Defining Global Benchmarks for Laparoscopic Right Posterior Sectionectomy/H67

An International Multicenter Study

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Objective: To establish global benchmark outcomes indicators for laparoscopic right posterior sectionectomies (L-RPSs)/H67.

Background: Minimally invasive liver resections have seen an increase in uptake in recent years. Over time, challenging procedures such as L-RPS/H67 are also increasingly adopted.

Methods: This is a post hoc analysis of a multicenter database of 854 patients undergoing minimally invasive RPS in 57 international centers in 4 continents between 2015 and 2021. There were 651 pure L-RPS and 160 robotic RPS. Sixteen outcome indicators of low-risk L-RPS cases were selected to establish benchmark cutoffs. The 75th percentile of individual center medians for a given outcome indicator was set as the benchmark cutoff

Results: There were 573 L-RPS/H67 performed in 43 expert centers, of which 254 L-RPS/H67 (44.3%) cases qualified as low-risk benchmark cases. The benchmark outcomes established for operation time, open conversion rate, blood loss $\geq$500 mL, blood transfusion rate, postoperative morbidity, major morbidity, 90-day mortality, and textbook outcome after L-RPS were 350.8 minutes, 12.5%, 53.8%, 22.9%, 23.8%, 2.8%, 0%, and 4%, respectively.

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Conclusions: The present study established the first global benchmark values for L-RPS/H6/7. The benchmark provided an up-to-date reference of the best achievable outcomes for surgical auditing and benchmarking.

Key Words: benchmark, global, hepatectomy, laparoscopic right posterior sectionectomy, minimally invasive

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In recent years, the use of benchmarking within the surgical community has gained traction for its practicality in the quality assessment of surgical procedures and their outcome. Simply put, benchmarking serves as a reference tool of the best achievable outcomes and provides a metric to which centers can endeavor their efforts in improving health care related outcomes, particularly in instances of surgical audits or where novel surgical procedures are evaluated.[1] Recently, we established international benchmark outcomes for laparoscopic liver resections (L-LRs) focusing on left lateral sectionectomy, left hepatectomy, and right hepatectomy (RH);[2] procedures chosen based on their represented level of complexity in L-LR as defined by Kawaguchi et al.[3]

Although not conventionally defined as a major hepatectomy given only that 2 segments are removed,[4] laparoscopic right posterior sectionectomy (L-RPS) or H67 according to the new world terminology[5] is a technically complex procedure and is recognized by most liver surgeons as being even more technically complicated than a right hepatectomy.[6] The horizontal resection plane, wide surface area of parenchymal transection coupled with challenging identification of the right posterior Glissonian pedicle buried within the liver theoretically increases the risk of bleeding or bile leak and underpins some of the procedural difficulties faced by surgeons, highlighting the steep learning curve necessary to overcome this technique.[7]

Despite these challenges, the rapid adoption of L-LR globally and an evolution in the understanding of certain technical considerations, coupled with the tandem improvement of surgical devices have led to an increasing number of studies reporting the feasibility, safety, and oncological efficiency of L-RPS/H67.[8–12] In an era where L-RPS/H67 may increasingly be adopted by surgeons, it is ever more imperative to establish benchmark values to promote safe and achievable outcomes in surgery. This present study was performed with the primary objective of establishing various clinically relevant intraoperative and postoperative benchmark values for L-RPS/H67 from low-risk patients who underwent surgery at high-volume expert centers globally.

METHODS

This was a post hoc analysis of an international multicenter database of 854 patients who underwent minimally invasive (MI)-RPS/H67 between January 2015 and December 2021 at 57 global centers. There were 652 pure L-RPS/H67 and 159 robotic (R)-RPS/H67. Of note, only pure L-RPS/H67 were included in benchmarking. Other approaches, such as hand-assisted and laparoscopic-assisted (hybrid) LR, were excluded in this study. Robotic RPS/H67 was included as a comparator group.

Ethical board approvals were obtained by all institutions according to their local requirements. Each individual center's investigators collected and entered their deidentified data into a standard Excel datasheet. These de-identified data were collated and analyzed centrally at the Singapore General Hospital. All data were audited and checked for accuracy by the last author with assistance from his study team. In the event of ambiguity, the contributing center was contacted to verify the accuracy of the data. The Singapore General Hospital Institution Review Board provided a waiver for this study due to its retrospective nature and use of only de-identified data.

Study Design

High Volume Experienced Centers

The study utilized a standardized methodology previously reported for procedures such as L-LR,[2] major liver resections,[13] liver transplantation,[14] and pancreatic surgery.[15] Centers that met the following criteria: (1) cumulative experience of over 80 MI-LR before January 2015, (2) average caseload ≥ 20 MI-LR per annum between 2015 and 2021,[2,16,17] and (3) academic interest in L-LR as evidenced by ≥ 1 PubMed-indexed publication on L-LR were defined as a high-volume expert center in this study. Forty centers from 4 continents met the study criteria for high-volume expert centers. These included 19 from Europe, 16 from Asia, and 2 from the Americas. In addition, 3 relatively new L-LR centers (1 Asia, 2 Europe) that did not meet criteria 1 were included as the L-LR programs in these 3 centers were initiated, and the cases were performed by 3 world-renowned highly experienced pioneering L-LR surgeons who had relocated to these centers. Seventeen centers that did not meet the criteria formed the control group. The identity of the centers was anonymized.

