ORIGINAL ARTICLE

"Idealized" vs. "True" learning curves: the case of laparoscopic liver resection

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Abstract

Background: Learning curves are believed to resemble an "idealized" model, in which continuous improvement occurs until a plateau is reached. We hypothesized that this "idealized" model would not adequately describe the learning process for a complex surgical technique, specifically laparoscopic liver resection (LLR).

Methods: We analyzed the first 150 LLRs performed by a surgeon with expertise in hepatobiliary/laparoscopic surgery but with no previous LLR experience. We divided the procedures performed in 5 consecutive groups of 30 procedures, then compared groups in terms of complications, operative time, length of stay, and estimated blood loss.

Results: We observed an increase in operative complexity (3.3% major operations in Group 1 vs. 23.3% in Group 5, $p = 0.05$). Complications decreased from Group 1 to Group 2 (20%–3%), but increased again as more complex procedures were performed (3% in Group 2–13% in Group 5). Similar improvement/regression patterns were observed for operative time and EBL.

Discussion: The "true" learning curve for LLR is more appropriately described as alternating periods of improvement and regression until mastery is achieved. Surgeons should understand the true learning curves of procedures they perform, recognizing and mitigating the increased risk they assume by taking on more complex procedures.

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Introduction

The development of laparoscopic surgery in the early 1990's represented a paradigm shift in the field of abdominal surgery. For cholecystectomies, appendectomies, and colectomies it quickly became the standard approach. Laparoscopic liver resection (LLR) was first reported in 1992,[1] however its expansion has been considerably slower when compared to other laparoscopic procedures.[2]

The slow adoption of LLR can be attributed to, at least in part, the perception that LLR is challenging and a difficult procedure to master. Yet, several studies have demonstrated LLR to be safe.[3–6] A growing body of work demonstrates improvements in patient outcomes with LLR when compared to a traditional open resection.[2,6–8] Surgeons routinely performing LLR tend to perform resections of increasing difficulty over time.[9] In this context, many have become interested in understanding the "learning curve" of LLR.

Learning curves have received increased attention,[10–12] as availability of perioperative outcomes data and the emergence of national benchmarking standards have transformed historically subjective approaches to performance assessment, certification, and advancement. Intuitively, many expect learning curves for a wide variety of surgical procedures to approximate the S-shaped (or "idealized") model (Fig. 1a). However, research across diverse

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fields suggests that learning progression is more complicated, and may in fact occur in a different 'shape'[13–15] (Fig. 1b).

Few studies have analyzed the learning curve effect in LLR,[16–19] the most rigorous of which was limited to data collected during the time when the LLR technique was being developed and standardized.[16] We therefore aimed to analyze the learning curve effect of the current LLR technique. We hypothesized that the idealized learning curve model would be insufficient to capture the complex and evolving inputs of experience and expertise of a surgeon learning this important technique.

Materials and methods

Patients

For this study, we analyzed the complete case series of a surgeon who recently started performing LLR, and for which we had access to the complete operative logs. Retrospective review of the operative database identified the first 150 patients operated on by the same surgeon, all of whom underwent LLR at the Massachusetts General Hospital between March 2007 and April 2015. Clinicopathological data was collected for all of these patients. Data analyzed included: gender, age, BMI, ASA score, indications for LLR, numbers of segments resected, operative time, estimated blood loss (EBL), readmissions within 30 days from operation, and length of stay. Morbidity was evaluated as the presence of Clavien–Dindo grade III–V complications.[20] A major operation was defined as a resection of four or more segments.[21] Operative mortality was defined as death within 90 days from the date of operation. Presence of comorbid conditions was evaluated using the Charlson Comorbidity Index (CCI).[22]

Surgical technique

The surgical technique for LLR has been extensively described by others.[23,24] Briefly, in our case series, the patients were placed in the supine position. In the majority of the cases, three to five ports were utilized. Of these ports, one or two were 11–15 mm ports, with the remainder being 5 mm ports. Hand-ports were used when a significant inferior vena cava dissection was performed. Pneumoperitoneum was maintained with CO_2, and electronic monitoring was used to keep intra-abdominal pressure between 12 and 15 mmHg. Parenchymal transection was performed using the Sonosurg. The portal pedicles and hepatic veins were transected utilizing hemolock clips or stapled using a vascular stapler (over the years varying staplers have been utilized). The resected specimen was then placed into an EndoCatch bag and removed either by enlarging a 15 mm port, through the hand port, or via a Pfannenstiel incision.

All the procedures were performed by a single operator, who had expertise in laparoscopic surgery and hepato-biliary pancreatic surgery, but with no experience of LLR prior to this series.

Statistical analysis

Statistical analysis was performed using STATA software, version 13.0 (StataCorp LP). Patients were divided into sequential groups of 30 consecutive cases for the purposes of comparison. Unadjusted comparison for categorical variables was performed using the χ^2 test, and for continuous variables using *t*-tests. Multivariable regression analyses were performed using multiple logistic or linear regression models to determine the impact of operator experience on each outcome of interest, namely complications (primary outcome), operative time, estimated blood loss (EBL), and length of stay (secondary outcomes), after controlling for age, gender, presence of malignancy, extent of resection (i.e. major vs. minor), ASA score, and Charlson score. Statistical significance was set at a level of $p = 0.05$.

Results

Descriptive results

For the 150 patients who underwent LLR, the median age was 65 years (mean = 58.7, SD = 16.3), and 64% of the patients were

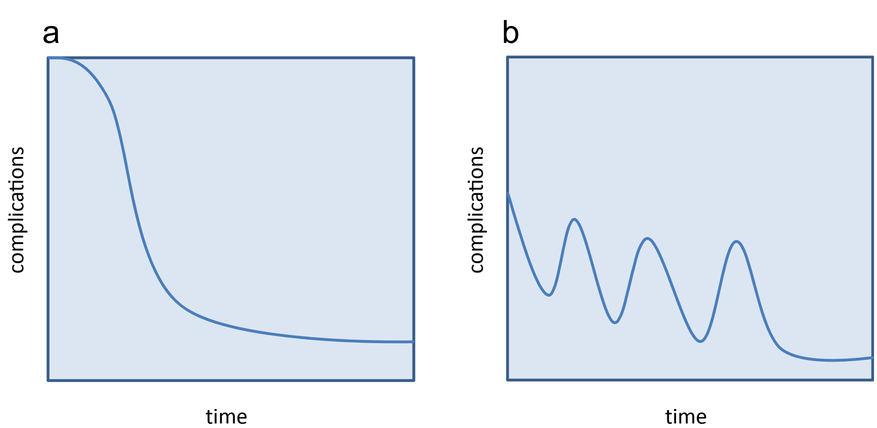

Figure 1 "Idealized"(a) vs. "true" learning curve (b)