ORIGINAL ARTICLE

Are the current difficulty scores for Laparoscopic Liver Surgery telling the whole story? An international survey and recommendations for the future.

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ABSTRACT

Background: Recent studies have suggested that the difficulty of laparoscopic liver resections are related to both patient and tumour factors, however the available difficulty scoring systems only incorporate tumour factors. The aim of this study was to assess the opinion of laparoscopic liver surgeons regarding the factors that affect the perceived difficulty of laparoscopic liver resections.

Method: Using a Visual Analogue Scale an international survey of laparoscopic liver surgeons was undertaken to assess the perceived difficulty of 26 factors previously demonstrated to affect the difficulty of a laparoscopic liver resection.

Results: 80 surgeons with a combined experience of over 7,000 laparoscopic liver resections responded to the survey. The difficulty of laparoscopic liver surgery was suggested to be increased by a BMI>35 by 89% of respondents; neo-adjuvant chemotherapy by 79%; repeated liver resection by 99% and concurrent procedures by 59% however these factors have not been included in the previous difficulty scoring systems.

Discussion: The results suggests that the difficulty of laparoscopic liver surgery is not fully assessed by the available difficulty scoring systems and prompts the development of a new difficulty score that incorporates all factors believed to increase difficulty**.**

INTRODUCTION

The acquisition and mastery of a complex skill is conventionally achieved in a step-wise fashion, requiring the initial mastery of simple tasks with the addition of increasingly complex steps to achieve proficiency with more complex skills. Laparoscopic liver surgery has enjoyed an increase in its uptake in recent years [1] as a result of its excellent short and long-term outcomes [2-5]. However, its dissemination has been far slower than that seen with other laparoscopic specialities. Whilst, over 40% of colorectal resections are performed laparoscopically [6, 7], the same can not be said for laparoscopic liver surgery [8], which is still limited to a handful of specialist tertiary liver centres due, in part, to the difficulty of the procedures [9, 10].

The European Guidelines Meeting for Laparoscopic Liver Surgery (EGMLLS) was held in February 2017 with the specific intent of developing guidelines for the safe expansion of laparoscopic liver surgery [11]. During the meeting the need for a step-wise progression in the training of laparoscopic liver surgeons was specifically highlighted. While the EGMLLS produced the first evidence based and expert validated clinical practice recommendations earlier publications have supported the notion of incremental increases in difficulty in order to develop technical competency prior to progressing to more complex resections [8, 12].

In order that progressive steps may be taken during the training of a laparoscopic liver surgeon there must be an objective means of pre-operatively attributing difficulty to a given operation. Ban *et al* (2014) proposed “a novel difficulty scoring system for laparoscopic liver resection” that highlighted five factors that made the resection of a

neoplasm more difficult [13]. This has been followed recently by a classification system proposed by Kawaguchi *et al.* (2017), which groups operations by difficulty to allow for patient selection based on the experience of the surgeon [14]. These classifications correlate well with one another demonstrating that small peripheral resections in the left liver are less complex than large, central or postero-superior resections on the right. However, while these difficulty scoring systems provide useful guidance they are still not perfect as they focus entirely on tumour factors and resection type and overlook several patient factors that have been previously demonstrated to affect the difficulty of a laparoscopic liver resection including neo-adjuvant chemotherapy, repeated resection, body habitus / Body Mass Index (BMI), Age and diabetes [15 - 20].

The recent publication by van der Poel *et al* (2017) re-enforces the importance of a step-wise progression in the training of a laparoscopic liver surgeon [21] and the ability to pre-operatively estimate of the difficulty of a specific resection is integral to this. The current absence of a difficulty score that incorporates patient, surgeon and tumour factors suggests that not all the important variables have been adequately recognised. The aim of this study was to assess the opinion of international laparoscopic liver surgeons to establish the currently held beliefs as to which factors affect the difficulty of a laparoscopic liver resection and hence which factors should be considered for incorporation in future difficulty scoring systems.

METHOD

To establish which factors are currently regarded as influencing the difficulty of laparoscopic liver resections a comprehensive literature review was performed using Ovid Medline and Pubmed in July 2016. All studies in English with more than 10 patients describing “difficult” resections and those requiring “conversion” during laparoscopic liver surgery were reviewed. The results of this literature review were used to produce of an online survey of 26 factors (see appendix 1 for survey) that was sent directly to 190 established laparoscopic liver surgeons and was disseminated through the E-AHPBA website to its members.