Low-risk Procedures

Only patients with a low-preoperative risk profile were selected for benchmarking.[15] The inclusion criteria included: (1) patients aged between 18 and 70 years old and (2) a low American Society of Anesthesiology score of ≤ 2. The exclusion criteria included: patients with very large tumors ≥ 10 cm, body mass index ≥ 35 kg/m, Child's B liver cirrhosis or portal hypertension, previous liver resections (repeat liver resections) or associating liver partition and portal vein ligation for staged hepatectomy, bilio-enteric anastomoses, hilar lymph node clearance, concomitant major operations such as colectomies, bowel resections and stoma reversals with L-RPS, and ≥ 2 multiple minor liver resections with L-RPS.

Definitions

L-RPS/H67 were classified according to the 2000 Brisbane classification[18] and New World terminology.[5] Postoperative complications were classified according to the Clavien-Dindo classification[19] and recorded for up to 90 days. Major complications were defined as complications > Clavien-Dindo grade 2. R1 resection was defined as a close resection margin of < 1 mm. Difficulty of resections was also graded according to the Iwate score.[20,21] Failure-to-rescue rate was defined as the ratio of the number of 90-day mortalities in patients with major complications (numerator) to the total number of patients with major complications (denominator).[22] Textbook outcomes (TOs) were defined previously according to Hobeika et al[23] and were considered in patients fulfilling 6 of the following outcomes: absence of blood transfusion, absence of postoperative morbidity, R0 surgical margin, absence of unplanned 30-day readmission, absence of postoperative

mortality, and absence of prolonged hospital stay defined as a postoperative stay of ≤50th percentile of the total cohort.

Outcome Indicators

Sixteen clinically relevant intra and postoperative outcomes indicators were selected to establish benchmark cutoffs of which 15 (except TO) were as previously reported.[2] The intraoperative outcomes selected were: operation duration, estimated blood loss, blood loss ≥500 mL, blood loss ≥1000 mL, intraoperative blood transfusion, and open conversion. The postoperative outcomes selected were: postoperative 90-day morbidity, postoperative 90-day major morbidity (>Clavien-Dindo grade 2), reoperation, postoperative 30-day and 90-day mortality, postoperative length of stay (LOS), 30-day unplanned readmission rates, R1 resection (< 1 mm margin for malignant tumors), and failure to rescue.

Benchmark Values and Statistical Analysis

A benchmark value was established for each of the 16 outcome indicators from patients who underwent L-RPS/H67. The 75th percentile (indicators of poor outcome) of individual center medians for a given outcome indicator was set as the benchmark cutoff as previously reported.[1,2,23,24] The Mann-Whitney *U* test was used for continuous variables, whereas the Fisher exact test and Pearson χ^2 test were used for categorical variables. All statistical analyses were performed using IBM SPSS V23.0 and Stata V17.0 (StataCorp).

Comparative Cohorts

We analyzed 2 separate cohorts of patients: (1) high-risk cases who underwent L-RPS/H67 in the experienced expert centers and (2) low-risk L-RPS/H67 meeting benchmark outcomes criteria who underwent resection at centers that did not meet the inclusion criteria as an expert center to test the benchmark values. In addition, we compared benchmark and non-benchmark robotic RPS/H67 cases performed with the benchmarks for L-RPS/H67. We also performed further subset analyses reporting benchmark outcomes separately in patients with hepatocellular carcinoma (HCC) and colorectal liver metastases (CRLM).

RESULTS

A total of 652 L-RPS were performed in 57 centers during the study period. Forty centers met the study criteria as expert centers, and 17 centers did not meet the study criteria. In total, 573 L-RPS/H67 were performed in the 40 expert centers. The flowchart demonstrating the selection of cases is summarized in Supplemental 1 (Supplemental Digital Content 1, http://links.lww.com/SLA/F174). The baseline clinicopathological features and outcomes of the 573 patients are summarized in Supplemental 2 (Supplemental Digital Content 1, http://links.lww.com/SLA/F174).

Of these, 254 L-RPS/H67 cases met the criteria for low-risk benchmark cases. The proportion of benchmark L-RPS in the 40 benchmark centers ranged from 0% to 100% (Fig. 1). The overall patient baseline clinicopathological features and outcomes are summarized in Table 1 and Supplemental 3 (Supplemental Digital Content 1, http://links.lww.com/SLA/F174).

Textbook Outcomes

In the entire cohort of 652 patients who underwent L-RPS in 57 centers, 275 (39%) completed TO (Table 1). Factors significantly associated with the completion of TO included younger age, benign tumors, absence of cirrhosis, solitary tumors, and single liver resection.

Benchmark Outcomes

The 16 benchmark cutoffs derived from the 75th percentile of the median of medians of each outcome indicator for each center were summarized in Table 2. The benchmark outcomes established for open conversion rate, blood loss ≥500 mL, blood transfusion rate, postoperative morbidity, major morbidity, and 90-day mortality after

