The Use of Endo-GIA Vascular Staplers in Liver Surgery and Their Potential Benefit: A Review

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Key Words

Liver resection • Stapler hepatectomy, technique • Stapler • Parenchymal transection

Abstract

Stapling devices have been introduced for safety and to reduce the overall operative time in many surgical procedures. In hepatobiliary surgery, i.e. liver resection, several types of staplers are in use. While transection of hepatic vessels with vascular staplers is well established, their use in dissecting hepatic parenchyma has only been assessed recently. Its advantages were especially a low rate of biliary complications (i.e., bile fistulas, bilioma) and reduced bleeding. As expected, the operative time was decreased dramatically while both the complication rate in general and the overall costs for stapler hepatectomy were comparable with other techniques used in high-volume centers. Thus, endo-GIA vascular staplers can be safely used to dissect the hepatic parenchyma in a routine clinical setting with low incidence of surgical complications.

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Introduction

Early milestones in the history of hepatobiliary surgery include the first successful elective liver resection, which was performed in 1888 [1], and a report of a true

anatomical right hepatectomy for cancer in 1952 [2]. However, the subsequent experience with hepatic resections was far from encouraging and it was not until the last 20 years that hepatic resections have been routinely performed.

Since surgical technique is a major factor to prevent complications, various methods and instruments have been developed for safe tissue-preserving dissection of the liver parenchyma. The blunt dissection has been widely replaced by various time-consuming methods, such as the Cavitron Ultrasonic Surgical Aspirator® (CUSA) technique and the jet cutter for major liver resections. These methods represent selective dissection techniques, whereas non-selective methods include the scalpel, scissors, high-frequency coagulation and the laser technique [3, 4]. The introduction of these surgical instruments has permitted large, non-anatomical wedge resections and liver resections to be performed with improved operative morbidity and mortality rates typically being less than 30 and 5%, respectively, in high-volume centers [5–11]. Despite tremendous improvements in both surgical technique and perioperative patient management (especially for hemorrhage, bile leakage, hematoma, infections and postoperative liver function, all associated with high morbidity and mortality), there are still major concerns after liver resection which require a high level of training leaving it still a demanding surgical procedure. Today, staplers have become a vital instrument in the practice of many surgical specialties. Rectal,

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Fig. 1. Division of the right hepatic vein. The liver is mobilized and freed from its ligaments. The right liver lobe is moved to the left upper quadrant of the abdomen. Subsequently, the right hepatic vein is encircled with a white rubber band and exposed for division with an endo-GIA vascular stapler. The right hepatic vein is located between both branches of the stapler to be divided. A typical situation during closure of the right hepatic vein for right hemihepatectomy is depicted.

Fig. 2. Instruments for stapler hepatectomy. **a** Clamp developed for fraction of the hepatic parenchyma. **b** Endo-GIA vascular stapler which can be used for stapler hepatectomy.

colonic, and esophageal anastomotic instruments allow safe and rapid anastomosis of the gastrointestinal tract, even when surgical exposure is compromised. Vascular staplers have increased the speed and safety of lobar resections of the lung [12, 13]. Recent publications observing a number of techniques using stapling devices in liver surgery showed it to be extraordinarily helpful in the safe ligation of inflow and outflow vessels [3, 4, 14–19].

Using staplers in unroofing hepatic cysts seems to be of benefit, as any unexpectedly injured bile duct or blood vessel is so sealed [16]. With the above-mentioned motive, left lateral segmentectomies [17, 19] and wedge resections [20] are conducted with staplers; serving as another non-selective dissection method. Admittedly, their general routine use for transection of liver parenchyma during liver resection has not been reliably proven pertinent and most of the literature to date gives only anecdotal evidence [19–21].

Surgical Technique of Stapler Hepatectomy

The technique referred to was introduced almost 5 years ago to our Department after L.H. Blumgart, N.Y., USA had demonstrated this procedure to the senior author of this review.

