The challenge in determining difficulty of laparoscopic liver resection: are we there yet?

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Laparoscopic liver resection (LLR) has evolved and improved over the years with a corresponding expansion of its indications. In 2014, after the 2nd International Consensus Conference on LLR in Morioka, Japan, it was concluded that LLR can be the standard of care for minor resections and is in the exploration phase for major resections. With increasing evidence supporting its safety and benefits, along with the expansion of accepted indications, the popularity of LLR has grown with an exponential increase in the number of surgeons adopting LLR worldwide (1-6).

This has led to many surgeons in large centers around the world attempting more challenging cases as they grew in experience and case volume (7,8). This is despite the learning curve in LLR being significant as the complexity of various LLR procedures can be quite subjective and its difficulty often not well appreciated by surgeons early in their learning curve (4,9,10). With this rise in adoption of LLR by surgeons of variable experience and skill level around the world, there was a recognized need for a way stratify the difficulty that they may experience attempting LLR in their center, scoring systems in surgery are not new and can be useful in this context. If designed and developed well, it can serve as an objective way to guide decision making and case selection (11,12). It was therefore not surprising that the concept of a difficulty score in LLR was a hotly discussed topic in the last consensus meeting as well as in recent inaugural World Congress of International Laparoscopic Liver Society in Paris (2,13,14).

We read with great interest the study by Kawaguchi *et al.* titled: "Difficulty of Laparoscopic Liver Resection: Proposal for a New Classification", recently published in *Annals of Surgery*. They analyzed their extensive experience of 452 LLR over a 20-year period and proposed a new classification of LLR difficulty. They utilized three intra-operative parameters as surrogates of difficulty, namely, blood loss, operative time and conversion rate and used their measures of central tendency such as median values or overall rates as threshold for assigning the points. These points then grouped various LLR procedures into three groups (low, intermediate and high grades of difficulty) (*Tables 1,2*). After the grouping, they further reported that the post-operative outcomes such as overall morbidity and major complications correlated significantly with increasing groups of difficulty (15).

Based on the study population and outcome analysis of Kawaguchi *et al.*, they allocated 1 point for each factor (blood loss >100 mL; operative time >190 min; conversion rate >4.2%) and classified different LLR procedure into three groups based on the number of points each LLR procedure had (*Table 1*). They recommended that the group I procedures are less difficult and can be attempted by liver surgeons at the beginning LLR phase and group III procedures should only be performed by experts. This study provides valuable insight and evidence that further acknowledges that the challenges of LLR cannot be extrapolated from open approaches. It provides an easy-to-use guide of which LLR procedures are easier and which

Table 1 Study characteristics of Ban's and Kawaguchi's difficulty score

Variables	Ban *et al.* 2014	Kawaguchi *et al.* 2018
Country of origin	Japan	France
Study population characteristics		
Study design	Retrospective review	Retrospective review
Number of patients	86 (planned 30 at each centre)	452
Number of centres	3	1
Number of surgeons	4	1
Duration of study	2011–2014	1995–2015
Age, median [range], years	68 [28–87]	64 [24–89]
BMI, median [range] (kg/m^2)	23.0 [16.5–31.6]	24.7 [15.9–38.6]
No. of malignancy cases, n (%)	81 (94.2)	390 (86.3)
Pathology, n (%)	HCC: 54 (62.8)	CRLM: 248 (54.8)
	Metastatic carcinoma: 27 (31.4)	HCC: 43 (9.5)
	Benign: 5 (5.8)	IHCC: 26 (5.8)
		Others—malignant: 73 (16.2)
Anatomical resection, n (%)	46 (53.5)	299 (66.1)
Major liver resection, n (%)	23 (26.7)	174 (38.5)
Operative time, median [range], min	296 [66–672]	190 [25–600]
Blood loss, median [range], mL	191 [0–1,500]	100 [0–4,500]
Blood transfusion required, n (%)	Not stated	25 (5.6)
Conversion rate, n (%)	Not stated	19 (4.2)
Inclusion criteria	Selected cases	All consecutive patients
Exclusion criteria	Extrahepatic bile duct resection, lymph node dissection	Cyst fenestration, repeat LLR (except wedge), multiple liver resection (>4), vascular/biliary reconstruction, concomitant extrahepatic procedures (except cholecystectomy)
Scoring system		
Type of parameters used	Preoperative	Intraoperative
Parameters used to determine score	Tumor location	Operative time
	Extent of liver resection	Intraoperative blood loss
	Tumor size (< or ≥3 cm)	Conversion (based on the measures of central tendency)
	Proximity of major vessel	
	Liver function (Child-Pugh A/B)	
Classification of difficulty	Score based: 1–10	Procedure based: 3 groups
Recommendations	Low difficulty: beginner and <10 cases	Group I (low difficulty): beginner and <10 cases
	Intermediate: 10–49 LLR cases	Group II (intermediate difficulty): after completing low difficulty cases
	High difficulty: ≥50 LLR cases and regularly performing intermediate cases	Group III (high difficulty): experts only, regularly performing intermediate cases

HCC, hepatocellular carcinoma; CRLM, colorectal liver metastases; IHCC, intrahepatic cholangiocarcinoma; LLR, laparoscopic liver resection.

