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REVIEW ARTICLE

Liver transection using vascular stapler: a review

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Abstract
The clinical experience using a novel technique of liver resection with vascular staplers for dissection of hepatic parenchyma, was documented most recently in a prospective manner. These data have clearly demonstrated for the first time that stapler hepatectomy is a safe and fast dissection technique in major liver surgery (e.g. hepatectomy) which is feasible in a routine clinical setting.

Key Words: *liver resection, parenchymal transection, stapler hepatectomy, liver resection technique, endo vascular stapler*

Introduction

Improvements in surgery very often depend on technical novelties. The introduction of stapling devices has been one of the most important improvements in surgery of the last decades and had a great impact on many different aspects. Today, staplers have become widely accepted for many types of open and laparoscopic procedures [1–6]. They provide fast and reliable sutures, thus saving time, decreasing blood-loss and increasing security. Resection of liver parenchyma is one of the most common procedures in hepatobiliary surgery [7,8]. One of the most important steps of this type of operation is the transection of the liver parenchyma. Since intraoperative hemorrhage is one of the main contributors to morbidity and mortality, the Pringle maneuver (PM) is still used quite frequently [9]. While liver resection should be radical enough to safely resect tumors the procedure should be performed in a tissue preserving manner. The additional demands of modern hepatic surgery are to omit PM or vascular control in general [10,11] and thus to decrease warm ischemia/reperfusion injury of the remnant liver [11–16]. New techniques for liver resection aim to not only being radical enough to offer curative treatment to underlying diseases while adequate functional tissue is left, but also to prevent any injury to remnant liver while there is minimal blood loss [11,14–17]. Therefore, optimal techniques aim to minimize bleeding and prevent ischemia/reperfusion injury to the liver by avoidance of methods of vascular control [13,18–20]. In about 80% of stapler hepatectomies, methods of vascular control are not needed, as reported elsewhere [21]. Only in few cases PM or other methods of blood inflow control are applied based on the surgeon's personal judgement.

For resection of liver parenchyma, various methods have been established over the past few years. Ultrasound dissection, microwave tissue coagulation and transection using water jets are among the improvements for liver resection that surgeons can choose from [7,22–27]. Further, the development of modern methods of coagulation, e.g. argon beam and electrocoagulation, offer fast and reliable techniques for prevention of seepage and have revolutionized hepatic surgery [28].

Today, vascular staplers have become an accepted tool in liver surgery. They are routinely used for dissection of hepatic vessels [29–31]. More than fifteen years ago, hepatic wedge resection with various types of stapling devices has been tried, but publications on this are limited [32]. In the 1990s, an operative procedure was developed that allows transection of liver parenchyma with staplers [33]. This has been introduced to the head of our institution by Leslie H. Blumgardt, Sloan Kettering Memorial

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Cancer Center, New York, NY, USA. Since October 2001 it has become the standard technique for liver resection in our department. Depending on the surgeons choice, more than 70% of all major hepatectomies have been performed as stapler hepatectomy over the last six years in our department [21]. Until now, we have performed more than 550 staplerhepatectomies with great success. The first 300 stapler hepatectomies underwent a critical prospective analysis [21,34]. Here we review our first experiences with endo-GIA vascular staplers for parenchymal transection during liver resection [21].

Stapler hepatectomy

The stapler can be assembled quite easily. After the staple cartridge is attached to a lengthy shaft the stapler is ready to use. It can be rotated freely, thus allowing easy handling and exact placement of the device (Figure 1). When the device is fired, two triple suture lines are performed simultaneously. Division of tissue is performed between these triple lines and vessels are securely closed.

Hepatectomies are performed in our department with the above described stapler, which has been approved for this indication in the USA (FDA 510(k) number K061095), based on a highly standardized protocol in patients with both benign and malign liver disease as described elsewhere [21]. Briefly, after opening the abdominal wall using a reversed L-shaped incision and exploration of the abdominal cavity, the liver is mobilized. Short hepatic veins and caudate veins from the inferior vena cava are clipped. If a hemihepatectomy is performed, the corresponding pedicle with portal vein, artery and bile duct and the corresponding hepatic vein are separated using linear vascular staplers. The appropriate hepatic artery is clipped additionally. After demarcation of the transectional line, a straight clamp is used for fracturing of hepatic parenchyma. Subsequently, this portion of liver is transected with a vascular stapler (Figure 2). The clamp and the stapler are used in an alternating manner until complete resection of the liver is achieved. During the liver resection a central venous pressure higher than 5 cm H_2O seems to be associated with an increased blood loss. Therefore, the central venous pressure should be as low as possible to reduce bleeding [35]. Besides mono and bipolar electrocoagulation, argon beam coagulation is used at the end of resection to achieve complete haemostasis.

Figure 1. Endo-GIA vascular stapler. Hepatectomies are performed in our department with endo-GIA vascular staplers. Picture depicts the compouds of the stapler.

