Perceived Complexity of Various Liver Resections: Results of a Survey of Experts with Development of a Complexity Score and Classification

Major K Lee IV, MD, PhD, Feng Gao, MD, Steven M Strasberg, MD, FACS

BACKGROUND: Liver resections have classically been distinguished as "minor" or "major" based on the number of segments removed. However, it is clear that the number of segments alone does not convey the complexity of a resection. To date, no study has formally assessed the complexity of various anatomic liver resections.

STUDY DESIGN: A 4-question survey was administered to 135 expert liver surgeons in 14 countries. The first 3 questions related to the country in which the surgeon was practicing and the surgeon's experience. In the fourth question, the experts were asked to rate the difficulty of various open, anatomic liver resections on a scale of 1 to 10.

RESULTS: Sixty-six of 135 (48.9%) surgeons responded to the survey. Twelve procedures were rated. The lowest mean score of 1.37—indicating least difficulty—was given to peripheral wedge resection. Left trisectionectomy with caudate resection was deemed most difficult, with a score of 8.28. The mean scores for the 2 procedures perceived as least difficult—peripheral wedge resection and left lateral sectionectomy—were lower than the mean scores of all the rest of the procedures at a highly statistically significant level ($p < 0.0001$). The 4 procedures with the highest scores shared the common attribute that they involved the right intersectional plane.

CONCLUSIONS: These data represent the first quantitative assessment of the perceived 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. (J Am Coll Surg 2015;220:64–69. © 2015 by the American College of Surgeons)

Since the first description of anatomic right hepatectomy in 1952,[1] hepatic resection has advanced significantly in both safety and complexity. As a result, resection has become the treatment of choice for many patients with benign and malignant liver lesions. Multiple factors account for the advance of liver surgery. One important factor is better appreciation of the anatomy of the liver as delineated initially by Couinaud[2] and Goldsmith and Woodbourne,[3] among others. Bismuth's landmark analysis in the 1980s summarized the anatomic details underlying these operations and the steps required to carry them out.[4,5] With this understanding, segment-oriented approaches to liver resection have become standard, with documented benefit.[6-8]

As illustrated by Couinaud's initial segmental description, each of the 8 segments has individual biliary drainage, vascular inflow, and vascular outflow. Each can therefore be resected independently without compromising other segments. This allows for a variety of anatomic liver resections, some of which are more complex and challenging than others. Classically, liver resections have been grouped as "minor" and "major" based on the number of Couinaud segments resected.[9,10] In this classification, a minor resection is one in which 2 or fewer segments are resected, and a major resection is one in which 3 or more segments are removed. The classical grouping into minor and major has been in use for more than 50 years. However, as liver resections have increased in variety and complexity, it has become apparent that a classification based simply on the number of segments is inadequate. For instance, left lateral sectionectomy (segments 2 and 3) and right anterior sectionectomy (segments 5 and 8) are both 2-segment resections, but are clearly not in

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From the Section of Hepato-Pancreato-Biliary Surgery, Washington University in Saint Louis, Barnes-Jewish Hospital, and the Siteman Cancer Center (Lee, Strasberg) and the Division of Biostatistics, Washington University School of Medicine (Gao), St Louis, MO; and the Department of Surgery, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA (Lee).

Correspondence address: Steven M Strasberg, MD, FACS, Washington University in Saint Louis, 4990 Children's Place, Suite 1160, Box 8109, Saint Louis, MO 63110. email: strasbergs@wustl.edu

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the same category of complexity. One basis for an updated classification would be the perceptions of expert surgeons concerning the complexity of various resections.

To date, no study has formally assessed the complexity of various anatomic liver resections. In this study, a questionnaire regarding the difficulty of a variety of open, anatomic liver resections was administered to experienced hepatic surgeons across the world. The results yielded a complexity score for each procedure that allowed ranking of liver resections by perceived difficulty and facilitated generation of a new 3-tier classification for these resections.

METHODS

Design

A 4-question survey was administered by email to 135 expert liver surgeons in 14 countries, from March 2014 through April 2014. The surgical experts were identified primarily by their contributions to the literature. All surveys were anonymous. The survey was created using a widely available internet tool (http://www.surveymonkey.com). See the online-only supplemental material for the survey questions.

The first 3 questions related to the country in which the surgeon was practicing and the surgeon's experience. In the fourth question, the experts were asked to rate the difficulty 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." The survey specified that all resections were to be considered open rather than laparoscopic procedures, and all resections, except a peripheral wedge resection, were considered anatomic in nature.

The expert surgeons were randomly divided into 2 groups before the surveys were sent out. The groups received surveys that differed slightly in order to evaluate the perceived increase in difficulty when formal caudate resection was added to a procedure. The survey administered to group 1 included the operations, "left hepatectomy with caudate resection" and "left trisectionectomy without caudate resection"; the survey administered to group 2 included the operations, "left hepatectomy without caudate resection" and "left trisectionectomy with caudate resection." The other 8 resections presented in the questionnaire were common to both groups.

Data analysis

For each procedure, the scores of perceived difficulty were summarized using mean and standard error. As stated, all recipients were asked to assess the difficulty of 8 procedures, but the other 2 procedures differed between the 2 groups. Results for the 8 procedures that were common to the 2 groups were compared using the Mann-Whitney rank-sum test. When analyzing the results, it was found that group 1 responders consistently rated the 8 in-common procedures as less difficult than group 2 responders. To make the scores among all 12 procedures comparable, a regression analysis was performed using a generalized estimating equation (GEE) to adjust surgeons' characteristics including country (US vs non-US) and the number of resections performed (annually and career). The 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.[11] Differences among individual procedures were further compared and the resultant p values were corrected for multiple comparisons using false discovery rate (FDR) adjustment.[12] All tests were 2-sided, and an adjusted p value of 0.05 or less was considered statistically significant. Statistical analysis was performed using SAS 9.2 (SAS Institutes).

RESULTS

Participants and their experience

Sixty-six of 135 (48.9%) surgeons responded to the survey: 33 surgeons from group 1 and 33 surgeons from group 2. Thirty-four of 66 (54.5%) responders practiced within the United States, and 39 practiced in North America (59.0%). Twelve (18%) surgeons practiced in Europe, and 12 practiced in Asia. Fifty-one of 66 (77.3%) respondents worked in a country in which English is a national language, and 51 of 81 (63.0%) experts from countries in which English is a national language responded to the survey as compared with 13 of 54 (24.1%) experts from countries in which it is not. This difference was highly significant by chi-square test ($p < 0.0002$). The countries in which 2 of the responding surgeons practiced were uncertain. Characteristics of the responding surgeons are summarized in Table 1.

Respondents encompassed all levels of experience: 30 of 66 surgeons (45.5%) had performed fewer than 500 resections in their career, while 36 of 66 (54.5%) had performed more. Notably, responders from group 1 tended to be more experienced than those from group 2; 22 of 33 (66.7%) surgeons from group 1 had performed more than 500 liver resections in their career, but only 14 of 33 (42.4%) from group 2 had done so. This trend approached, but did not achieve, statistical significance ($p = 0.140$). However, the current annual surgical volume was similar between the 2 groups ($p = 0.781$). Group 1 responders consistently rated the same operation as less difficult than group 2 responders (data not shown). For instance, the unadjusted mean difficulty for a right hepatectomy among group 1 responders was 4.58