Review Article

Laparoscopic liver resections in two stages for the treatment of colorectal metastases: a review

Gabriele Spoletini, Salvatore Barbaro, Martina Fontana, Mohammed Abu Hilal

Department of Hepatobiliary and Pancreatic Surgery, University Hospital Southampton NHS Foundation Trust, Southampton, UK

Contributions: (I) Conception and design: G Spoletini, M Abu Hilal; (II) Administrative support: M Fontana; (III) Provision of study materials or patients: All authors; (IV) Collection and assembly of data: G Spoletini, S Barbaro; (V) Data analysis and interpretation: G Spoletini, M Abu Hilal; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Mohammed Abu Hilal. Department of Hepatobiliary and Pancreatic Surgery, University Hospital Southampton NHS Foundation Trust, Southampton, UK. Email: Mohammed.AbuHilal@uhs.nhs.uk.

Abstract: Recent progresses in minimally invasive surgery have made complex hepatobiliary operations possible with a laparoscopic approach. Classic two-stage hepatectomy (TSH) and more recently associating liver partition and portal vein ligation for staged hepatectomy (ALPPS) are getting reported more often as feasibility, safety and oncological efficiency have been demonstrated in selected cases. Herein we review the available literature in the field of laparoscopic liver resections in two stages with a focus on the management of colorectal liver metastases (CRLMs).

Keywords: Laparoscopy; two-stage; hepatectomy; associating liver partition and portal vein ligation for staged hepatectomy (ALPPS); liver metastases

Received: 21 December 2016; Accepted: 15 January 2017; Published: 15 April 2017.
doi: 10.21037/ales.2017.02.12
View this article at: http://dx.doi.org/10.21037/ales.2017.02.12

Introduction

Colorectal cancer is one the most common malignant disease, accounting for 1 million cases worldwide every year. Colorectal liver metastases (CRLMs) occur in 40–60% of patients and surgery represents the treatment of choice, resulting in a 5-year survival rate up to 58%. On presentation, only 20% of patients with bilobar CRMLs are resectable up front. This is due to the extent of the metastatic burden to the liver and the amount of parenchyma to be excised in order to achieve a curative resection (1). In order to prevent postoperative liver failure, it is routine practice to aim for a future remnant liver volume (FRLV) of more than 20–25% in patients with healthy livers, of more than 30% after chemotherapy, and more than 40% in chronic liver disease (2).

The two-stage hepatectomy (TSH) strategy was originally developed by Adam *et al*. to allow a curative surgical treatment in otherwise unresectable patients due to a predicted low FRLV. Such approach consists of a combination of a first operation that clears up the least diseased lobe, usually the left, and a second one that involves the contralateral lobe. Between the two stages, hypertrophy of the future remnant liver is induced by means of either portal vein ligation (PVL) applied during the first operation or portal vein embolization (PVE) performed percutaneously after the first stage (3,4). Despite rendering many patients operable, TSH still carries a risk of disease progression between the two stages, with a reported dropout rate ranging between 15% and 30% (5).

More recently, associating liver partition and portal vein ligation for staged hepatectomy (ALPPS) has been proposed as an alternative two-stage approach with the same intent of inducing hypertrophy of the FRLV. ALPPS was first introduced in 2012 by Schnitzbauer *et al*. and has now been performed in more than 700 patients (6). It consists of a first stage during which more often the left lobe clearance is performed in association with right PVL and in situ splitting along the right side of the falciform to induce a rapid hypertrophy of the FRLV, followed

by the second stage major resection after few days or weeks (7). Enthusiastic reports regarding faster growth kinetics of the FRLV have been mitigated by reported increase in morbidity and mortality associated with ALPPS in comparison to TSH (8).

Despite their aggressive nature, both types of such two-stage operations have been performed laparoscopically with different modifications to the classical first descriptions and in many cases a first laparoscopic stage was followed by an open second stage.

This article aims to review the current literature about laparoscopic TSH and ALPPS.

Laparoscopic two-stage hepatectomy

The first case of a pure laparoscopic two-stage hepatectomy was reported by our group in 2010. The patient had two metachronous CRLMs, one in the left lateral section and a larger one in the centre of the right hemiliver, 2 years following a laparoscopic anterior resection of the rectum. A left lateral sectionectomy was performed as a first stage procedure, followed by a right-sided percutaneous PVE a week later. The patient eventually underwent a laparoscopic right hemihepatectomy 6 weeks after compensatory hypertrophy was achieved (9).

In the same year, Machado *et al*. reported the case of a patient with synchronous liver metastases with a small left hemiliver. The first stage consisted of a laparoscopic segment 3 resection and right sided PVL. After 4 weeks, 43% FRLV was obtained and a laparoscopic right hemihepatectomy was performed (10).