Costs

For some authors, it is doubtful whether staplers, being expensive surgical tools, can be used cost effectively [36]. Undeniably, linear vascular staplers increase the total material costs significantly. Nonetheless, since stapler hepatectomy has been introduced to our department, it has become the technique of our choice and both, the total operative time and need for transfusions decreased, being main contributors to costs of liver resection [21,34]. Thus, mean costs for a hepatectomy decreased by 2.400, – € per case. For our analysis of costeffectiveness, material costs, costs for anaesthesia and surgery itself and costs of hospital and ICU stay were considered relevant [21,34].

Blood loss and the need for vascular control

In surgery, hemorrhage can be one of the most important intraoperative problems and also is considered to be an important determinant factor for postoperative outcome. Therefore, one of the modern surgery's aims is to prevent blood loss and to reduce patient morbidity [37]. With refinement of surgical techniques the overall need for PM and other methods of vascular inflow control in liver resections has decreased. Especially stapler hepatectomy offers some great advantages. Both the median intraoperative blood loss (major resection: 800 ml; minor resection 500 ml) and the median operative time (major resection: 240 min; minor resection: 155 min) with a median of only 7 minutes for the parenchymal phase are decreased compared with conventional techniques, while methods for vascular control (e.g. PM, total vascular exclusion (TVE) or intermittend TVE) are not needed in most cases, thus preventing damage to the remnant liver tissue due to ischemia/reperfusion injury [10,11]. One should also keep in mind that in many cases of hepatectomy steatotic or otherwise affected organs are being operated. These organs may have a shorter ischemia tolerance and therefore are more susceptible to ischemia/reperfusion injury [37]. Recent data suggests

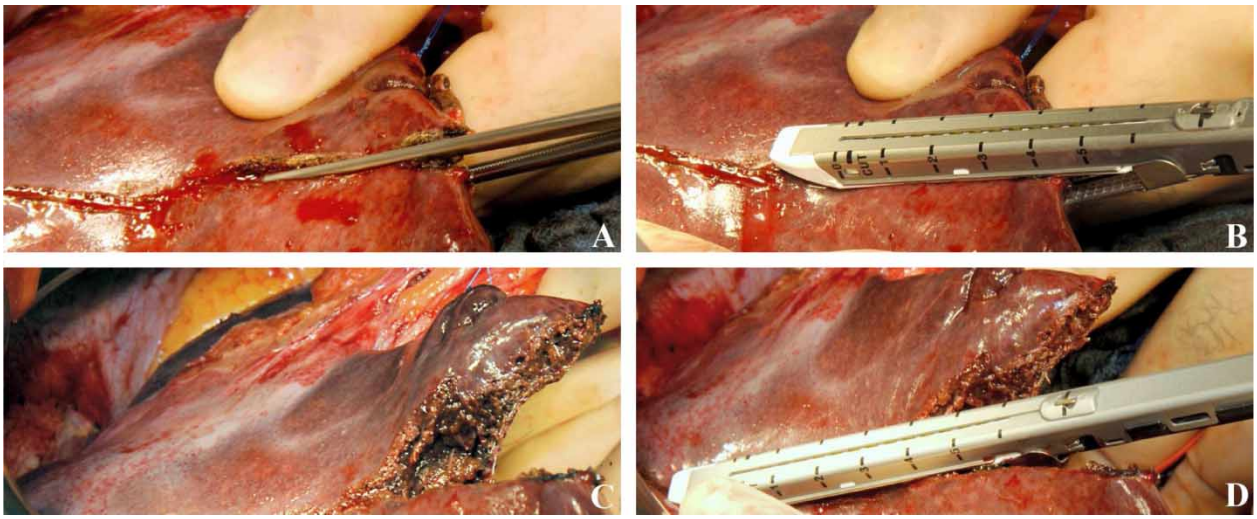

Figure 2. Stepwise transection of liver tissue for resection. (A) A straight clamp is used for fracturing of hepatic parenchyma. (B) Subsequently, this portion of liver is transected with a vascular stapler. (C) Vessels of the transectional plane are securely closed. (D) The clamp and the stapler are used in an alternating manner until complete resection of the liver is achieved.

that vascular control promotes growth of colorectal metastases [9,38], which are one of the main indications to liver parenchyma resection (approximately 37% in our institution). With modern techniques like stapler hepatectomy PM, TVE and intermittent TVE can no longer be considered to be state of the art and can no longer be employed with clean conscience as a routine [11].

Complications

Overall morbidity and mortality are at low levels comparable to other high-volume centers performing hepatectomies with conventional techniques [21,34,39]. In a recent article, we have published the risk and outcome analysis of the first 300 cases of stapler hepatectomy in our department [21]. Overall morbidity and mortality were 4.3 and 33%, respectively. Blood loss higher than 1.200 ml and total operative time greater than 180 min could be identified as main predictors to postoperative complications ($p < 0.01$). Concomitant extrahepatic resection or age did not correlate to increased morbidity.

Conclusion

Based on our recent publication, stapler hepatectomy can be used as a technique for both minor and major resection of liver parenchyma for malign and benign liver disease [21,29]. To our experience, the use of vascular linear staplers for the parenchymal phase of liver resection is a fast, safe and cost-effective surgical procedure. While overall morbidity and mortality rates are comparable to those of other high-volume centers using conventional standard resection techniques, vascular control is not needed as a standard, thus reducing potentially ischemia/reperfusion injury after liver resection.

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