Original article

Performance of a modified three-level classification in stratifying open liver resection procedures in terms of complexity and postoperative morbidity

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Background: **Traditional classifications for open liver resection are not always associated with surgical complexity and postoperative morbidity. The aim of this study was to test whether a three-level classification for stratifying surgical complexity based on surgical and postoperative outcomes, originally devised for laparoscopic liver resection, is superior to classifications based on a previously reported survey for stratifying surgical complexity of open liver resections, minor/major nomenclature or number of resected segments.**

Methods: **Patients undergoing a first open liver resection without simultaneous procedures at MD Anderson Cancer Center (Houston cohort) or the University of Tokyo (Tokyo cohort) were studied. Surgical and postoperative outcomes were compared among three grades: I (wedge resection for anterolateral or posterosuperior segment and left lateral sectionectomy); II (anterolateral segmentectomy and left hepatectomy); III (posterosuperior segmentectomy, right posterior sectionectomy, right hepatectomy, central hepatectomy and extended left/right hepatectomy).**

Results: **In both the Houston (1878 patients) and Tokyo (1202) cohorts, duration of operation, estimated blood loss and comprehensive complication index score differed between the three grades (all $P < 0{\cdot}050$) and increased in stepwise fashion from grades I to III (all $P < 0{\cdot}001$). Left hepatectomy was associated with better surgical and postoperative outcomes than right hepatectomy, extended right hepatectomy and right posterior sectionectomy, although these four procedures were categorized as being of medium complexity in the survey-based classification. Surgical outcomes of minor open liver resections also differed between the three grades (all $P < 0{\cdot}050$). For duration of operation and blood loss, the area under the curve was higher for the three-level classification than for the minor/major or segment-based classification.**

Conclusion: **The three-level classification may be useful in studies analysing open liver resection at Western and Eastern centres.**

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Introduction

Classifications of liver resections in terms of complexity are useful for patient counselling, surgical education and clinical research[1–6]. Tung[1] introduced the terms ‘minor’ and ‘major’ liver resection in 1979, and originally defined major liver resection as resection of at least two sections (where a section is equivalent to Couinaud segment(s) II + III, IV, V + VIII or VI + VII). More recently, many authors have used the term major liver resection for three or more contiguous segments to compare patient cohorts in terms of complexity of liver resection procedures[7–10]. Others have classified liver resection procedures as wedge resection, segmentectomy, sectionectomy or hemihepatectomy according to the number of resected Couinaud segments[11–14]. However, the minor/major classification and the segment-based classification do not always stratify procedures effectively with respect to surgical and postoperative outcomes[5,6,15,16].

Recently, some new three-level classifications have been reported for open liver resection (OLR)[16] and laparoscopic liver resection (LLR)[6]. The three-level classification for OLR[16], the S-L classification, is based on surgeons' responses to two international web surveys and categorizes 19 OLR procedures as being of low, medium or high complexity. The three-level classification for LLR[6], the G-K classification, is based on duration of operation, estimated blood loss and rate of conversion to open surgery, and categorizes 11 LLR procedures as being of low, intermediate or high difficulty (grade)[6]. Interestingly, the three-level LLR classification partially overlaps with the three-level OLR classification. In the present study, it was hypothesized that a three-level classification based on the G-K classification would stratify OLR procedures with respect to surgical complexity and postoperative outcomes more accurately than the S-L, minor/major or segment-based classifications.

To test this hypothesis, the performance of the classifications in stratifying OLR procedures was compared in terms of duration of operation, estimated blood loss and comprehensive complication index (CCI) score in Western and Eastern cohorts with different patient demographics and clinical characteristics.

Methods

Prospectively compiled databases were searched to identify consecutive patients who underwent liver resection at MD Anderson Cancer Center during 1998–2016, or who had liver resection for hepatocellular carcinoma or liver metastases from colorectal, gastric or neuroendocrine cancer at the University of Tokyo during 1994–2014. Those who had undergone biliary reconstruction, LLR, repeat liver resection, concomitant extrahepatic procedures (except cholecystectomy), or multiple wedge resections and/or segmentectomies were excluded. All operations were performed after informed consent had been obtained. The study was approved by the MD Anderson Cancer Center and University of Tokyo institutional review boards.

