Review Article

Modifications of ALPPS – from complex to more complex or from complex to less complex operations

Wan Yee Lau and Eric CH Lai

Hong Kong, China

BACKGROUND: **Associating liver partition and portal vein ligation for staged hepatectomy (ALPPS) has recently been developed to induce rapid liver hypertrophy to reduce the chance of post-hepatectomy liver failure in patients with borderline or insufficient future liver remnant. ALPPS is still in an early developmental stage and its techniques have not been standardized. This study aimed to review the technical modifications of the conventional ALPPS procedure.**

DATA SOURCES: **Studies were identified by searching MEDLINE and PubMed for articles published from January 2007 to December 2016 using the keywords "associating liver partition and portal vein ligation for staged hepatectomy" and "ALPPS". Additional articles were identified by a manual search of references from key articles.**

RESULTS: **There have been a lot of modifications of the conventional ALPPS. These are classified as: (1) modifications aiming to improve surgical results; (2) modifications aiming to expand surgical indications; (3) salvage ALPPS; (4) ALPPS using the minimally invasive approach. Some of these modifications have made the conventional ALPPS procedure to become even more complex, although there have also been other attempts to make the procedure less complex. The results of most of these modifications have been reported in small case series or case reports. We need better well-designed studies to establish the true roles of these modifications. However, it is interesting to see how this conventional ALPPS procedure has evolved since its introduction.**

CONCLUSIONS: **There is a trend for the use of minimally invasive procedure in the phase 1 or 2 of the conventional ALPPS procedure. Some of these modifications have expanded the use of ALPPS in patients who have been considered to have unresectable liver tumors. The long-term oncological outcomes of these modifications are still unknown.**

(***Hepatobiliary Pancreat Dis Int 2017;16:346-352***)

KEY WORDS: **associating liver partition and portal vein ligation for stage hepatectomy;**
hepatocellular carcinoma;
hepatectomy;
liver metastasis;
portal vein embolization

Introduction

Associating liver partition and portal vein ligation for staged hepatectomy (ALPPS) is a new strategy which has been developed to induce accelerated hypertrophy of future liver remnant (FLR) in order to increase resectability of liver tumors and reduce the risk of postoperative liver failure. Since its introduction, many surgeons around the world have rapidly adopted ALPPS as it has the advantages of inducing rapid liver hypertrophy of 47% to 100% over a median of 6 to 16 days, and 95% to 100% completion of tumor resection rate for the 2-staged operation.[1-20] Even in patients with chronic liver diseases, severe steatosis, liver fibrosis or cirrhosis, liver hypertrophy rates, although less predictable, have been reported to vary from 18.7% to 100% over a median of 7 days.[21-27] The main criticisms of ALPPS are its high morbidity and mortality rates. The morbidity rates after ALPPS have been reported to be 15.3% to 100% with ≥Clavien-Dindo Grade II being 13.6% to 44%, and the reported mortality rates ranged from 0 to 29%.[1-20] Thus ALPPS is not accepted by some surgeons who believe portal vein embolization or portal vein ligation to be much safer than ALPPS. Because of the longer time

Author Affiliations: Faculty of Medicine, The Chinese University of Hong Kong, Shatin, New Territories, Hong Kong SAR, China (Lau WY and Lai ECH); Department of Surgery, Pamela Youde Nethersole Eastern Hospital, Hong Kong SAR, China (Lai ECH)

Corresponding Author: Professor Wan Yee Lau, MD, FRCS, FACS, FRACS (Hon), Professor of Surgery, Faculty of Medicine, The Chinese University of Hong Kong, Prince of Wales Hospital, Shatin, New Territories, Hong Kong SAR, China (Tel: +852-2632-2626; Fax: +852-2632-5459; Email: josephlau@cuhk.edu.hk)

doi: 10.1016/S1499-3872(17)60034-1
Published online June 30, 2017.

interval to wait for the FLR to hypertrophy adequately, the risk of drop out from completion of tumor resection is significantly lower in ALPPS, due to either tumor progression or insufficient hypertrophy of FLR.[28-32]

Since the introduction of the conventional ALPPS, surgeons have reported on various modifications of the procedure, aiming to decrease the perioperative morbidity and mortality rates, to improve postoperative long-term survival and to improve the completion of tumor resection of the ALPPS phase 2 operation. This article aimed to review the technical modifications of the conventional ALPPS procedure.