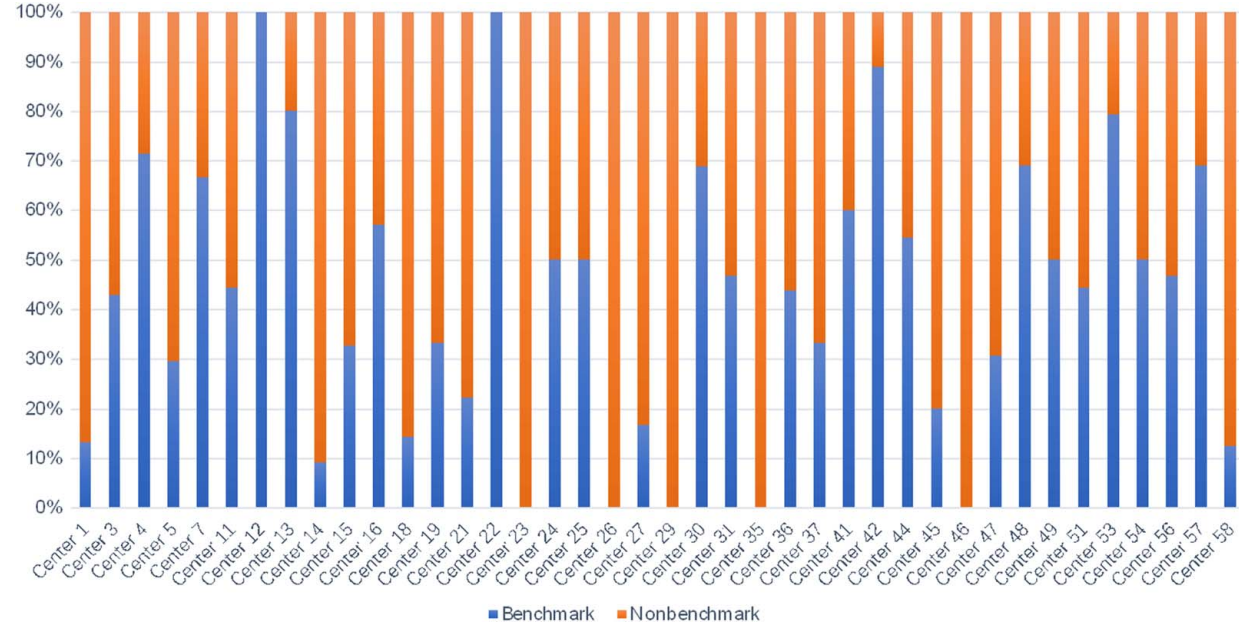

FIGURE 1. Proportion of benchmark cases performed across the 40 benchmark centers.

TABLE 1. Baseline Clinicopathological Features 254 Low-risk Patients Operated in the 40 Expert Centers Selected for Benchmarking and the Entire Cohort of 652 Patients in 57 Centers Stratified to Patients Who Completed TO and Uncompleted TO

	Low-risk RPS/ H67 (N = 254)	All L-RPS/ H67 (N = 652)	Completed TO (N = 257)	Uncompleted TO (N = 395)	*P*
Centers; n	40	57	—	—	—
Median BMI (kg/cm^2); IQR*†	24.0 (21.4–26.4)	24.2 (21.8–27.0)	24.4 (22.0–27.0)	24.1 (21.7–27.0)	0.152
Median age (IQR)‡	56 (49–62)	63 (53–71)	61 (52–59)	64 (54–72)	**0.034**
Sex (M); n (%)§	171 (67.3)	429 (65.8)	158 (61.5)	271 (68.6)	0.061
ASA score; n (%)‖					
I	56 (22.1)	82 (12.5)	41 (16.0)	41 (10.4)	0.175
II	198 (78.0)	409 (62.4)	158 (61.7)	251 (63.5)	—
Previous abdominal surgery; n (%)¶	59 (23.2)	214 (32.7)	82 (32.3)	132 (33.4)	0.764
Concomitant minor surgery; n (%)#	7 (2.8)	66 (10.1)	23 (8.9)	43 (10.9)	0.423
Malignancy; n (%)**	216 (85.0)	579 (88.4)	221 (86.0)	358 (90.6)	0.066
HCC; n (%)††	142 (65.7)	323 (49.3)	122 (47.5)	201 (50.9)	0.302
CRLM; n (%)	51 (23.6)	185 (28.2)	69 (26.8)	116 (29.4)	—
ICC; n (%)	9 (4.2)	37 (5.6)	15 (5.8)	22 (5.6)	—
Other LM; n (%)	11 (5.1)	28 (4.3)	13 (5.1)	15 (3.8)	—
Other malignancy; n (%)	3 (1.4)	6 (1.0)	2 (0.8)	4 (1.0)	—
Child A cirrhosis; n (%)‡‡	74 (29.1)	187 (28.5)	59 (39.4)	128 (60.6)	**0.009**
Neoadjuvant chemotherapy for CRLM; n (%)	29 (59.9)	95 (52.2)	40 (58.8)	55 (48.2)	0.167
Multifocal tumors; n (%)§§	56 (22.1)	189 (28.9)	60 (23.3)	129 (32.7)	**0.010**
Multiple resections; n (%)‖‖	17 (6.7)	73 (11.1)	21 (8.2)	52 (13.2)	**0.048**
Median tumor size (mm); IQR¶¶##	40 (27–60)	40 (27–60)	40 (25–55)	40 (28–60)	0.208
Iwate score; n (%)***					
Low	0	0	0	0	0.278
Intermediate	17 (6.7)	27 (4.1)	12 (4.7)	15 (3.8)	—
High	67 (26.4)	168 (25.6)	74 (28.8)	94 (23.8)	—
Expert	170 (67.0)	457 (69.8)	171 (66.5)	286 (72.4)	—

Bold values are statistically significant $P < 0.05$
P value comparing completed TO versus uncompleted TO.
*missing n = 3.
†missing (all L-RPS) n = 14.
‡missing (all L-RPS) n = 3.
§missing (all L-RPS) n = 3.
‖missing (all L-RPS) n = 4.
¶missing (all L-RPS) n = 6.
#missing (all L-RPS) n = 3.
**missing (all L-RPS) n = 3
††missing (all L-RPS) n = 3.
‡‡missing (all L-RPS) n = 3.
§§missing (all L-RPS) n = 3.
‖‖missing (all L-RPS) n = 3
¶¶missing n = 1.
##missing (all L-RPS) n = 10.
***missing (all L-RPS) n = 3.
ASA indicates American Society of Anesthesiology; BMI, body mass index; ICC, intrahepatic cholangiocarcinoma; IQR, interquartile range; LM, liver metastases.