The survey required the recipients to use a modified Visual Analogue Scale (VAS) to rate how the 26 factors found during the literature review affected the difficulty of a resection. A VAS was selected as it has been demonstrated to be simple to use, reproducible and allow the production of quantitative data from subjective opinion [(22)]. The scale ranged from 0 (the associated factor does not affect the difficulty of a laparoscopic liver resection) through to 5 (the associated factor adds maximal difficulty to a laparoscopic liver resection). In addition, the respondents were also asked to provide an estimate of how many laparoscopic liver resections they had personally performed.

Although it is not possible to attribute a single, specific value to the number of procedures a laparoscopic liver surgeon must perform to be proficient numerous papers have reported that the learning curve for minor resections is between 20 and 60 procedures, while that for major resections is between 30 and 60 procedures [(23 – 26)]. Hence, a subgroup analysis was performed comparing the responses of those surgeons

who had performed less than 100 procedures (still on the learning curve) with those who have performed more than 100 procedures (completed the learning curve) to establish the effect of increasing experience on the perception of difficulty in laparoscopic liver surgery.

For descriptive purposes the VAS scores were grouped as follows: 0 and 1 representing factors "*adding no or minimal difficulty to a laparoscopic liver resection*"; 2 and 3 "*adding moderate difficulty to a laparoscopic liver resection*" and 4 and 5 "*adding maximal difficulty to a laparoscopic liver resection*" with the mode (most frequent response) reported. Statistical analysis was performed on the original ungrouped data using IBM SPSS Statistics version 24. Tests for normality were performed using Kolmogorov–Smirnov and Shapiro–Wilk tests. The Mann-Whitney U test was used for non-parametric outcomes of binary variables and one-way ANOVA was used for comparison of multiple variables. Percentages are listed as whole numbers. Statistical significance was defined as $p<0.05$.

RESULTS

The survey returned 80 responses (42% response rate) from a mixed cohort of surgeons from Europe, Northern America and Asia with a collective experience of 7,196 laparoscopic liver resections. The median (range) was 34 (<10 to >650) laparoscopic liver resections. Nineteen respondents (24%) had performed over 100 procedures and were responsible collectively for 5,090 (71%) procedures, while 9 respondents (11%) had a personal experience of over 200 procedures and between them had a collective experience of 3,810 (53%) procedures. Regarding centres the median (range) was 80 (5 to >300) liver resections annually with 5% to 65% of these performed laparoscopically.

The responses of the whole cohort are shown in table 1. Factors associated with a clinically significant change in VAS (defined as a categorical change e.g. from "*adding no or minimal difficulty to a laparoscopic liver resection"* to *"adding moderate difficulty to a laparoscopic liver resection*") are shown in figure 1. Subgroup analysis comparing median VAS of the factors between surgeons with a personal experience of less than or greater than 100 laparoscopic liver resections are shown in Table 2.

DISCUSSION

This survey provides an accurate representation of the current opinion of international laparoscopic liver surgeons, both in terms of experienced and more junior surgeons. It reports the opinions of surgeons whom are collectively responsible for 7,196 procedures (at the time of survey). When this is considered with respect to the largest, and most recent, meta-analysis of laparoscopic liver surgery that reports 9,527 patients [(2)] it is reasonable to conclude that this survey provides a fair representation of the currently held beliefs.

The results highlight that both patient and tumour factors are believed to contribute to the difficulty of a laparoscopic liver resection. Among the factors believed to add moderate difficulty to a laparoscopic liver resection were an elevated BMI; neo-adjuvant chemotherapy; previous open abdominal surgery and concurrent procedures. Whilst previous liver resections and a close proximity to the major hilar structures were felt to add maximal difficulty. These results are supported by previous studies that demonstrated that these factors increase the likelihood of conversion during of laparoscopic liver resections [(15 - 20)] however they have not been included in the previous difficulty scores proposed by Ban *et al* (2014) and by Kawaguchi *et al* (2017) [(13, 14)].

Interestingly, the majority of factors were attributed the same difficulty ratings on the VAS within the sub-group analysis performed between surgeons whom had performed less than 100 procedures and those with more than 100 procedures. The only differences arose with respect to wedge resections; left lateral sectionectomies; the resections of lesions between 3 and 5cm in diameter and those deeper than 1cm

from the liver capsule that were attributed higher difficulty rating by less experienced surgeons.

The current results suggest that both experienced and relatively inexperienced laparoscopic liver surgeons believe multiple factors affect the difficulty of a laparoscopic liver resection. However, the currently available scoring systems used to estimate the difficulty of laparoscopic liver surgery do not take into account all the factors that are believed to affect difficulty. With the fundamental need to quantify the difficulty of a laparoscopic liver resection to enable pre-operative patient selection this study calls for the development of a new scoring system that incorporates patient factors, surgical history, as well as tumour and operative factors.

