNITZBAUERA A, SCHADDE E. The HPB controversy of the decade: 2007-2017 - ten years of ALPPS[J]. Eur J Surg Oncol, 2018, 44(10): 1624-1627
- [4] LINECKER M, BJÖRNSSON B, STAVROU G A, et al.

- Risk adjustment in ALPPS is associated with a dramatic decrease in early mortality and morbidity [J]. *Ann Surg*, 2017, 266(5): 779-786
- [5] PIRON L, DESHAYES E, ESCAL L, et al. Portal vein embolization: present and future [J]. *Bull Cancer*, 2017, 104(5): 407-416
- [6] TUSTUMI F, ERNANI L, COELHO F F, et al. Preoperative strategies to improve resectability for hepatocellular carcinoma: a systematic review and meta-analysis [J]. *HPB(Oxford)*, 2018, 20(12): 1109-1118
- [7] GUIU B, CHEVALLIER P, DENYS A, et al. Simultaneous trans-hepatic portal and hepatic vein embolization before major hepatectomy: the liver venous deprivation technique [J]. *Eur Radiol*, 2016, 26(12): 4259-4267
- [8] 刘畅, 张晓赓, 金 湛, 等. 肝静脉系统栓堵术在第二阶段根治性肝癌切除术中的应用 [J]. *中国普外基础与临床杂志*, 2019, 26(7): 841-846
- [9] POPESCU G A, ALEXANDRESCU T, GRIGORIE R T, et al. Good to know: the ALPPS procedure - embracing a new technique [J]. *Chirurgia (Bucur)*, 2017, 112(3): 332-341
- [10] VENNARECCI G, GRAZI G L, SPERDUTI I, et al. ALPPS for primary and secondary liver tumors [J]. *Int J Surg*, 2016, 30: 38-44
- [11] ROBLES-CAMPOS R, BRUSADIN R, LÓPEZ-CONESA A, et al. Long-term outcome after conventional two-stage hepatectomy versus tourniquet-ALPPS in colorectal liver metastases: a propensity score matching analysis [J]. *World J Surg*, 2019, 43(9): 2281-2289
- [12] D'HAESE J G, NEUMANN J, WENIGER M, et al. Should ALPPS be used for liver resection in intermediate-stage HCC? [J]. *Ann Surg Oncol*, 2016, 23(4): 1335-1343
- [13] SANDSTRÖ M P, RØSOK B I, SPARRELID E, et al. ALPPS improves resectability compared with conventional two-stage hepatectomy in patients with advanced colorectal liver metastasis: results from a Scandinavian multicenter randomized controlled trial (LIGRO trial) [J]. *Ann Surg*, 2018, 267(5): 833-840
- [14] HUISKENS J, SCHADDE E, LANG H, et al. Avoiding postoperative mortality after ALPPS-development of a tumor-specific risk score for colorectal liver metastases [J]. *HPB(Oxford)*, 2019, 21(7): 898-905
- [15] DILI A, BERTRAND C, LEBRUN V, et al. Hypoxia protects the liver from small for size syndrome: a lesson learned from the associated liver partition and portal vein ligation for staged hepatectomy (ALPPS) procedure in rats [J]. *Am J Transplant*, 2019, 19(11): 2979-2990
- [16] DEAL R, FREDERIKS C, WILLIAMS L, et al. Rapid liver hypertrophy after portal vein occlusion correlates with the degree of collateralization between lobes—a study in pigs [J]. *J Gastrointest Surg*, 2018, 22(2): 203-213
- [17] SCHLEGEL A, LESURTEL M, MELLOUL E, et al. ALPPS: from human to mice highlighting accelerated and novel mechanisms of liver regeneration [J]. *Ann Surg*, 2014, 260(5): 839-846
- [18] LANG H, BAUMGART J, MITTLER J. Associating liver partition and portal vein ligation for staged hepatectomy in the treatment of colorectal liver metastases: current scenario [J]. *Dig Surg*, 2018, 35(4): 294-302
- [19] ALVAREZ F A, ARDILES V, SANCHEZ CLARIA R, et al. Associating liver partition and portal vein ligation for staged hepatectomy (ALPPS): tips and tricks [J]. *J Gastrointest Surg*, 2013, 17(4): 814-821