Prior to the described pure laparoscopic cases, Are *et al*. described the feasibility and safety of laparoscopic right PVL in a population of 9 patients (out of whom 5 with CRLMs) in 2008. Three patients also had wedge resections of left-sided metastatic deposits. Neither mortality nor morbidity related to PVL was registered. Only five patients could progress to an open second stage major hepatectomy whilst the other four experienced disease progression, which precluded further resection (11).

Similarly, in a case series of 6 patients in Manchester, laparoscopic right PVL was applied at the time of staging laparoscopy in patients requiring a right hepatic trisectionectomy in the presence of a small FLR and as part of a staged liver resection in patients with bilobar liver disease sparing segments 1 and 4 (12).

Our group described the first series of 7 patients undergoing laparoscopic TSH in 2012, highlighting a clear benefit in terms of minimal adhesions encountered at the time of the second stage. All patients had left-sided liver resections and 2 had right PVL during the first stage. A right hepatectomy was performed laparoscopically (one required conversion) in three patients for the second stage while the remaining were carried out with an open approach (13).

Kilburn *et al*. reported a series of 7 patients who underwent a laparoscopic first stage followed by an open second stage, thus reinforcing the concept of safety and feasibility when utilizing a minimally invasive approach in patients who are expected to receive multiple procedures (14).

In 2015, Fuks *et al*. published the largest series of laparoscopic TSH so far. Thirty four patients were planned for TSH. All patients underwent a laparoscopic first stage (five with concomitant PVL) and 26 progressed successfully to a laparoscopic second-stage, including 18 laparoscopic right or extended right hepatectomies. The reported low conversion rate, small amount of blood loss and limited morbidity, suggest that this complex surgery is feasible and safe using the laparoscopic approach. In addition, the oncological efficiency of laparoscopic TSH has been confirmed by the low incidence of R1 resections. The authors recognise that this kind of surgery is of the highest complexity and should be considered only in centres with advanced expertise in hepatobiliary "open" and laparoscopic surgery (15).

Laparoscopic ALPPS

The first totally laparoscopic ALPPS was reported in 2012 by Machado *et al*. During the second stage, the authors were favourably impressed by the small amount of adhesions and completion of surgery was easily done (16). Again, after a seminal experience with two laparoscopic ALPPS procedures and more than 20 performed in open settings, the same group from Sao Paulo, Brazil, started to offer ALPPS laparoscopically as their standard practice. Comparing 10 laparoscopic ALPPS (out of which 9 for CRLMs) with those 20 done through laparotomy, they registered less severe complications and no postoperative liver failure in the laparoscopic group despite achieving a lower grade of hypertrophy in the FRLV. Despite the intrinsic selection bias of the study, the authors argued that minimising surgical related invasiveness might contribute to lower morbidity associated in particular with the first stage (17). The group also emphasised on the advantage

encountered during the second stage after they stopped mobilising the right hemiliver during the first stage. On a later report they introduced a technique of selective arterial clamping to replace Pringle manoeuvre. Common hepatic artery clamping was found to reduce blood loss by antagonising the compensatory arterial overflow that follows the deprivation of portal flow to one liver lobe (18). Several modifications to the original description of ALPPS have been proposed with the intent to overpass issues related to the increased rates of bile leak, surgical trauma and different indications for ALPPS other than CRLMs (19-21).

The use of ablative techniques in a laparoscopic setting for simplifying the first stage ALPPS in patients with CRLMs has also been described. Cillo *et al*., after ligating the right portal branch, applied ultrasound-guided microwave ablation with multiple antenna insertions within the future liver transection plane on the right side of the falciform ligament in order to create an avascular groove between the cancer and the FLR; during the second stage, a laparoscopic right trisectionectomy was carried out along a bloodless transection line with both scissors and an ultrasound dissector. No Pringle manoeuvre was necessary (22). Based on the same principle, Jiao *et al*. described the first totally laparoscopic radiofrequency assisted liver partition with portal vein ligation (RALPP) after having authored and gained experience with such technique in a series of 11 cases done with a first laparoscopic stage followed by an "open" second stage (23,24).

Robotic ALPPS has been shown in a video case report by Vicente *et al*. and remains the first published of its kind in the literature so far (25).

Discussion

Laproscopic liver surgery (LLS) has been expanding in the last 20 years. Initial reports have confirmed its feasibility, safety and oncological efficiency in minor and major hepatectomies, although many expected that different factors such as liver lesions of large size, close to major vessels, located within the less accessible posterior segments and finally an unfavourable distribution of lesions could have limited further expansion of LLS. Our team, within other enthusiastic laparoscopic units, have already reported excellent results in this field for almost all of the abovementioned potential obstacles (26-28).