CONCLUSION

The acquisition of a complex skill requires a progressive, step-wise approach. In order that patients can be appropriately selected for a laparoscopic liver resection an objective, pre-operative difficulty scoring system must be available. The results of the current survey demonstrate that international laparoscopic liver surgeons believe that patient factors and surgical history play an important role in the difficulty of a given resection and hence should be included in future difficulty scoring systems.

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REFERENCES

1. Nguyen, Gamblin, Geller. **World Review of Laparoscopic Liver Resection 2,804 Patients**. Ann Surg. 2009: 250(5), 831-841.

2. Ciria, Cherqui, Geller, Briceno, Wakabayashi. **Comparative Short-term Benefits of Laparoscopic Liver Resection: 9000 Cases and Climbing.** Ann Surg. 2016: 263(4), 761-777.

3. Martínez-Cecilia, Cipriani, Vishal, Ratti, Tranchart, Barkhatov, et al. **Laparoscopic Versus Open Liver Resection for Colorectal Metastases in Elderly and Octogenarian Patients: A Multicenter Propensity Score Based Analysis of Short- and Long-term Outcomes.** Ann Surg. 2017: 265(6), 1192-1200.

4. Cipriani, Rawashdeh, Stanton, Armstrong, Takhar, Pearce, et al. **Propensity score-based analysis of outcomes of laparoscopic versus open liver resection for colorectal metastases.** Br J Surg. 2016: 103(11), 1504-1512.

5. Memeo, de'Angelis, Compagnon, Salloum, Cherqui, Laurent, Azoulay. **Laparoscopic vs. open liver resection for hepatocellular carcinoma of cirrhotic liver: a case-control study.** World J Surg. 2014: 38(11), 2919-2926.

6. Kwon, Billingham, Farrokhi, Florence, Herzig, Horvath, et al. **Adoption of laparoscopy for elective colorectal resection: a report from the Surgical**

Care and Outcomes Assessment Program. J Am Coll Surg. 2012: 214, 909–918.

7. Simorov, Shaligram, Shostrom, Boilesen, Thompson, Oleynikov. **Laparoscopic colon resection trends in utilization and rate of conversion to open procedure: a national database review of academic medical centers**. Ann Surg. 2012: 256(3), 462–468.

8. Coelho, Kruger, Fonseca, Araujo, Jeismann, Perini, et al. **Laparoscopic liver resection: Experience based guidelines.** World J Gastrointest Surg. 2016: 27(8), 5-26.

9. Tzanis, Shivathirthan, Laurent, Abu Hilal, Soubrane, Kazaryan, et al. **European experience of laparoscopic major hepatectomy.** J Hepatobiliary Pancreat Sci. 2013: 20(2), 120-124.

10. de'Angelis, Memeo, Calderaro, Felli, Salloum, Compagnon, et al. **Open and laparoscopic resection of hepatocellular adenoma: trends over 23 years at a specialist hepatobiliary unit.** HPB (Oxford). 2014: 16(9), 783-788.

11. Abu Hilal. **Why do we need guidelines in laparoscopic liver surgery?** HPB (Oxford). 2017: 19(4), 287-288.

12. Kluger, Vigano, Barroso and Cherqui. **The learning curve in laparoscopic major liver resection**. J Hepatobiliary Pancreat Sci. 2013: 20(2), 131-136.

13. Ban, Tanabe, Otsuka, Nitta, Abe, Hasegawa, et al. **A novel scoring system for laparoscopic liver resection**. J Hepatobiliary Pancreat Sci. 2014: 21(10), 745-753.

14. Kawaguchi, Fuks, Kokudo, Gayet. **Difficulty of Laparoscopic Liver Resection: Proposal for a New Classification**. Ann Surg. 2017. Epub ahead of print.

15. Halls, Cipriani, Berardi, Barkhatov, Lainas, Alzoubi, et al. **Conversion for unfavourable intra-operative events results in significantly worst outcomes during laparoscopic liver resection: Lessons learned from a multi-centre review of 2,861 cases.** Ann Surg. Epub ahead of print.

16. Ratti, D'alessandro, Ciprianni, Giannone, Catena, Aldrighetti. **Influence of Body Habitus on Feasibility and Outcome of Laparoscopic Liver Resections: A Prosective Study**. J Hepatobiliary Pancreat Sci. 2016: 23, 373-381.

17. Yu, Yu, Fang. **The Impact of Body Mass Index on Short-Term surgical outcomes after laparoscopic hepatectomy, a retrospective study**. BMC Anesthesiology. 2016: 16(29).