L-RPS/H67 were 12.5%, 53.8%, 22.9%, 23.8%, 2.8%, and 0%, respectively. When compared with L-RH benchmark outcomes, which we had previously described,[2] the benchmark values in L-RH for blood loss ≥ 500 mL and blood transfusion rate appeared lower than those in the L-RPS group (47.1% and 10.5%, respectively). Benchmark values for 90-day mortalities were similar, whereas open conversion, postoperative morbidity, and major morbidity values in the L-RH were higher than in the L-RPS/H67 group (13% vs 12.5%, 50% vs 21.8% and 20% vs 2.8%, respectively). Supplemental 4 (Supplemental Digital Content 1, http://links.lww.com/SLA/F174) summarizes the liver-specific major morbidities.

Outcome Comparisons

We validated the applicability of benchmark outcomes in high-risk L-RPS/H67 performed in benchmark expert centers and low-risk L-RPS/H67 performed in non-benchmark centers (Table 3). Both in the cohorts of high-risk cases performed in benchmark centers and low-risk cases performed in non-benchmark centers, outcomes such as intraoperative blood transfusion, blood loss, blood loss ≥ 500 mL, blood loss ≥ 1000 mL, open conversion, and TO were within the benchmark cutoff values. Thirty-day and 90-day mortality, reoperation, and failure to rescue were beyond benchmark values for high-risk cases in expert centers but within benchmark values for low-risk cases performed in non-benchmark centers, whereas the postoperative LOS was beyond benchmark values for low-risk cases performed in non-benchmark centers but within for high-risk cases in expert centers. Thirty-day readmission, 90-day morbidity, postoperative major morbidity, and R1 resection were beyond the benchmark cutoffs in both cohorts.

Comparison among the 3 cohorts of robotic cases with the laparoscopic benchmark values are summarized in Supplemental 5 (Supplemental Digital Content 1, http://links.lww.com/SLA/F174). Most outcomes were within

TABLE 2. Sixteen Benchmark Outcome Measures After L-RPS/H6/7 in Low-risk Cases From 40 Expert Centers

Variables	L-RPS/H67		L-RH/H5678
	Median of Medians ACROSS Centers (Range)	Benchmark Cutoff (75th Percentile)	Benchmark Cutoff (75th Percentile)
Operation time (min)	320.8 (175.0–390.0)	≤350.8	≤426
Estimated blood loss (mL)	313 (50–4750)	≤450	≤400
Blood loss ≥500 mL	35.4 (0–100)	≤53.8	≤47.1
Blood loss ≥1000 mL	8.3 (0–100)	≤32.0	0.0
Intraoperative blood transfusion (%)	0 (0–60.0)	≤22.9	≤10.5
Open conversion (%)	0.0 (0.0–28.6)	≤12.5	≤13.0
Postoperative 90 d morbidity	12.5 (0.0–100.0)	≤23.8	50.0
Postoperative major morbidity	0.0 (0.0–18.2)	≤2.8	≤20.0
Reoperation (%)	0.0 (0.0–12.5)	0	0
30 d readmission (%)	0.0 (0.0–12.5)	0	≤8.3
Postoperative LOS (d)	6 (5–14)	≤7	≤7.5
R1 (<1 mm) resection (malignancy only) (%)	0.0 (0.0–100.0)	0.0	≤18.2
Failure to rescue (%)	0	0	0
30 d mortality (%)	0	0	0
90 d mortality (%)	0 (0–5.0)	0	0
TO (%)	37.5 (0.0–100.0)	>4.0	NA

Benchmark cutoffs for L-RH by Goh BKP, et al. Defining Global Benchmarks for Laparoscopic Liver Resections: An International Multicenter Study. *Ann Surg 2023;277:e839-48.*[2]

NA indicates not available.

benchmark values with the exception of 30-day readmission, 90-day morbidity, failure to rescue, and R1 resection.

Geographical Differences in Benchmark Cases

In the 254 low-risk cases performed, there were 3 (1.2%) cases from the Americas, 67 (26.4%) cases from Europe, and 184 (72.4%) cases from Asia. 135 (73.4%) cases performed in Asian benchmark centers were in centers performing >75 L-LR per annum compared with 39 (55.7%) of cases in non-Asian benchmark centers. Table 4 summarizes the 16 benchmark outcomes stratified by geographical location of the benchmark centers. In general, a comparison between Asian and European benchmark centers demonstrated fewer open conversions and lower R1 resections for malignancy in the former. However, a longer postoperative LOS and higher proportion of patients with blood loss of ≥500 mL was evident in Asian benchmark centers. Notably, in Asian benchmark centers, 134 (72.2%) and 17 (9.2%) resections were performed for HCC and CRLM, respectively, whereas in European centers, 8 (11.9%) and 33 (49.3%) were performed for HCC and CRLM.