Methods

Studies were identified by searching MEDLINE and PubMed for articles published from January 2007 to December 2016 using the keywords "associating liver partition and portal vein ligation for staged hepatectomy" and "ALPPS". Additional articles were identified by a manual search of references from key articles. All articles on technical modifications of ALPPS were included in this review.

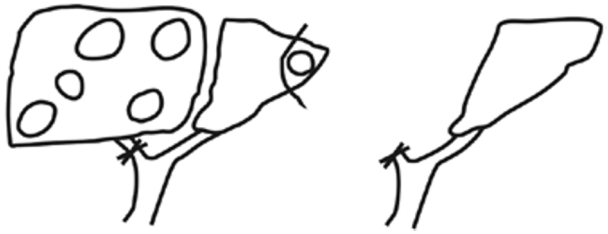
Results

Conventional ALPPS and its initial development

Professor Hans Schlitt from Regensburg, Germany first carried out this operation in 2007. He originally planned to carry out an extended right hepatectomy for a patient with hilar cholangiocarcinoma. During the operation, he found the FLR to be too small for the patient's survival after surgery. He then decided to carry out a biliary bypass. For optimal exposure and positioning of a jejunal loop for the left hepaticojejunostomy, he carried out an *in situ* split of the liver parenchyma on the right side of the falciform ligament. To induce liver hypertrophy of the liver segments 2 and 3, he ligated the right portal vein. Out of curiosity, he performed computed tomography (CT) on postoperative day 9 and found the left lateral section of the liver had adequately hypertrophied. He then carried out the originally planned extended right hepatectomy as a second staged operation. The patient recovered well from the operation. This novel approach was formally presented as a poster presentation on 3 such cases in the 9th European-African Hepato-Pancreato-Biliary Association Congress in Cape Town, South Africa, in 2011 by Dr. Hauke Lang from Mazin, Germany.[33] In the same year, de Santibañes and his colleagues from Argentina adopted this technique and reported their initial experiences on 3 patients.[34] Schlitt and his colleagues reported the technique which they called "right portal vein ligation combined with *in situ* splitting" on 25 patients.[1] Reports started to come from regions around the world with overwhelming enthusiasm. In 2012, de Santibañes and Clavien proposed the acronym for this procedure as associating liver partition and portal vein ligation for staged hepatectomy, or ALPPS in short.[35] Fig. 1 shows the diagrammatic representation of the conventional ALPPS procedure.

Modifications of the conventional ALPPS

Although ALPPS is still considered by many surgeons to be in an early developmental phase, and its indications and contraindications have not been well-defined, many technical modifications of the conventional ALPPS have been successfully carried out and reported. Unfortunately, almost all these reports are case reports or small case series which limit meaningful statistical comparison on treatment outcomes. Validation of success of these techniques are still lacking. Technical standardization of some of these modifications is needed before the effectiveness and safety of these modifications can be clarified. However, it is interesting to review the gradual changes in the technical modifications of the conventional ALPPS and the reasoning behind the modifications – a change from complex to more complex, and subsequently from complex to less complex operations using minimally invasive approaches.



First operation	Postoperative day 6 CT	Second operation on postoperative day 7
• Excise all tumors in left lateral section • Ligate right portal vein • Transect liver along right side of falciform ligament • Cholecystectomy • Operative cholangiogram through cystic duct • Surture any bile leak site • Introduce two abdominal drains	• After left lateral section hypertrophied	• Divide right hilar pedicle to carry out extended right hepatectomy

Fig. 1. Conventional ALPPS.