Liver resection classification systems

A three-level liver resection classification was used in this study. This was a modified version of the previously reported G-K classification (*Fig. 1*), which classifies 11 different LLR procedures as grade I (low difficulty), grade II (intermediate difficulty) or grade III (high difficulty) according to duration of operation, estimated blood loss and rate of conversion to open surgery[6]. When LLR procedures were classified according to the original G-K classification, morbidity rates increased in stepwise fashion from grade I to grade III[6]. Typically, wedge resection is defined as resection of less than one Couinaud segment, and segmentectomy as resection of one Couinaud segment. However, wedge resection may include a wide variety of surgical complexity, such as a procedure involving removal of almost an entire Couinaud segment. In the modified G-K classification used in the present study, the definition of wedge resection was narrowed to 'resection of less than one Couinaud segment for removal of a tumour less than 3 cm in diameter'. The definition of segmentectomy was expanded to 'resection of less than one Couinaud segment for removal of a tumour at least 3 cm in diameter or anatomical removal of one Couinaud segment'. This definition is in line with other studies[16–19] that stratified the difficulty of LLR and OLR.

The S-L classification used in this study[16] (*Fig. 1*) is an updated version of the original classification[5] and classifies 19 different OLR procedures as being of low, medium or high complexity. The classification is based on two international web-based surveys in which liver surgeons rated OLR procedures on a scale from 1 (easier) to 10 (most difficult).

The minor/major and segment-based classifications included the same 11 liver resection procedures as the original G-K classification (*Fig. 1*). In the minor/major classification, resection of less than three contiguous Couinaud segments was defined as minor liver resection, and resection of three or more contiguous Couinaud segments as major liver resection[3,16]. In the segment-based classification, OLR procedures were classified as entailing resection of one Couinaud segment or less, two contiguous Couinaud segments, or three or more contiguous Couinaud segments (*Fig. 1*).

Definitions

Duration of operation was measured as time from first skin incision to final skin closure. Estimated blood loss was based on the official anaesthesia record at the end of the operation. Surgical complications were defined as any deviation from the normal postoperative course within 90 days after hepatic resection. These were scored using the CCI[20] and graded according to the Clavien–Dindo classification[21], in which grade IIIa or higher complications are considered major. Postoperative hepatic insufficiency was defined by a postoperative peak serum total bilirubin level greater than 7 mg/dl[22,23]. Bile leak was defined according to the International Study Group of Liver Surgery criteria[24]. Liver resections were defined in accordance with the Brisbane 2000 Terminology[25].

Fig. 1 Classifications of liver resection procedures

a G-K LLR classification

Grade I (low difficulty)
- Wedge resection (AL segment*)
- Wedge resection (PS segment†)
- Left lateral sectionectomy

Grade II (intermediate difficulty)
- Segmentectomy (AL segment*)
- Left hepatectomy

Grade III (high difficulty)
- Segmentectomy (PS segment†)
- Right hepatectomy
- Extended right hepatectomy
- Right posterior sectionectomy
- Central hepatectomy
- Extended left hepatectomy

b S-L OLR classification

Low complexity
- Peripheral wedge resection < 3 cm
- Left lateral sectionectomy

Medium complexity
- Left hepatectomy without CR
- Right hepatectomy without CR
- Right posterior sectionectomy
- Left hepatectomy with CR
- Isolated CR
- Right trisectionectomy without CR

High complexity
- Right anterior sectionectomy
- Right hepatectomy with CR
- Righ hepatectomy with HJ
- Anatomical middle hepatectomy
- Right trisectionectomy with CR
- Left trisectionectomy without CR
- Right trisectionectomy with HJ
- Left trisectionectomy with CR
- Right hepatectomy with PVR‡
- Right trisectionectomy with PVR‡
- Right hepatectomy with IVC reconstruction

c Minor/major classification§

Minor
- Grade I
  - Wedge resection (Al segment*)
  - Wedge resection (PS segment†)
  - Left lateral sectionectomy
- Grade II
  - Segmentectomy (AL segment*)
- Grade III
  - Segmentectomy (PS segment†)
  - Right posterior sectionectomy

Major
- Grade II
  - Left hepatectomy
- Grade III
  - Right hepatectomy
  - Extended right hepatectomy
  - Central hepatectomy
  - Extended left hepatectomy

d Segment-based classification§

≤ 1 segment or less
- Grade I
  - Wedge resection (Al segment*)
  - Wedge resection (PS segment†)
- Grade II
  - Segmentectomy (AL segment*)
- Grade III
  - Segmentectomy (PS segment†)

2 segments
- Grade I
  - Left lateral sectionectomy
- Grade III
  - Right posterior sectionectomy