Benchmark Outcomes in Subset of Patients With Colorectal Liver Metastases and Hepatocellular Carcinoma

Table 5 summarizes the benchmark cutoffs derived in the subset of patients with CRLM and HCC. Benchmark cutoffs for CRLM were higher for operation time, blood loss ≥1000 mL, open conversion rate, postoperative major morbidity, R1 resection, and TO. Of note, 133/142 (93.7%) HCC and 17/51 (33.3%) CRLM were resected in Asian centers whereas 8/142 (5.6%) and 33/51 (64.7%) CRLM were resected in Asian centers

DISCUSSION

In the present study, we established 16 benchmark values for perioperative outcomes after L-RPS/H67 with an international multicenter database as previously described.[2] Comparison between results from previously published studies on L-RPS/H67 such as 2 recent international multicenter studies[9,12] and a single center series[8] demonstrated that various outcomes such as major morbidity rate,[9] blood loss,[8] open conversion rate[12] and R1 resection rate[8,9,12] were beyond the current proposed benchmark outcomes. These findings are not surprising as these previous studies included both high and low-risk patients in their study cohort.

The benchmark cutoffs established for L-RPS/H67 in this study demonstrated that the benchmark cutoff for L-RPS/H67 was higher than L-RH/H5678 for blood loss, blood loss ≥500 mL, blood loss ≥1000 mL, and blood transfusion rate compared with our previous benchmark study for L-RH/H5678.[2] However, postoperative morbidity and major morbidity cutoffs were lower.[2] These results support the findings from previous studies,[25] which suggest that although RPS/H67 is technically more complicated than RH/H5678 with an increased risk of bleeding, the postoperative morbidity rates tended to be lower with RPS/H67 due to liver parenchymal preservation. The TO established for L-RPS/H67 was also lower than that established for L-RH/H5678 (24.2%) by Hobeika et al[23] in the French nationwide study, suggesting that L-RPS/H67 is indeed a more complicated procedure than L-RH/H5678. More recently, benchmark values were published for L-LR for tumors located in segments 7 or 8 in a multicenter study including 19 international expert centers.[26] The benchmark values established for operation time (373 min) and postoperative morbidity (31%) were higher than the present study whereas that for blood loss (250 mL), blood transfusion (11.56%), open conversion (4.4%) and hospital stay (6 days) were lower. Notably, a major limitation of the

TABLE 3. Comparison of the 16 Benchmark Outcome Measures in Non-benchmark Cases in the Benchmarking Centers and Benchmark Low-risk Cases in the Centers Which Did Not Meet Our Inclusion Criteria as a High-volume Expert Center

Variables	High-risk Non-benchmark L-RPS Cases in Benchmark Centers (N = 319)	Benchmark L-RPS in Non-benchmark Centers (N = 36)	Benchmark Cutoff (%)
% benchmark cases	254 (44.3)	36 (45.6)	NA
Operation time; min (IQR)	311 (150–390)	375 (271–437)	≤350.8
Intraop blood transfusion; n (%)	54 (16.9)	8 (22.2)	≤22.9
Median blood loss; mL	350 (200–600)	300 (130–525)	≤450
Blood loss ≥500 mL; n (%)	130 (40.8)	9 (25.0)	≤53.8
Blood loss ≥1000 mL; n (%)	47 (14.7)	3 (8.3)	≤32.0
Open conversion; n (%)	32 (10.0)	4 (11.1)	≤12.5
Postoperative LOS; d (IQR)	6 (5–10)	8 (6–10)	≤7
30 d readmission; n (%)	10 (3.1)	1 (2.8)	0.0
90 d morbidity; n (%)	89 (27.9)	9 (25.0)	≤23.8
Postoperative major morbidity; n (%)	32 (10.1)	3 (8.3)	≤2.8
Reoperation; n (%)	7 (2.2)	0	0
30 d mortality; n (%)	1 (0.3)	0	0
90 d mortality; n (%)	4 (1.3)	0	0
Failure to rescue; n (%)	1 (.3.1)	0	0
R1 (<1 mm) resection for malignancy (%)	76 (24.0)	3 (9.7)	0
TO; n (%)	104 (32.6)	10 (27.8)	>4

NA indicates not available.

study was the authors included various extents/types of liver resections, whereby 54% of the resections were partial LR, 24.4% were segmentectomies, and 21% were sectionectomies/more making the findings difficult to interpret and compare with our present study.

Benchmark values were also tested in 2 separate cohorts of patients: (1) a group of high-risk cases who underwent L-RPS/H67 in experienced expert centers and (2) a group of low-risk L-RPS/H67 who underwent resection at centers that did not meet the inclusion criteria as an expert center (Table 3). Important findings from this analysis were that while most outcomes fell within or close to benchmark cutoffs; postoperative morbidity, major morbidity, and 30-day readmissions were beyond benchmark cutoffs in both groups. The poorer outcomes observed in non-benchmark centers suggest that operative volume and experience may play a role in patient outcomes. Furthermore, high-risk cases such as patients with significant comorbidities, larger tumors, or advanced cirrhosis, not surprisingly, were also associated with poorer outcomes (mortality, reoperation, failure to rescue, 30-day readmission, 90-day morbidity, postoperative major morbidity, and R1 resection) even when performed in benchmark centers.[27,28] There were more outcome measures beyond benchmark values in this cohort, even when compared with that of low-risk benchmark cases performed in non-benchmark centers (30-day readmission, 90-day morbidity, postoperative major morbidity, R1 resection, and postoperative stay). These findings suggest that patient and procedure risk levels were major factors that affected the performance and achievement of predefined quality standards, even in the presence of adequate expertise.[2]

Ever since the first laparoscopic liver wedge resection was reported in 1991, there has been a rapid development of LLR over the past 3 decades.[29–33] Since then, many different types of complex LLR have been performed and the indications for LLR has expanded in many expert centers to procedures which were previously considered a contraindication to laparoscopy.[4,27,34] L-RPS/H67 is widely accepted as one of the most challenging LLRs to perform and is categorized under a procedure of "high difficulty" based on the Iwate criteria and the Institute Mutualiste Montsouris scoring system.[3,35] Despite the technical challenges, its advantages lie in the preservation of liver parenchyma resulting in a reduction in postoperative morbidity such as liver decompensation.[25] However, difficulty in accessing the posterior Glissonian inflow, exposure of the right hepatic vein, coupled with a wide surface area of transection across a horizontal plane increases the risk of intractable bleeding, bile leak and positive surgical margins.[8] Although numerous studies have demonstrated the feasibility and safety of L-RPS/H67,[8,10] it is still associated with a steep learning curve and is mainly performed only in experienced expert centers today.[12] Hence, defining benchmark cutoffs for L-RPS/H67 would prove useful for surgeons embarking on L-RPS/H67 as it provides a quantifiable reference of best achievable results when evaluating individual and center performance.