- [20] HERNANDEZ-ALEJANDRO R, BERTENS K A, PINEDA-SOLIS K, et al. Can we improve the morbidity and mortality associated with the associating liver partition with portal vein ligation for staged hepatectomy (ALPPS) procedure in the management of colorectal liver metastases? [J]. *Surgery*, 2015, 157(2): 194-201
- [21] SCHNITZBAUER A A, SCHADDE E, LINECKER M, et al. Indicating ALPPS for colorectal liver metastases: a critical analysis of patients in the international ALPPS registry [J]. *Surgery*, 2018, 164(3): 387-394
- [22] SCHADDE E, ARDILES V, ROBLES-CAMPOS R, et al. Early survival and safety of ALPPS: first report of the International ALPPS Registry [J]. *Ann Surg*, 2014, 260(5): 829-836
- [23] HASSELGREN K, RØSOKBI, LARSEN P N, et al. ALPPS improves survival compared with TSH in patients affected of CRLM: survival analysis from the randomized controlled trial LIGRO [J]. *Ann Surg*, 2021, 273(3): 442-448
- [24] ZHOU J, SUN H C, WANG Z, et al. Guidelines for diagnosis and treatment of primary liver cancer in China (2017 edition) [J]. *Liver Cancer*, 2018, 7(3): 235-260
- [25] MATSUO K, HIROSHIMA Y, YAMAZAKI K, et al. Immaturity of bile canalicular-ductule networks in the future liver remnant while associating liver partition and portal vein occlusion for staged hepatectomy (ALPPS) [J]. *Ann Surg Oncol*, 2017, 24(9): 2456-2464
- [26] 陆 峰, 王 科, 李相成. 术后并发症对于联合大范围肝切除治疗进展期肝门部胆管癌长期预后的影响 [J]. *南京医科大学学报(自然科学版)*, 2019, 39(2): 220-223
- [27] OLDHAFFER K J, STAVROU G A, VAN GULIK T M, et al. ALPPS—where do we stand, where do we go? Eight recommendations from the first international expert meeting [J]. *Ann Surg*, 2016, 263(5): 839-841

- [28] OLTHOF P B, COELEN R J S, WIGGERS J K, et al. High mortality after ALPPS for perihilar cholangiocarcinoma: case-control analysis including the first series from the international ALPPS registry [J]. *HPB (Oxford)*, 2017, 19(5):381-387
- [29] LI J, KANTAS A, ITTRICH H, et al. Avoid "all-touch" by hybrid ALPPS to achieve oncological efficacy [J]. *Ann Surg*, 2016, 263(1):e6-e7
- [30] BEDNARSCH J, CZIGANY Z, LURJE I, et al. The role of ALPPS in intrahepatic cholangiocarcinoma [J]. *Langenbecks Arch Surg*, 2019, 404(7):885-894
- [31] DENG Z F, JIN Z R, QIN Y H, et al. Efficacy of the associating liver partition and portal vein ligation for staged hepatectomy for the treatment of solitary huge hepatocellular carcinoma: a retrospective single-center study [J]. *World J Surg Oncol*, 2021, 19(1):95
- [32] WANG Z, PENG Y, HU J, et al. Associating liver partition and portal vein ligation for staged hepatectomy for unresectable hepatitis B virus-related hepatocellular carcinoma: a single center study of 45 patients [J]. *Ann Surg*, 2020, 271(3):534-541
- [33] VENNARECCI G, FERRARO D, TUDISCO A, et al. The ALPPS procedure: hepatocellular carcinoma as a main indication; an Italian single-center experience [J]. *Updates Surg*, 2019, 71(1):67-75
- [34] HUANG G. Associating liver partition and portal vein ligation for staged hepatectomy versus portal vein embolization in staged hepatectomy for hepatocellular carcinoma: a randomized comparative study [J]. *J Clin Oncol*, 2020, 38(15s):4578