Table 2 Comparison of various laparoscopic resection difficulty scores

Variables	Kawaguchi *et al.* 2018	Ban *et al.* 2014	Wakabayashi *et al.* 2016 (IWATE criteria)	Hasegawa *et al.* 2017
Country of origin	France	Japan	International panel	Japan
Parameters used to determine score	Intraoperative blood loss	Tumor location	Tumor location (S1 and S4a, S4b added)	Tumor location
	Conversion (based on the measures of central tendency)	Extent of liver resection	Extent of liver resection	Extent of liver resection
		Tumor size (< or ≥3 cm)	Tumor size (< or ≥3 cm)	Obesity (BMI< or >30 kg/m^2)
		Proximity of major vessel	Proximity of major vessel	Platelet count (< or >100K)
		Liver function (Child-Pugh A/B)	Liver function (Child-Pugh A/B)	
			HALS/hybrid (minus 1 point)	
Classification of difficulty	Procedure based: 3 groups	Score based: 1–10	Score based: 0–12	Score based: 0–7
Levels of difficulty and its procedures	Group I (low difficulty): left lateral sectionectomy, wedge resections	Low: score 1–3 (e.g., simple and small partial hepatectomy in S3)	Low: score 0–3 (e.g., simple and small partial hepatectomy in S3)	Group 1 (low difficulty): 1 or less (e.g., non-anatomical, LLS)
	Group II (intermediate difficulty): anterolateral segmentectomy, left hepatectomy	Intermediate: score 4–6 (e.g., left lateral sectionectomy)	Intermediate: score 4–6 (e.g., left lateral sectionectomy)	Group 2 (medium difficulty): 2–3 (e.g., segment 7/8 tumours, anatomical resections)
	Group III (high difficulty): posterosuperior segmentectomy, right posterior sectionectomy, right hepatectomy, central hepatectomy, extended left/right hepatectomy	High: score 7–10 (e.g., simple hemihepatectomy)	Advanced: score 7–9 (e.g., simple hemihepatectomy)	Group 3 (high difficulty): 4 or more (e.g., major hepatectomy, tumour segment 7/8 with low platelets counts equal or less than 100)
			Expert: score 10–12 (posterior sectionectomy for S7 tumor ≥3 cm)	
Benefits	Large study population	Multicentre results across three expert institutions with cross review of preoperative data	More refined and comprehensive than the score of Ban *et al.*	Includes preoperative parameters to predict difficulty
	Intraoperative parameters used to design the score	Well-validated in several studies with correlation with surrogates of difficulty and outcome	Utilise routine pre-operative information during surgical planning	Removes cases on learning curve (1st 86 cases not included)
	Internally validated with postoperative outcomes	Larger proportion of cases with HCC	A larger gradient of difficulty scores and levels	Simple and easy to use score
	More applicable for practice with CRLM as the majority indication		International panel of experts' opinions	Significant proportion of cases with HCC
	Easy to use			Difficulty level correlated with postoperative outcomes

Table 2 (*continued*)

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Variables	Kawaguchi *et al.* 2018	Ban *et al.* 2014	Wakabayashi *et al.* 2016 (IWATE criteria)	Hasegawa *et al.* 2017
Limitations	Single expert surgeon experience	Small series, single country's experience	Not validated	Single centre experience
	Group III not well stratified	Difficulty level not correlated with postoperative outcomes	More complicated to calculate and difficult to remember	Excluded segment 1
	Low level of cirrhosis			Not validated
	Not validated			

HCC, hepatocellular carcinoma; HALS, hand-assisted laparoscopic surgery; LLS, left lateral sectionectomy; CRLM, colorectal liver metastases.

ones are more technically demanding. This is unique and objective as it is created from intra-operative data on the basis of common and well-established surrogates of technical difficulty such as blood loss, operative time and conversion rate. It was further internally validated with their postoperative outcomes. However, as the authors rightly pointed out, this study was limited by retrospective data from a single institution study by a single surgeon, albeit by a renowned institution lead by with an eminent expert and pioneer in LLR (Brice Gayet). It is also because this score is generated by a single group of expert surgeons, the arbitrary thresholds derived from their experience which provided the points (blood loss >100 mL; operative time >190 min; conversion rate >4.2%) may not hold true for the rest of the world, especially in centers or surgeons with less experience. Consequently, the difficulty score based on this expert group may be an under-estimation or an under-representation of the current reality in other centers.

Furthermore, some information was not available in the study including the proportion of patients with significant chronic liver disease such as cirrhosis or chemotherapy associated steatohepatitis. Not unsurprisingly, the majority of the indications were for colorectal liver metastases (CRLM) and hepatocellular carcinoma (HCC) accounted for less than 10% of their study population, consistent with the disease pattern common in the West. This differs from most centers in the East where patients with HCC on the background of cirrhosis account for a large proportion (4,16). This study and its findings are therefore likely more applicable to centers with similar disease pattern with CLRM as its major indication for liver resection. The classification may be less translatable to other regions of the world or centers which has a larger portion of cirrhotic and HCC patients.