Another key finding in this study was the influence of geographic differences with respect to perioperative outcomes following L-RPS/H67 (Table 4). Asian benchmark centers performing L-RPS/H67, in general, had better perioperative outcomes such as reduced blood loss ≥500 mL, open conversion rate, and R1 resections compared with European centers. However, the postoperative LOS was longer as opposed to their Western counterparts. These findings are comparable to other international studies on liver resections which have been published previously.[2,36] While the reason for these findings cannot be definitively ascertained and deserves further investigation in the future, one possible reason would be the higher individual center volume in Asian centers compared with European centers in this study. The higher R1 resection rate observed in European centers could also be attributed to the difference in the type of indications for LR whereby CRLM was the main indication in European centers compared with HCC in Asian centers. The longer postoperative stay observed in Asian centers may be attributed to the cultural differences

TABLE 4. Summary and Comparison of the Outcomes in 254 Low-risk Cases Performed Stratified by Geographical Location: Europe and Asia and Statistical Comparison Between Asia and European Centers

	L-RPS/H67		
Variables	**Europe (N = 67)**	**Asia (N = 184)**	***P***
Operation time, min (IQR)	333 (240–390)	295 (225–375.5)	0.290
Intraoperative blood transfusion, n (%)	6 (9.0)	30 (16.3)	0.159
Median blood loss, mL (IQR)	250 (112.5–500)	325 (200–600)	0.114
Blood loss ≥ 500 mL, n (%)	14 (20.9)	71 (38.6)	**0.010**
Blood loss ≥ 1000 mL, n (%)	9 (13.4)	24 (13.0)	1.000
Open conversion, n (%)	10 (14.9)	12 (6.5)	**0.045**
Median postoperative LOS, days (IQR)	5 (3-7)	7 (5-9)	**< 0.001**
30 d readmission, n (%)	0	1 (0.5)	1.000
90 d morbidity, n (%)	14 (20.9)	27 (14.7)	0.250
Postoperative major morbidity, n (%)	3 (4.5)	8 (4.4)	1.000
Reoperation, n (%)	2 (3.0)	1 (0.5)	0.175
30 d mortality, n (%)	0	0	NA
90 d mortality, n (%)	1 (1.5)	0	0.267
Failure to rescue, n (%)	0	0	NA
R1 (< 1 mm) resection for malignancy (%)	12 (17.9)	9 (4.9)	**< 0.001**
TO, n (%)	29 (43.3)	58 (31.5)	0.099

Bold values are statistically significant $P < 0.05$
P value: comparison between Asian and European centers.
Centers from the Americas were excluded as there were only 3 cases.
IQR indicates interquartile range; NA, not available.

and variations in health care delivery systems between these two regions. Several studies previously evaluating health care behaviors and length of hospital stay between Asians and western patients consistently demonstrate a longer hospital stay with the former.[37,38] Further studies focusing on this subject are needed to clarify these findings. These studies should ideally control for differences in baseline characteristics and other potential confounding factors.

TABLE 5. Sixteen Benchmark Outcome Measures After L-RPS/H6/7 in Low-risk Cases From 40 Expert Centers Derived From Patients With HCC and CRLM

	L-RPS for Patients With HCC/H67 (N = 142)		L-RPS for Patients With CRLM/H67 (N = 51)		L-RH/H5678
Variables	**Median of Medians Across Centers (Range)**	**Benchmark Cutoff (75th Percentile)**	**Median of Medians Across Centers (Range)**	**Benchmark Cutoff (75th Percentile)**	**Benchmark Cutoff (75th Percentile)**
Operation time (min)	300.0 (175.0–390.0)	≤ 326.5	345.0 (230.0–499.0)	≤ 412.5	≤ 426
Estimated blood loss (mL)	350 (50–4750)	≤ 500	250 (100–1000)	≤ 425	≤ 400
Blood loss ≥ 500 mL (%)	33.3 (0.0–100.0)	≤ 55.0	30.0 (0.0–100.0)	≤ 52.3	≤ 47.1
Blood loss ≥ 1000 mL (%)	0.0 (0.0–50.0)	≤ 14.6	0.0 (0.0–100.0)	≤ 33.3	0
Intraoperative blood transfusion (%)	0.0 (0.0–50.0)	≤ 22.5	0.0 (0.0–66.7)	≤ 24.7	≤ 10.5
Open conversion (%)	0.0 (0.0–33.3)	≤ 6.3	0.0 (0.0–100.0)	≤ 26.7	≤ 13.0
Postoperative 90 d morbidity (%)	7.7 (0.0–100.0)	≤ 29.2	0.0 (0.0–33.3)	≤ 21.6	50
Postoperative major morbidity (%)	0.0 (0.0–33.3)	0	0.0 (0.0–33.3)	≤ 4.6	≤ 20
Reoperation (%)	0.0 (0.0–16.7)	0	0.0 (0.0–16.7)	0	0
30 d readmission (%)	0.0 (0.0–33.3)	0	0.0 (0.0–0.0)	0	≤ 8.3
Postoperative LOS	7 (5–14)	≤ 8	6 (4–11)	≤ 7	≤ 7.5
R1 (< 1 mm) resection (malignancy only)	0.0 (0.0–100.0)	0	0.0 (0.0–100.0)	≤ 18.2	≤ 18.2
Failure to rescue	0	0	0	0	0
30 d mortality (%)	0	0	0	0	0
90 d mortality (%)	0	0	0	0	0
TO (%)	50.0 (0.0–100.0)	> 17.8	50.0 (0.0–100.0)	> 0	NA

NA indicates not available.