18. Cauchy, Fuks, Nomi, Schwarz, Dokmak, Scatton, et al. **Risk Factors and consequences of conversion in laparoscopic major liver resection**. Br J Surg. 2015: 102(7), 785-795.

19. Shelat, Serin, Samim, Besselink, Saati, Gioia, et al. **Outcomes of repeat laparoscopic liver resection compared to the primary resection.** World J Surg. 2014: 38, 3175-3180.

20. Costi, Scatton, Haddad, Randone, Andaus, Massault, Soubrane. **Lessons learned from the first 100 laparoscopic liver resections: not delaying conversion may allow reduced blood loss and operative time**. J laparoendosc Adv Surg Tech. 2012: 22(5), 425-431.

21. van der Poel, Huisman, Busch, Abu Hilal, van Gulik, Tanis and Besselink. **Stepwise introduction of laparoscopic liver surgery: validation of guideline recommendations.** HPB. ePub ahead of print.

22. Miller and Ferris. **Measurement of subjective phenomena in primary care research: The Visual Analogue Scale.** Family practice Research Journal. 1993: 13(1), 15-24.

23. Vigano, Laurent, Tayar et al. **The learning curve in Laparoscopic Liver Resection: Improved Feasibility and Reproducibility.** Annals of Surgery. 2009: 250 (5), 772-782.

24. Dagher, Gayet, Tzanis et al. **International experience for laparoscopic major liver resection**. J Hepatobiliary Pancreat Sci. 2014: 21(10), 732-736.

25. Hasegawa, Nitta, Takahara et al **Safely extending the indications of laparoscopic liver resection: When should we start laparoscopic major hepatectomy?** Surg Endosc. 2016.

26. Van der Poel, Besselink, Cipriani et al. **Outcome and learning curve in 159 consecutive patients undergoing total laparoscopic hemihepatectomy**. JAMA Surg. 2016.

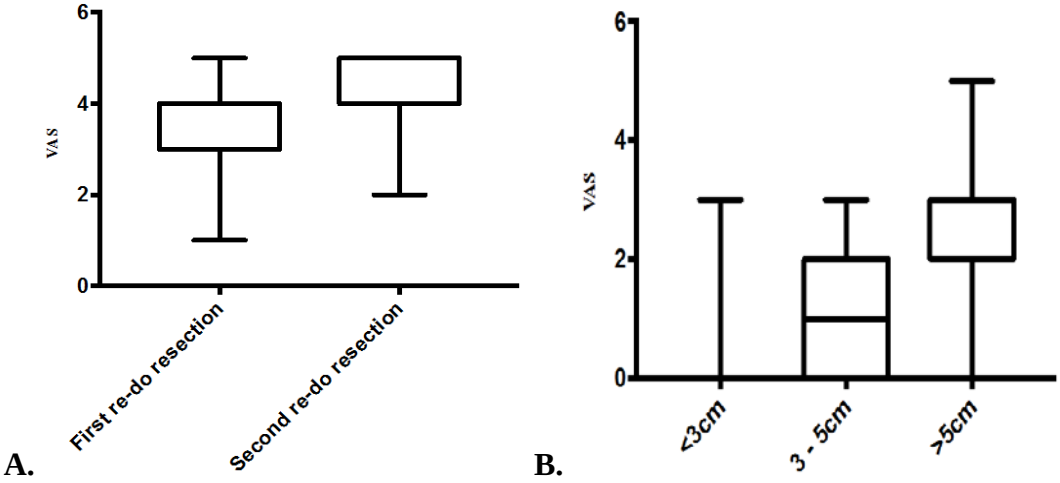
Table 1. Responses from the entire cohort (n=80)

Category	Factors	Percentage response		
		Adds no / minimal difficulty (VAS 0 & 1)	**Adds moderate difficulty (VAS 2 & 3)**	**Adds maximal difficulty (VAS 4 & 5)**
Patient factors	BMI >30	40	**51**	9
	BMI >35	11	**48**	41
	Male gender	**79**	21	0
	Age > 65	**85**	13	2
	Age >75	**71**	21	8
	ASA >3	**45**	36	19
	Cirrhosis	4	31	**65**
	Neo-adjuvant Chemotherapy	21	**58**	21
Surgical history	Previous laparoscopic surgery	**69**	26	5
	Previous open surgery	23	**65**	12
	Previous liver resection	1	**51**	48
	Two previous liver resections	0	19	**81**
Tumour factors	Benign lesion	**96**	4	0
	Lesion size <3cm	**96**	4	0
	Lesion size 3-5cm	**64**	36	0
	Lesion size >5cm	24	**54**	22
	Deep location (>1cm from capsule)	35	**50**	15
	Lesion <2cm from hilum / IVC	14	42	**44**
Planned operation	Wedge resection	**78**	22	0
	Anatomical Segmentectomy	41	**48**	11
	Left Lateral Sectionectomy	**91**	5	4
	Left Hepatectomy	31	**54**	15
	Right Hepatectomy	14	**47**	39
	Anterior Sectionectomy	15	41	**44**
	Posterior Sectionectomy	9	27	**64**
	Concurrent procedure	41	**53**	6