A reversed L-shaped incision from the xiphoid to the tip of the twelfth right rib or a standard transverse abdominal incision (with or without extension in the midline to the xiphoid) is mostly made use of. Following an incipient abdominal exploration in search of extrahepatic disease, the falciform triangular ligament is then mobilized, thereafter dissection is conducted, exposing the hepatic veins and the porta hepatis. To enable the complete liver mobilization the short hepatic and caudate veins from the inferior vena cava (IVC) are clipped or ligated. In performing hemihepatectomy or extended hemihepatectomy, the adequate hepatic arterial branch is divided between ligation with sutures followed by division of the portal venous branch with the vascular stapler or via suture. Subsequently, the appropriate hepatic vein(s) are divided with the endo-GIA vascular stapler (fig. 1). The transectional line is then made afterwards and the liver capsule then divided with diathermy. To allow subsequent dissection of the hepatic parenchyma, the liver tissue was fractured stepwise with a clamp (fig. 2a, b, 3a) and subsequently divided with endo-GIA vascular staplers (fig. 2b, 3b). Where the necessity was given, intraoperative ultrasound was used to guide the dissection. Following the resection procedure, argon beam coagula-

Fig. 3. Surgical steps for parenchymal transection during stapler hepatectomy. **a** After marking the transectional line, the liver capsule was divided with diathermy. For subsequent dissection of the hepatic parenchyma the liver tissue was fractured stepwise with a clamp as shown in figure 2a. **b** Crushed dissectional line with introduced stapler. **c** Subsequently, transection and division of the hepatic parenchyma can be performed stepwise with endo-GIA vascular staplers. **d** Resection (right hemihepatectomy is shown) has been completed. The dissectional plane usually does not show major oozing or leakage of bilious fluid.

tion was applied to abort minor oozing. After securing hemostasis (fig. 3d), easy-flow drains were placed in the subphrenic and subhepatic space. Using this technique of liver resection there was no need to perform Pringle's maneuver or other vascular control in 90% of all patients, as reported elsewhere [22].

Discussion

Major liver resection remains one of the more technically challenging operations. Subtle nuances in surgical technique can make a substantial difference in patient outcome. Control of operative blood loss is one of the most immediate concerns when performing liver resection. There is solid evidence of the derogatory impact of exceeding hemorrhage and blood transfusion in patients

Fig. 4. Cost analysis in euros (EUR). For stapler hepatectomy the intraoperative costs including surgery, anesthesiology, blood products and the average number of endo-GIA vascular staplers (Tyco 030412, 60 cm; Tyco 030403, handset) used added up to EUR 5,197, reflecting the intraoperative costs influenced by the resection technique. The median hospital stay (EUR 4,928) and ICU stay (EUR 1,257) add up to a total of EUR 11,382. On average, when comparing both methods, there was a cost-benefit of more than EUR 2,400 in favor of stapler hepatectomy in this analysis.

who undergo liver resection. Excessive blood loss goes along with increased perioperative morbidity and in case of colorectal metastases, a shorter disease-free interval [23, 24].

Since the late 1970s, when operative mortality was 13% and more than 20% for major resections, with 20% of deaths resulting from intraoperative bleeding [25], much effort has been done to especially reduce intraoperative bleeding with both occlusion of the hepatic inflow and total vascular occlusion introduced by Bismuth et al. [26] and Huguet et al. [27] followed by others [28–30].

The employment of vascular staplers to divide hepatic veins (fig. 1) [17] and portal branches during hemihepatectomy since the 1990s is viewed as an accomplishment that has assisted in averting blood loss and hence tapering the requirement of inflow occlusion [3, 4, 14–19]. Furthermore, left lateral segmentectomies and wedge resections performed with stapler also showed favorable results [17, 19, 20]. The same results can be obtained with laparoscopy and stapler for unroofing of hepatic cysts since any inadvertently injured bile duct or blood vessel is sealed. Stapling devices can be especially useful in patients with coagulopathy and in the treatment of complex liver abscesses [14–16, 19, 31]. However, it was only most recently that a large series of staplers being used for the phase of parenchymal transection for liver resection was published. A series of 300 patients who underwent stapler hepatectomy was documented prospectively to elucidate whether this technique for parenchymal dissection is applicable in a routine clinical setting. Both its feasibility and safety with its associated surgical risk factors for the development of postoperative complications were assessed [22].