Comparison between benchmark values of CRLM with HCC demonstrated that benchmark values for CRLM, such as operation time, open conversion rate, major morbidity, R1 resection, and no TOs were higher for CRLM. The higher R1 resection rate associated with CRLM may be explained by selection bias and currently accepted surgical practice whereby resection for multifocal tumors and a planned R1 resection (especially R1 vascular margin) is widely accepted for CRLM but less so for HCC. Similarly, the higher benchmark value observed for CRLM, such as open conversion rate, may likely be due to the confounding effect of geographical location whereby the proportion of liver resections for CRLM compared with HCC tended to be higher in western centers compared with those in the East. Nonetheless, it is difficult to explain the difference observed in major morbidity and operation time between both indications, and further studies are needed to clarify this.

To our knowledge, this is the first study to identify global benchmark values for L-RPS/H67. These findings suggest that L-RPS/H67 performed in expert centers today is associated with good outcomes. These benchmark values will serve as a useful comparative tool for surgeons embarking on L-RPS/H67 and also for surgeons adopting newer surgical modalities such as robotic surgery.

There are several limitations in this present study that are worth highlighting. Firstly, the retrospective nature of this study renders it susceptible to issues of bias and confounders. The use of prospective databases coupled with enrollment of only low-risk L-RPS/H67 cases from expert centers to derive benchmark values may, however, reduce selection bias. Secondly, it is important to highlight that for a highly complicated procedure like L-RPS/H67, it is likely that the procedure may not have completely matured even in some of the expert centers in this study. This hypothesis is supported by the significant open conversion rate of 9.1% observed in this study, even in low-risk benchmark cases (Table 2). Hence, we postulate that as centers become technically more proficient, there will be a need to revisit and update these benchmark values in the future. Finally, our study investigated only short-term perioperative outcomes rather than long-term sequelae following L-RPS/H67, this is especially important for resections involving malignancy. Future large-scale studies would be useful in understanding the long-term oncologic impact of L-RPS/H67.

CONCLUSIONS

We established the first global benchmark values for L-RPS/H67 utilizing a large international multicentric database. Cases selected for benchmarking were low-risk cases operated at expert centers, thereby representing the best possible outcomes of L-RPS/H67. The results of this study provide an up-to-date reference of the best achievable outcomes for the evaluation of surgical performance after L-RPS/H67 and allow for meaningful comparison between different practicing surgeons, institutions, and countries.

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REFERENCES

1. Staiger RD, Schwandt H, Puhan MA, et al. Improving surgical outcomes through benchmarking. *Br J Surg*. 2019;106:59–64.
2. Goh BKP, Han H-S, Chen K-H, et al. Defining global benchmarks for laparoscopic liver resections: an international multicenter study. *Ann Surg*. 2023;277:e839–e848.
3. Kawaguchi Y, Fuks D, Kokudo N, et al. Difficulty of laparoscopic liver resection: proposal for a new classification. *Ann Surg*. 2018;267:13–17.
4. Teo JY, Kam JH, Chan CY, et al. Laparoscopic liver resection for posterosuperior and anterolateral lesions-a comparison experience in an Asian centre. *Hepatobiliary Surg Nutr*. 2015; 4:379–390.
5. Nagino M, DeMatteo R, Lang H, et al. Proposal of a new comprehensive notation for hepatectomy: the "new world" terminology. *Ann Surg*. 2021;274:1–3.
6. Lee MKt Gao F, Strasberg SM. Completion of a liver surgery complexity score and classification based on an international survey of experts. *J Am Coll Surg*. 2016;223:332–342.
7. Chan FK, Cheng KC, Yeung YP, et al. Learning curve for laparoscopic major hepatectomy: use of the cumulative sum method. *Surg Laparosc Endosc Percutan Tech*. 2016;26:e41–e45.
8. Siddiqi NN, Abuawwad M, Halls M, et al. Laparoscopic right posterior sectionectomy (LRPS): surgical techniques and clinical outcomes. *Surg Endosc*. 2018;32:2525–2532.
9. Chiow AKH, Fuks D, Choi G-H, et al. International multicentre propensity score-matched analysis comparing robotic versus laparoscopic right posterior sectionectomy. *Br J Surg*. 2021;108:1513–1520.
10. Homma Y, Honda G, Kurata M, et al. Pure laparoscopic right posterior sectionectomy using the caudate lobe-first approach. *Surg Endosc*. 2019;33:3851–3857.
11. Ding Z, Fang H, Huang M, et al. Laparoscopic versus open in right posterior sectionectomy: a systematic review and meta-analysis. *Langenbecks Arch Surg*. 2023;408:25.
12. van der Heijde N, Ratti F, Aldrighetti L, et al. Laparoscopic versus open right posterior sectionectomy: an international,