- [35] CHAN A, ZHANG W Y, CHOK K, et al. ALPPS versus portal vein embolization for hepatitis-related hepatocellular carcinoma: a changing paradigm in modulation of future liver remnant before major hepatectomy [J]. *Ann Surg*, 2021, 273(5):957-965
- [36] SCHNITZBAUER A A, LANG S A, GOESSMANN H, et al. Right portal vein ligation combined with in situ splitting induces rapid left lateral liver lobe hypertrophy enabling 2-staged extended right hepatic resection in small-for-size settings [J]. *Ann Surg*, 2012, 255(3):405-414
- [37] ARDILES V, SCHADDE E, SANTIBANES E, et al. Commentary on "happy marriage or " dangerous liaison ": ALPPS and the anterior approach" [J]. *Ann Surg*, 2014, 260(2):e4
- [38] 李鹏鹏, 王志恒, 黄 昱, 等. 肝脏三维可视化技术在肝脏恶性肿瘤治疗规划中的应用研究 [J]. *中华外科杂志*, 2017, 55(12):916-922
- [39] DODEN K, KAWAGUCHI M, YOSHIMURA T, et al. The impact of using a 4K 3D surgical microscope during associating liver partition and portal vein ligation for hepatocellular carcinoma treatment: a case report with operative video [J]. *Int J Surg Case Rep*, 2021, 85:106195
- [40] PETROWSKY H, GYÖRI G, DE OLIVEIRA M, et al. Is partial-ALPPS safer than ALPPS? A single-center experience [J]. *Ann Surg*, 2015, 261(4):e90-e92
- [41] LINECKER M, KAMBAKAMBA P, REINER C S, et al. How much liver needs to be transected in ALPPS? A translational study investigating the concept of less invasiveness [J]. *Surgery*, 2017, 161(2):453-464
- [42] HUANG H C, BIAN J, BAI Y, et al. Complete or partial split in associating liver partition and portal vein ligation for staged hepatectomy: a systematic review and meta-analysis [J]. *World J Gastroenterol*, 2019, 25(39):6016-6024
- [43] WU X, RAO J, ZHOU X, et al. Partial ALPPS versus complete ALPPS for staged hepatectomy [J]. *BMC Gastroenterol*, 2019, 19(1):170
- [44] GALL T M, SODERGREN H, FRAMPTON A E, et al. Radio-frequency-assisted liver partition with portal vein ligation (RALPP) for liver regeneration [J]. *Ann Surg*, 2015, 261(2):e45-e46
- [45] GRINGERI E, BOETTOR, D'AMICO F E, et al. Laparoscopic microwave ablation and portal vein ligation for staged hepatectomy (LAPS): a minimally invasive first-step approach [J]. *Ann Surg*, 2015, 261(2):e42-e43
- [46] LÓPEZ-LÓPEZ V, ROBLES-CAMPOS R, BRUSADIN R, et al. Tourniquet-ALPPS is a promising treatment for very large hepatocellular carcinoma and intrahepatic cholangiocarcinoma [J]. *Oncotarget*, 2018, 9(46):28267-28280
- [47] CAI X, TONG Y, YU H, et al. The ALPPS in the treatment of hepatitis B-related hepatocellular carcinoma with cirrhosis: a single-center study and literature review [J]. *Surg Innov*, 2017, 24(4):358-364
- [48] SERENARI M, RATTI F, ZANELLO M, et al. Minimally-invasive stage 1 to protect against the risk of liver failure: results from the hepatocellular carcinoma series of the associating liver partition and portal vein ligation for staged hepatectomy Italian registry [J]. *J Laparoendosc Adv Surg Tech A*, 2020, 30(10):1082-1089
- [49] MICHAL K, SAU M, TAMARA G M H, et al. A better route to ALPPS: minimally invasive vs. open ALPPS [J]. *Surg Endosc*, 2020, 34(6):2379-2389
- [50] VICENTE E, QUIJANO Y, IELPO B, et al. First ALPPS procedure using a total robotic approach [J]. *Surg Oncol*, 2016, 25(4):457

[收稿日期] 2021-11-07

(本文编辑:陈汐敏)