Two stage liver resections represent a relevant turnaround in the history of the treatment of CRLMs. Nevertheless, TSHs are associated with major technical difficulties, which can be augmented with a laparoscopic approach. Thus, reports of laparoscopic TSH are still scarce and often only the first of the two stages is carried out laparoscopically (29). The much desired hypertrophy of the remnant liver can be associated with serious anatomical distortion making the intraoperative findings difficult to interpreter. In addition, hilar adhesions caused by the PVL or the periportal fibrosis encountered after the portal vein embolization can add a significant challenge to the hilar dissection during the second stage (30).

With ALPPS, the interval between the two stages is shorter and the adhesions are reported to be more inflammatory and less fibrous comparing to TSH (31). Nevertheless, almost all authors highlighted the benefit of less adhesions and blood loss with laparoscopic surgery in both TSH and ALPPS, consistently with the widely accepted benefits of laparoscopy, such as minor parietal incisions, fewer foreign bodies, reduced and gentler manipulation of tissues, and a close and humid environment with pneumoperitoneum (32).

Despite the help from finer instrumentation in the last decade, laparoscopic major liver surgery remains a technically challenging field of action. The use of robotic assistance has been advocated to help overcoming technical barriers and to promote more widespread application of a minimally invasive approach in TSH and ALPPS (33). As yet, case series with robotic ALPPS are lacking. Laparoscopic TSH and ALPPS are gaining acceptance and enthusiastic reports continue to emerge. Notably, such literature is produced by centres with great expertise in both advanced laparoscopic and hepato-biliary surgery.

In conclusion, laparoscopic liver resections in two stages for the treatment of colorectal metastases are technically feasible in selected cases, without compromising oncologic principles. However advanced experience in open and laparoscopic liver surgery is needed for a safe completion of such procedures.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editor (Giovanni Battista Levi Sandri) for

the series "Laparoscopic Liver Surgery" published in *Annals of Laparoscopic and Endoscopic Surgery*. The article has undergone external peer review.

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/ales.2017.02.12). The series "Laparoscopic Liver Surgery" was commissioned by the editorial office without any funding or sponsorship. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Postriganova N, Kazaryan AM, Røsok BI, et al. Margin status after laparoscopic resection of colorectal liver metastases: does a narrow resection margin have an influence on survival and local recurrence? HPB 2014;16:822-9.
2. Gruttadauria S, Vasta F, Minervini MI, et al. Significance of the effective remnant liver volume in major hepatectomies. Am Surg 2005;71:235-40.
3. Adam R, Laurent A, Azoulay D, et al. Two-stage hepatectomy: A planned strategy to treat irresectable liver tumors. Ann Surg 2000;232:777-85.
4. Jaeck D, Oussoultzoglou E, Rosso E, et al. A two-stage hepatectomy procedure combined with portal vein embolization to achieve curative resection for initially unresectable multiple and bilobar colorectal liver metastases. Ann Surg 2004;240:1037-49; discussion 1049-51.
5. Wicherts DA, Miller R, de Haas RJ, et al. Long-term results of two-stage hepatectomy for irresectable colorectal cancer liver metastases. Ann Surg 2008;248:994-1005.
6. Enrolment Status | ALPPS [Internet]. Cited 2016 Dec 10. Available online: http://www.alpps.net/?q=registry
7. Schnitzbauer AA, Lang SA, 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. Ann Surg 2012;255:405-14.
8. Li J, Ewald F, Gulati A, et al. Associating liver partition and portal vein ligation for staged hepatectomy: From technical evolution to oncological benefit. World J Gastrointest Surg 2016;8:124-33.
9. Jain G, Parmar J, Mohammed MM, et al. "Stretching the limits of laparoscopic surgery": two-stage laparoscopic liver resection. J Laparoendosc Adv Surg Tech A 2010;20:51-4.
10. Machado MA, Makdissi FF, Surjan RC, et al. Two-stage laparoscopic liver resection for bilateral colorectal liver metastasis. Surg Endosc 2010;24:2044-7.
11. Are C, Iacovitti S, Prete F, et al. Feasibility of laparoscopic portal vein ligation prior to major hepatectomy. HPB 2008;10:229-33.
12. Ayiomamitis GD, Low JK, Alkari B, et al. Role of laparoscopic right portal vein ligation in planning staged or major liver resection. J Laparoendosc Adv Surg Tech A 2009;19:409-13.
13. Di Fabio F, Whistance R, Rahman S, et al. Exploring the role of laparoscopic surgery in two-stage hepatectomy for bilobar colorectal liver metastases. J Laparoendosc Adv Surg Tech A 2012;22:647-50.
14. Kilburn DJ, Chiow AK, Lewin J, et al. Laparoscopic approach to a planned two-stage hepatectomy for bilobar colorectal liver metastases. ANZ J Surg 2016;86:811-5.
15. Fuks D, Nomi T, Ogiso S, et al. Laparoscopic two-stage hepatectomy for bilobar colorectal liver metastases. Br J Surg 2015;102:1684-90.
16. Machado MA, Makdissi FF, Surjan RC. Totally laparoscopic ALPPS is feasible and may be worthwhile. Ann Surg 2012;256:e13; author reply e16-9.
17. Machado MA, Makdissi FF, Surjan RC, et al. Transition from open to laparoscopic ALPPS for patients with very small FLR: the initial experience. HPB (Oxford) 2017;19:59-66.
18. Surjan RC, Makdissi FF, Basseres T, et al. First totally laparoscopic ALPPS procedure with selective hepatic artery clamping: Case report of a new technique. Medicine (Baltimore) 2016;95:e4236.
19. Boggi U, Napoli N, Kauffmann EF, et al. Laparoscopic Microwave Liver Ablation and Portal Vein Ligation: An Alternative Approach to the Conventional ALPPS Procedure in Hilar Cholangiocarcinoma. Ann Surg Oncol