multicenter, propensity score-matched evaluation. *Surg Endosc*. 2021;35:6139–6149.
13. Rossler F, Sapisochin G, Song G, et al. Defining Benchmarks for major liver surgery: a multicenter analysis of 5202 living liver donors. *Ann Surg*. 2016;264:492–500.
14. Muller X, Marcon F, Sapisochin G, et al. Defining benchmarks in liver transplantation: a multicenter outcome analysis determining best achievable results. *Ann Surg*. 2018;267: 419–425.
15. Sanchez-Velazquez P, Muller X, Malleo G, et al. Benchmarks in pancreatic surgery: a novel tool for unbiased outcome comparisons. *Ann Surg*. 2019;270:211–218.
16. Russolillo N, Aldrighetti L, Cillo U, et al. Risk-adjusted benchmarks in laparoscopic liver surgery in a national cohort. *Br J Surg*. 2020;107:845–853.
17. van der Poel MJ, Fichtinger RS, Bemelmans M, et al. Implementation and outcome of minor and major minimally invasive liver surgery in the Netherlands. *HPB (Oxford)*. 2019; 21:1734–1743.
18. Strasberg SM. Nomenclature of hepatic anatomy and resections: a review of the Brisbane 2000 system. *J Hepatobiliary Pancreat Surg*. 2005;12:351–355.
19. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg*. 2004;240:205–213.
20. Halls MC, Berardi G, Cipriani F, et al. Development and validation of a difficulty score to predict intraoperative complications during laparoscopic liver resection. *Br J Surg*. 2018;105:1182–1191.
21. Goh BKP, Prieto M, Syn N, et al. Validation and comparison of the Iwate, IMM, Southampton, and Hasegawa difficulty scoring systems for primary laparoscopic hepatectomies. *HPB (Oxford)*. 2021;23:770–776.
22. Ghaferi AA, Birkmeyer JD, Dimick JB. Complications, failure to rescue, and mortality with major inpatient surgery in medicare patients. *Ann Surg*. 2009;250:1029–1034.
23. Hobeika C, Fuks D, Cauchy F, et al. Benchmark performance of laparoscopic left lateral sectionectomy and right hepatectomy in expert centers. *J Hepatol*. 2020;73:1100–1108.
24. Gero D, Muller X, Staiger RD, et al. How to establish benchmarks for surgical outcomes?: a checklist based on an international expert delphi consensus. *Ann Surg*. 2022;275:115–120.
25. Willems E, D'Hondt M, Kingham TP, et al. Comparison between minimally invasive right anterior and right posterior sectionectomy vs right hepatectomy: an international multicenter propensity score-matched and coarsened-exact-matched analysis of 1,100 patients. *J Am Coll Surg*. 2022;235:859–868.
26. Lopez-Lopez V, Morise Z, Gavara CG, et al. Global outcomes benchmarks in laparoscpic liver surgery for segments 7 and 8: international multicenter analysis. *J Am Coll Surg*. 2024;239: 375–386.
27. Kabir T, Syn NL, Guo Y, et al. Laparoscopic liver resection for huge (>/=10 cm) hepatocellular carcinoma: a coarsened exact-matched single-surgeon study. *Surg Oncol*. 2021;37:101569.
28. Goh BKP, Syn N, Lee SY, et al. Impact of liver cirrhosis on the difficulty of minimally-invasive liver resections: a 1:1 coarsened exact-matched controlled study. *Surg Endosc*. 2021;35: 5231–5238.
29. Wakabayashi G, Cherqui D, Geller DA, et al. Recommendations for laparoscopic liver resection: a report from the second international consensus conference held in Morioka. *Ann Surg*. 2015;261:619–629.
30. Goh BK, Wang Z, Koh YX, et al. Evolution and trends in the adoption of laparoscopic liver resection in Singapore: analysis of 300 cases. *Ann Acad Med Singap*. 2021;50:742–750.
31. Chua D, Syn N, Koh YX, et al. Learning curves in minimally invasive hepatectomy: systematic review and meta-regression analysis. *Br J Surg*. 2021;108:351–358.
32. Goh BKP, Lee SY, Teo JY, et al. Changing trends and outcomes associated with the adoption of minimally invasive hepatectomy: a contemporary single-institution experience with 400 consecutive resections. *Surg Endosc*. 2018;32:4658–4665.
33. Reich H, McGlynn F, DeCaprio J, et al. Laparoscopic excision of benign liver lesions. *Obstet Gynecol*. 1991;78(pt 2):956–958.
34. Wang Z, Linn YL, Chong Y, et al. Laparoscopic versus open caudate lobe liver resections: a 1:2 propensity score-matched controlled study based on a single institution experience. *ANZ J Surg*. 2022;92:2157–2162.
35. Wakabayashi G. What has changed after the Morioka consensus conference 2014 on laparoscopic liver resection? *Hepatobiliary Surg Nutr*. 2016;5:281–289.
36. Tsilimigras DI, Sahara K, Moris D, et al. Assessing textbook outcomes following liver surgery for primary liver cancer over a 12-year time period at major hepatobiliary centers. *Ann Surg Oncol*. 2020;27:3318–3327.
37. Adepoju OE, Kim LH, Starks SM. Hospital length of stay in patients with and without serious and persistent mental illness: evidence of racial and ethnic differences. *Healthcare (Basel)*. 2022;10:1128.
38. Kondo A, Zierler BK, Isokawa Y, et al. Comparison of lengths of hospital stay after surgery and mortality in elderly hip fracture patients between Japan and the United States—the relationship between the lengths of hospital stay after surgery and mortality. *Disabil Rehabil*. 2010;32:826–835.