Completion of a Liver Surgery Complexity Score and Classification Based on an International Survey of Experts

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BACKGROUND: Liver resections have classically been distinguished as "minor" or "major," based on number of segments removed. This is flawed because the number of segments resected alone does not convey the complexity of a resection. We recently developed a 3-tiered classification for the complexity of liver resections based on utility weighting by experts. This study aims to complete the earlier classification and to illustrate its application.

STUDY DESIGN: Two surveys were administered to expert liver surgeons. Experts were asked to rate the difficulty of various open liver resections on a scale of 1 to 10. Statistical methods were then used to develop a complexity score for each procedure.

RESULTS: Sixty-six of 135 (48.9%) surgeons responded to the earlier survey, and 66 of 122 (54.1%) responded to the current survey. In all, 19 procedures were rated. The lowest mean score of 1.36 (indicating least difficult) was given to peripheral wedge resection. Right hepatectomy with IVC reconstruction was deemed most difficult, with a score of 9.35. Complexity scores were similar for 9 procedures present in both surveys. Caudate resection, hepaticojejunostomy, and vascular reconstruction all increased the complexity of standard resections significantly.

CONCLUSIONS: These data permit quantitative assessment of the difficulty of a variety of liver resections. The complexity scores generated allow for separation of liver resections into 3 categories of complexity (low complexity, medium complexity, and high complexity) on a quantitative basis. This provides a more accurate representation of the complexity of procedures in comparative studies. (J Am Coll Surg 2016;223:332–342. © 2016 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

In 1956, Claude Couinaud introduced a classification that divided liver resections into "minor" (≤2 segments) and "major" (≥3 segments) types.[1] At that time, most resections of ≤2 segments were subsegmental resections or left lateral sectionectomies, and most resections of ≥3 segments were right or left hepatectomies. The minor procedures not only resected less liver, but they were technically less complex. The terms *minor* and *major* fit the procedures well with regard to both the amount of liver resected and the complexity of doing so. With time, more kinds of liver resections were introduced and it became evident that complexity of liver resection is not solely related to the amount of liver resected. For instance, several types of 2-segment resections vary widely in complexity. Left lateral sectionectomy is a much less difficult procedure than right anterior sectionectomy, although both are 2-segment resections. Isolated resection of the caudate lobe is anatomically complex, and the complexity of this minor procedure seems to be at least equal to that of some major resections. It is clear that the major or minor classification can lead to inappropriate comparisons of outcomes because within these categories there is a wide range in difficulty of procedures. Therefore, an improved method of classification that lessens this problem is desirable. This method would allow expression of variables in addition to size as determinants of complexity.

This is the second of 2 articles devoted to creating a new classification for the complexity of liver resections

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using utility grading, a powerful tool that allows weighting of multidimensional states. Experts can integrate many factors, such as the number of segments resected, anatomic accessibility, proximity to major vascular structures, size of transection plane, and other variables to estimate complexity quantitatively.

In both studies, experts rated the complexity of liver resections on a scale from 1 to 10. The study was done in 2 parts to avoid taxing respondents with >20 questions in one survey and compromising validity. Doing the study in 2 parts allowed repetition of questions to determine consistency of results. The first study included 12 different liver resections.[2] The results were used to complete a 3-tier classification of complexity. This preliminary classification was validated recently by Muangkaew and colleagues[3] in a study of 150 liver resections for hepatocellular carcinoma. In the current study, 9 resection types were reassessed to test for reproducibility. Also, the effects of the addition of vascular reconstruction, biliary reconstruction, and concomitant caudate lobe resection were assessed. All of these additions to standard resections are now performed with increasing frequency.[4-7] In all, 19 different liver resections have been rated. Adjusted complexity scores were developed for each resection, and a new complexity classification was generated. Additionally, an example is provided in tabular form demonstrating how quantitative weighting of liver resection complexity can be used to compare 2 large groups of liver resections to determine whether they differ significantly in complexity.

METHODS

Study design

A 5-question survey was administered by email to 122 expert liver surgeons in 13 countries from April 2015 through May 2015. The survey was anonymous and was created using a widely available Internet survey tool (http://www.surveymonkey.com). The surgeons were identified primarily by contributions to the literature on hepatic surgery. The selection of experts was shifted somewhat from our earlier study to include predominantly countries in North America and Europe in which English is a national language. This change was instituted because of a low response rate in the first survey from other countries.[2]

The first 4 questions related to the country in which the surgeon was practicing, experience in liver surgery, and type of practice. The fifth question asked the experts to rate the complexity of various liver resections on a scale of 1 to 10. Level 1 was labeled as "easier," and level 10 was labeled as "more difficult or complex." The survey specified that all resections were to be considered open rather than laparoscopic procedures, and all resections other than peripheral wedge resection were to be considered anatomic in nature. The same survey was sent to all 122 surgeons.

Data analysis

To increase the precision of measurement and statistical power, we pooled the data from the current survey (survey #2) with the first survey (survey #1).[2] A total of 19 procedures (3 procedures specific to survey #1, 7 procedures specific to survey #2, and 9 procedures common to both) were scored in the pooled data. As noted previously, the purpose of repeating 9 procedures in the second survey was to estimate the consistency of results between the 2 surveys. Also, as the newly added procedures involving caudate resections, vascular resections, and biliary-enteric anastomoses were expected to be rated as more complex, there was the possibility that this would systematically drive the scores of other procedures toward the "easier" end. To account for this possibility, a regression model using a generalized estimating equation was first fitted to estimate and compare the mean scores for the 9 procedures common to both surveys after adjusting for surgeons' characteristics, including country (US vs non-US) and the number of resections performed. Generalized estimating equation also allowed us to account for the correlation among scores from the same surgeon and provided an efficient way to handle repeated measurement data without requiring multivariate normal distribution.[8] The results indicated only a slight shift (approximately 4%) in the mean scores, and the scores from the current survey were then aligned by multiplying 104% to each procedure. Next, similar generalized estimating equation regression models were used to compare the mean scores and rank the relative complexity among all procedures, as well as to assess the association between perceived complexity and other characteristics, such as surgeon's experience or practice patterns. The resultant p values were corrected for multiple comparisons using false discovery rate adjustment.[9] All tests were 2-sided and an adjusted p value ≤ 0.05 was taken to indicate statistical significance. The statistical analysis was performed using SAS, version 9.4 (SAS Institute). The Cochran-Armitage test was used to evaluate the ranking of procedures in the hypothetical comparison of procedures given in the Discussion.

RESULTS

Participant demographics

One hundred and twenty-two surveys were administered. One hundred and ten of these were sent to North America and Europe. Sixty-six of 122 (54.1%) surgeons responded to the survey. This was slightly higher than our previous