2016;23:884.
20. Zhang Y, Yang H, Chen Y, et al. Totally Laparoscopic Associating Liver Tourniquet and Portal Ligation for Staged Hepatectomy via Anterior Approach for Cirrhotic Hepatocellular Carcinoma. J Am Coll Surg 2015;221:e43-8.
21. Cai X, Peng S, Duan L, et al. Completely laparoscopic ALPPS using round-the-liver ligation to replace parenchymal transection for a patient with multiple right liver cancers complicated with liver cirrhosis. J Laparoendosc Adv Surg Tech A 2014;24:883-6.
22. Cillo U, Gringeri E, Feltracco P, et al. Totally Laparoscopic Microwave Ablation and Portal Vein Ligation for Staged Hepatectomy : A New Minimally Invasive Two-Stage Hepatectomy. Ann Surg Oncol 2015;22:2787-8.
23. Jiao LR, Hakim DN, Gall TM, et al. A totally laparoscopic associating liver partition and portal vein ligation for staged hepatectomy assisted with radiofrequency (radiofrequency assisted liver partition with portal vein ligation) for staged liver resection. Hepatobiliary Surg Nutr 2016;5:382-7.
24. Gall TM, Sodergren MH, Frampton AE, et al. Radio-frequency-assisted Liver Partition with Portal vein ligation (RALPP) for liver regeneration. Ann Surg 2015;261:e45-6.
25. Vicente E, Quijano Y, Ielpo B, et al. First ALPPS procedure using a total robotic approach. Surg Oncol 2016;25:457.
26. Cipriani F, Rawashdeh M, Ahmed M, et al. Oncological outcomes of laparoscopic surgery of liver metastases: a single-centre experience. Updates Surg 2015;67:185-91.
27. Cipriani F, Rawashdeh M, Stanton L, et al. Propensity score-based analysis of outcomes of laparoscopic versus open liver resection for colorectal metastases. Br J Surg 2016;103:1504-12.
28. van der Poel MJ, Besselink MG, Cipriani F, et al. Outcome and Learning Curve in 159 Consecutive Patients Undergoing Total Laparoscopic Hemihepatectomy. JAMA Surg 2016;151:923-8.
29. Levi Sandri GB, Colace L, Vennarecci G, et al. Laparoscopic first step approach in the two stage hepatectomy. Hepatobiliary Surg Nutr 2015;4:345-7.
30. Shelat VG, Serin K, Samim M, et al. Outcomes of repeat laparoscopic liver resection compared to the primary resection. World J Surg 2014;38:3175-80.
31. Brustia R, Scatton O, Perdigao F, et al. Vessel identifications tags for open or laparoscopic associating liver partition and portal vein ligation for staged hepatectomy. J Am Coll Surg 2013;217:e51-5.
32. Gutt CN, Oniu T, Schemmer P, et al. Fewer adhesions induced by laparoscopic surgery? Surg Endosc 2004;18:898-906.
33. Levi Sandri GB, Guerra F. Are We Ready to Perform Fully Minimally Invasive ALPPS? Ann Surg 2015. [Epub ahead of print].

doi: 10.21037/ales.2017.02.12
Cite this article as: Spoletini G, Barbaro S, Fontana M, Abu Hilal M. Laparoscopic liver resections in two stages for the treatment of colorectal metastases: a review. Ann Laparosc Endosc Surg 2017;2:70.