Based on the results of the described study, it was concluded that parenchymal transection with endo-GIA

vascular staplers is a feasible and safe technique for liver resection with mortality (4%) and morbidity (33%) as low as in recently published large series of non-selected patients who underwent liver resection in other high-volume centers [5, 32–34]. In contrast to other series [5, 32, 33], only 10% of patients underwent the Pringle maneuver and no other vascular control was applied during resection. This is indeed astonishing since a median blood loss of only 700 ml (major resection: 800 ml, minor resection: 500 ml) during stapler hepatectomy was recorded. In antagonism to this, Jarnagin et al. reported of a moderate blood loss of 600 ml; nevertheless, ≥ 3 segments resection which confers to major hepatectomy in their investigations led to a blood loss of more than 1,000 ml, which in turn contrasts to 800 ml observed in the cases of stapler hepatectomy [5, 22]. Moreover, a median blood loss between 1,000 and 1,325 ml is reported in a series including $\geq 70\%$ cases of hepatic vascular exclusion-aided major hepatectomy [35]. Analogous values were published for blood loss during liver resection with portal triad clamping or extrahepatic control of the hepatic veins [28, 34]. This led to the transfusion of blood products in up to 50% of the cases [28, 34]. More recently, 750 ml was reported as the median intraoperative blood loss and about 17% of patients in this study report required transfusion. However, 27% of their patients underwent the Pringle maneuver during liver resection which is in contrast to stapler hepatectomy [22, 33]. With inflow and outflow control before dissection of liver parenchyma, a more substantial reduction of the intraoperative blood loss can be attained. The fact that hepatic vascular exclusion associates with unpredictable hemodynamic intolerance, increased postoperative complications which results in longer hospital stay its application should be restricted to lesions involving the cavo-hepatic intersection

[28]. Moreover, the extended Pringle maneuver may lead to complications due to ischemic injury of the remnant liver and abdominal visceral venous stagnation [36]. Following stapler hepatectomy there was no need for RBCs and FFPs transfusion in 84 and 89% of cases. For patients requiring transfusion, a median of 3 units RBC and 4 units FFP were endowed [22].

One of the major obstacles after liver resection is biliary leakage and bilioma with a persistently high incidence. After stapler hepatectomy, bile leak or bilioma was recorded in only 8% of cases [22] which can rarely be achieved with conventional resection techniques [37]. The innovative advantage of using staplers is that they are generally very fast, in contrast to CUSA. If this is confirmed in a randomized prospective clinical trial, this would present significant advantages for both the patient and the surgeon.

Treatment costs become more and more a focus in clinical medicine, thus novel methods need to be evaluated not only for patient's safety but also for their cost-effectiveness. For stapler hepatectomy the most recently performed evaluation of the intraoperative costs (including surgery, anesthesiology, blood products and the average number of endo-GIA vascular staplers (Tyco 030412,

60 cm; Tyco 030403, handset)), the median hospital stay and ICU stay added up to a total of EUR 11,382. Most interestingly, there was a cost-benefit when comparing stapler and conventional methods of more than EUR 2,400 in favor of stapler hepatectomy (fig. 4) [22].

Clinical Implications

Employing endo-GIA vascular staplers for transection of liver tissue is auspicious; taking into account the data recently published [22], stapler hepatectomy may prove to be an expedient, broadly applied and safe method for the parenchymal phase of liver resection with a morbidity and mortality which may match up to that of conventional resection techniques utilized by other high-volume centers [5–11]. Stapler hepatectomy, being both an efficient and reliable surgical procedure, calls for the necessity of controlled clinical trials so as to further investigate and improve this liver resection technique.

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