If we were to solely consider complexity, traditional nomenclature such as the Brisbane classification in terms or what defines a major or minor resection in open liver surgery, are less applicable in LLR (17,18). Complexity or difficulty scores are not new in liver surgery, Lee *et al.* previously published a perceived complexity score for open liver resection based on a survey of 66 experts (11). Earlier, Ban *et al.* also published a difficultly score for LLR which has been validated by several groups since its introduction (19-23). The LLR difficulty score by Ban *et al.* was created by a group of Japanese LLR experts from multiple institutions based on factors that they deemed from their own subjective experience as factors that can potentially beget a LLR procedure less or more difficult (19,20). They identified five significant factors—the type of the planned LLR procedure, tumor location, presence of Child-Pugh B liver cirrhosis, tumor's size (3 cm), location and its proximity to major vessels (main or second order Glissonian pedicles, major hepatic veins or inferior vena cava). The degree of difficulty was assessed by the operator using a score of 1–10 and the score is then similarly translated to 3 levels of difficulty (low, intermediate and high). Linear modeling was performed and there was good inter-rater agreement concordance between the operators' and reviewers' assessments of difficulty. The value of score of Ban *et al.* lies in that it utilizes available and common factors all liver surgeons assess pre-operatively during their surgical planning, thus it is familiar and routine. It is a score ranging from 1–10, providing a more gradual gradient and finer distinction between procedures of increasing difficulty. This may be useful as it allows surgeons early in their LLR learning curve to adopt a gentler slope to climb and also provide guidance on the proper and appropriate selection of cases according to their level. This score was published in 2014 and therefore had the benefit of time, which allowed several groups including our own center to externally validate it (3,21-23). This score was later modified by Wakabayashi *et al.* and named it as the IWATE criteria by these additional refinements such as including segment 1, distinguishing segment 4 into S4a and S4b, adding hand-assisted/hybrid as another factor and having 4 levels based on 0–12 points [low (0–3), intermediate (4–6), advanced (7–9), expert(10–12)] (24). This IWATE score has yet to be validated.

Table 1 summarizes and compares the features of the two studies and their difficulty score. As illustrated, in Kawaguchi's study, group I and II has only two procedures per group and group III has six procedures. Without experience or a mentor's guidance, a beginner LLR surgeon may find it challenging to distinguish which of the six procedures in group III are more or less difficult. Some of the factors used in Ban's study and the IWATE criteria can help in this aspect. For the same procedure, there are nuances that contribute to its difficulty. For example, a right hepatectomy in cirrhotic patient with a large tumor near the hilum is quite different from a right hepatectomy in a patient with a normal liver and a small tumor far away from hilum. *Table 2* lists the procedures in the three groups in Kawaguchi's study and compares it alongside Ban's study, the IWATE criteria and Hasegawa's study, illustrating some of their similarities as well as their unique features (15,16,19,24). Each of the difficulty scoring systems has its own pros and cons (25). An ideal scoring system should be simple, accurate, quantitative, widely applicable and well validated. Its assessment factors should be easily available pre-operatively as well. While Kawaguchi's and Ban's score each have their merits, and in their way have helped advance the concept of an objective assessment of LLR difficulty, the perfect difficulty score is probably still a work-in-progress (16). There exists other known patient and tumor factors that have shown to affect the difficulty of a LLR, but have not been evaluated and/or left out in these scores. In a recent survey by the European-African Hepato-Pancreato-Biliary Association (E-AHPBA), there were 26 factors in four categories such as patient history, surgical history, tumor factors and planned operation that were identified from the literature to be potential factors that could affect the difficulty of LLR. The respondents used a modified Visual Analogue Scale (0–5) to rate how much each of the 26 factors they felt affected the difficulty of a resection. Based on the majority of the surgeons surveyed, it reported that difficulty was likely to be significantly increased by the following factors: a BMI >35, neo-adjuvant chemotherapy, repeated liver resection(s) and concurrent procedures. These factors have not been included in the existing difficulty scoring systems (25). Hasegawa *et al.* also recently published their version of a LLR difficulty score, using operative time as a predictor of difficultly, other than the additional similar factors they found as predictors, such as extent of resection, tumor location, BMI (< or >30 kg/m^2); platelet counts (< or > 100k) were also found as a significant factor in their score. These indicates that there may be some other factors that deserve a review, and may be considered to be incorporated in the design of a better and a more accurate score (16). These scores will benefit from larger multi-institutional studies from both Eastern and Western experience for external validation and further refinement of the ideal LLR difficulty score (16).

In summary, the study of Kawaguchi *et al.* has provided great insight from their breadth and depth of experience and has created a simple classification to guide surgeons on the difficulty of various LLR procedures. The perfect difficulty score is something we look forward to having one day. As with most things, it probably lies somewhere in between extremes: between one that is easy to use and one that is complex and rigorous enough to be accurate and applicable in most situations.

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