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ORIGINAL ARTICLE

Comparative analysis of learning curve in complex robot-assisted and laparoscopic liver resection

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Abstract

Background: There is no comparative analysis of the learning curves for robot-assisted and laparoscopic liver resection. We aimed to compare learning curves in complex robotic and conventional laparoscopic liver resections with regards to estimation of the difficulty index score.

Methods: The results of 131 consecutive liver resections were analyzed retrospectively (40 robot-assisted and 91 laparoscopic). The learning curve evaluation was based on calculation of procedures number before significant change of the difficulty index for minimally invasive liver resection or the rate of posterosuperior segments resection. Groups of early and late experience were compared in every type of approach (robot-assisted and laparoscopic).

Results: Significant increase of difficulty index (from 5.0 [3.0–7.7] to 7.3 [4.3–10.2]) of robotic procedures required 16 procedures. It was necessary to perform 29 laparoscopic resections in order to significantly increase the rate of laparoscopic posterosuperior segments resection but without significant increase of difficulty index. The implementation of minimally invasive liver resection started with the robotic approach.

Conclusion: The learning curve for robot-assisted liver resections is shorter in comparison with laparoscopic resections. The inclusion of robot-assisted resections in a minimally invasive liver surgery program may be useful to rapidly increase the complexity of laparoscopic liver resections.

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Introduction

During the past quarter of a century since the first laparoscopic liver resection (LLR) was done, laparoscopic technology has become widely used in hepatobiliary surgery. The results of more than 9000 LLR were reviewed in 2015.[1]

The advantages of LLR over open procedures, with regards to short-term results, have been proven by many comparative analyses.[2,3] Survival after LLR is comparable with open resection or even longer in patients with metastatic colorectal cancer and hepatocellular carcinoma.[4–6]

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Nevertheless, it is obvious that the encouraging results of LLR in the majority of series are not without the influence of patient selection, often treated for single lesions located in the anterior segments. As shown in a recent multi-center study, the laparoscopic approach was selected in approximately 30% of all liver resections and in more than 60% of left lateral sectionectomies.[7]

Lesions in the posterior segments of the liver, as well as those with major vascular involvement were not recommended for LLR until recently. Lately published papers indicate that lesions adjacent to major hepatic vasculature do not have to be contraindications to LLR in expert centers.[8] It has been shown that robotic assistance is more effective in parenchymal-sparing liver resection in patients with tumors of posterosuperior liver

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segments, while the conventional laparoscopic approach usually leads to major liver resection, sacrificing a substantial volume of normal liver.[9,10]

Due to a lack of and controversial results of comparative studies, it remains unclear whether there any advantages to the robotic approach over conventional laparoscopic technologies in difficult-to-reach liver segments resection. To our knowledge, there is still no comparative analysis of learning curves in robot-assisted liver resection (RLR) and LLR, particularly for lesions of difficult-to-reach segments.

Evaluation of the learning curve is typically required for several different measures, reflecting the complexity of the operation or its result. The novel point-based scoring system to assess the difficulty of LLR was recommended in 2014 at the 2nd International Consensus Conference of Laparoscopic Liver Resection.[11] The difficulty scoring system (DSS) was based on an integrated assessment of the complexity of resection, and is useful for standardization of data prior to comparison; however, to date it has not been used for a comparative evaluation of learning curves for minimally invasive liver resection. We aimed to compare learning curves in complex RLR and LLR with regards to estimating short-term results and difficulty index score.

Methods

Study design: observational cohort study. We obtained data on RLR and LLR which were recorded in a prospective database and analyzed retrospectively. All minimally invasive liver resections were performed between May 2010 and June 2016. The first 16 RLR and first 20 LLR were performed at the A.V. Vishnevsky Institute of Surgery with 24 RLR and 71 LLR performed consecutively at the Moscow Clinical Scientific Center. All patients provided informed consent prior to surgery. The primary inclusion criteria were anatomical or partial liver resection for different benign diseases (FNH, hemangioma, adenoma, biliary cystadenoma, liver abscess, intrahepatic cholangiolithiasis), parasitic lesions (hydatid and alveolar echinococcosis) and malignant tumors (colorectal and noncolorectal cancer metastases, hepatocellular carcinoma, intrahepatic and hilar cholangiocarcinoma, gallbladder cancer). Patients with hydatid echinococcosis were included only if total pericystectomy was performed. Patients who underwent minimally invasive unroofing for simple biliary cysts or partial pericystectomy for hydatid echinococcosis were excluded.

A 10-level difficulty index of LLR was calculated as proposed by Ban *et al.*[12] The primary endpoint of this study was to count the number of procedures before a significant increase of difficulty index or the rate of resection of posterosuperior segments as the most powerful category for calculation of difficulty index. Significant changes of difficulty index or the rate of resection of posterosuperior segments were the main conditions for chronological allocation of patients into subgroups of early and late experience for both robotic and laparoscopic approach. The division of RLR and LLR groups into mentioned above subgroups actually reflected the beginning of regular application of minimally invasive technique for complex liver resection with high difficulty index, including posterosuperior segments resection that took place in 2013 for RLR and in 2014 for LLR.

The secondary points were to estimate the duration of liver resection, blood loss, morbidity, mortality and hospital stay. Morbidity was evaluated according to the Clavien–Dindo classification.[13] Grade II–V complications were included in the evaluation. Perioperative mortality was defined as death within 30 days after the procedure or before hospital discharge.

All procedures were performed by two surgeons in equal ratio. At the beginning of the learning curve, operating surgeons had no large experience in laparoscopic surgery but were skilled in open liver surgery, including sophisticated liver resection.

Surgical technique

All LLR and RLR were performed as pure laparoscopic procedures without hand-assistant maneuver. An anti-Trendelenburg position (30°) of the table was used in all cases. For anterolateral segments and segments 1, and 4a resection, patients were placed in the supine position. In segment 7, and 8 resection the right-side-up or left lateral decubitus positions were used. During LLR, the surgeon stood to the right side of the patient. The position of the trocars for anterolateral segments resection was standard for both conventional laparoscopic and robot-assisted approach. As a rule, an optic port was placed through the incision in the umbilical region with surgical (robotic) trocars placed in right and left upper quadrants. By default, assistant trocars were inserted between the optical and surgical ports with one additional trocar placed in the epigastric region near the midline. In the majority of cases, only two robotic arms were used. During conventional laparoscopic procedures, different ports could be used for surgical instrumental handling. We applied the same trocar position for resection of posterosuperior segments, as described by Kazaryan A.M. *et al.* (2011).[14] If necessary, minimally invasive access was converted into an upper midline incision of 8–10 cm in length (the hybrid technique) that was sufficient to complete the procedure. Conversion to a hybrid technique was performed if it was technically challenging to continue the operation safely in a fully laparoscopic variant. The DaVinci S Surgical System (Intuitive Surgical, Inc., Sunnyvale, California) robotic cell was used in the early period, and the DaVinci Si was applied in the late period of the learning curve.

Statistical analysis

Continuous data presented as median values were compared using Mann-Whitney U test. The Two-tailed Fisher's Exact test was used for comparing categorical variables. Spearman correlation coefficient was used to examine the association between series of discrete variables. A p-value of less than 0.05 was considered statistically significant. "Statistica 12" software package was applied for data analysis.

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