Table 2. Comparative VAS (median and inter-quartile ranges (IQR)) between surgeons with a personal experience of less than 100 laparoscopic liver resections and more than 100 laparoscopic liver resections

Factor	**Median (IQR) VAS for surgeons with <100 procedures (n=61)**	**Median VAS (IQR) for surgeons with >100 procedures (n=19)**	**p-value**
BMI >30	2 (0 – 3)	2 (0 – 3)	0.903
BMI >35	3 (2 – 4)	3 (2 – 4)	0.436
Male gender	0 (0 – 1)	0 (0 – 1)	0.573
Age > 65	0 (0)	0 (0 – 1)	0.767
Age >75	0 (0 – 2)	1 (0 – 2)	0.510
ASA >3	2 (1 – 3)	1 (1 – 3)	0.367
Cirrhosis	4 (3 – 5)	4 (3 – 4)	0.661
Neo-adjuvant Chemotherapy	2 (2 – 3)	3 (2 – 4)	0.186
Previous laparoscopic surgery	1 (0 – 2)	1 (1 – 2)	0.190
Previous open surgery	3 (1 – 3)	3 (2 – 3)	0.519
Previous liver resection	3 (3 – 4)	3 (3 – 4)	0.719
Two previous liver resections	4 (4 – 5)	4 (4 – 5)	0.767
Benign Lesion	0 (0 – 1)	0 (0)	0.186
Lesion size <3cm	0 (0)	0 (0)	0.94
Lesion size 3-5cm	**1 (1 – 2)**	**1 (0 – 1)**	**0.020**
Lesion size >5cm	2 (2 – 4)	2 (1 – 2)	0.070
Deep location (>1cm from capsule)	**2 (1 – 3)**	**1 (1 – 2)**	**0.045**
Lesion <2cm from Hilum / IVC	4 (2 – 4)	3 (2 – 3)	0.153
Wedge resection	**1 (0 – 2)**	**0 (0)**	**0.012**
Anatomical segmentectomy	2 (1 – 3)	2 (1 – 3)	0.902
Left lateral sectionectomy	**0 (0 – 1)**	**0 (0)**	**0.043**
Left Hepatectomy	2 (1 – 3)	2 (1 – 3)	0.206
Right Hepatectomy	3 (2 – 4)	3 (2 – 4)	0.987
Anterior sectionectomy	3 (2 – 5)	3 (3 – 4)	0.911
Posterior sectionectomy	4 (3 – 5)	4 (3 – 5)	0.183
Concurrent Procedure	2 (1 – 3)	2 (1 – 2)	0.661

Figure 1. Box-and-whisker plots of VAS reported by surgeons of difficulty added by A. Repeated resection (p<0.001) and B. Tumour size (<0.001).



Appendix 1. Pre-operative assessment of complexity of laparoscopic liver surgery survey.

1. For each of the following factors please indicate whether each makes the perceived operation more difficult (option given to select one score ranging from 0 (adds no difficulty) to 5 (adds maximal difficulty)):

Factors:
BMI >30
BMI >35
Male gender
Age > 65
Age >75
ASA >3
Cirrhosis
Neo-adjuvant Chemotherapy
Previous Laparoscopic Surgery
Previous Open Surgery (midline)
Previous Liver Resection (first re-do resection)
Previous Liver Resection (second re-do resection)
Concurrent Procedure (e.g. colonic resection)
Benign Lesion
Tumour size <3cm
Tumour size 3 - 5cm
Tumour size >5cm
Deep location (>1cm from capsule)
Lesion <2cm from Hilar structures / IVC
Wedge Resection (any segment)
Anatomical Segmentectomy
Left Lateral Sectionectomy
Left Hepatectomy
Right Hepatectomy
Anterior Sectionectomy (right-sided)
Posterior Sectionectomy (right-sided)

2. Name of surgeon completing form (optional):

3. Surgeon: Approximate number of laparoscopic liver resections performed (cumulative)

4. Centre: Total number of liver resections per year (open, hybrid or laparoscopic)

5. Centre: Approximate number of liver resections performed (cumulative)

6. Centre: Proportion of resections performed by laparoscopy (%)