≥ 3 segments
- Grade I
  - Left hepatectomy
- Grade III
  - Right hepatectomy
  - Extended right hepatectomy
  - Central hepatectomy
  - Extended left hepatectomy

a G-K classification of laparoscopic liver resection (LLR) procedures[6]. Left hepatectomy – resection of segments II, III and IV ± I; right hepatectomy – resection of segments V, VI, VII and VIII ± I; extended right hepatectomy – resection of segments IV, V, VI, VII and VIII ± I; right posterior sectionectomy – resection of segments VI and VII; central hepatectomy – resection of segments V and VIII or segments IV, V and VIII; extended left hepatectomy – resection of segments I, II, III, IV, V and VIII. **b** S-L classification of open liver resection (OLR) procedures[16]. **c** Minor/major classification. **d** Segment-based classification. *Anterolateral (AL) segments are defined as Couinaud segments II, III, IVb, V and VI. †Posterosuperior (PS) segments are defined as Couinaud segments I, IVa, VII and VIII. ‡Main to left. §Grade refers to grade in the G-K LLR classification. CR, caudate resection; HJ, hepaticojejunostomy; PVR, portal vein reconstruction; IVC, inferior vena cava.

Comparison of classifications

The performance of the modified three-level G-K classification was compared with that of the other three classifications in stratifying OLR procedures with respect to surgical and postoperative outcomes.

To test whether the new classification categorized OLR procedures in three levels more effectively than the S-L classification or minor/major classification, 11 different OLR procedures (*Fig. 1a*) and the six 'minor' OLR procedures (*Fig. 1c*) were grouped using the modified G-K classification, and surgical and postoperative outcomes were compared between procedures in the three levels of the modified G-K classification. To compare the modified G-K and S-L classifications, outcomes of left hepatectomy, classified as a procedure of intermediate/medium complexity in the modified G-K and S-L classifications, were compared with outcomes of right hepatectomy, extended right hepatectomy (or right trisectionectomy) and right posterior sectionectomy. These are classified as high-complexity procedures in the modified G-K classification, but medium-complexity procedures in the S-L classification (*Fig. 1*).

To test whether the modified G-K classification performed better than the minor/major or segment-based classification, the areas under the receiver operating characteristic (ROC) curves (AUCs) were compared. This analysis was not performed for the S-L classification because wedge resection for tumours with a diameter of 3 cm or more and resection of one Couinaud segment were not classified in the S-L classification.

In addition, surgical and postoperative outcomes of wedge resection and segmentectomy were compared between anterolateral (AL) and posterosuperior (PS) segments, because stratification according to AL or PS segments has been established for LLR but not OLR[6,26–28].

Statistical analysis

Categorical variables, expressed as numbers and percentages, were compared using Fisher's exact test or χ^2 test as appropriate. CCI scores, presented as mean(s.d.), were compared among groups using Student's *t* test for two groups or ANOVA for three groups. Other continuous variables are presented as median (i.q.r.), and were compared using Wilcoxon's rank-sum test for two groups or the Kruskal–Wallis test for three groups. Holm's method[29] was used to adjust *P* values in multiple testing of the variables in the three groups. Trends in intraoperative and postoperative outcomes with a stepwise increase from grade I to grade III were evaluated using the Cochran–Armitage trend test[30] for categorical variables and Jonckheere–Terpstra trend test[31] for continuous variables. The sensitivity and specificity of each classification were estimated by ROC curve analysis, and AUCs were compared to evaluate the diagnostic performance of each classification using the method described by DeLong and colleagues[32]. A CCI score of 26·2, which corresponds to one postoperative complication of Clavien–Dindo grade IIIa, was used as the threshold between high (CCI score 26·2 or higher) and low (CCI score less than 26·2) complication severity[10]. $P \leq 0{\cdot}050$ was considered statistically significant. Statistical analysis was undertaken in SAS® version 9.4 (SAS Institute, Cary, North Carolina, USA) and EZR (Saitama Medical Centre, Jichi Medical University, Saitama, Japan), a graphical user interface for R software (R Foundation for Statistical Computing, Vienna, Austria)[33].

Results

Of 3898 patients who underwent liver resection at MD Anderson Cancer Center during 1998–2016, 1878 (48·2 per cent) met the selection criteria and were included. Of 2623 patients who had liver resection for hepatocellular carcinoma or liver metastases at the University of Tokyo during 1994–2014, 1202 (45·8 per cent) met the inclusion criteria (*Fig. S1*, supporting information). Hereafter, these groups are referred to as the Houston cohort and Tokyo cohort respectively. Demographic and clinical characteristics of the cohorts are summarized in *Table S1* (supporting information). Median age and the male : female ratio were lower in the Houston cohort (both $P < 0{\cdot}001$). The most common indication for OLR was colorectal liver metastasis (62·1 per cent of patients) in the Houston cohort and hepatocellular carcinoma (71·2 per cent) in the Tokyo cohort.

Surgical and postoperative outcomes by procedure

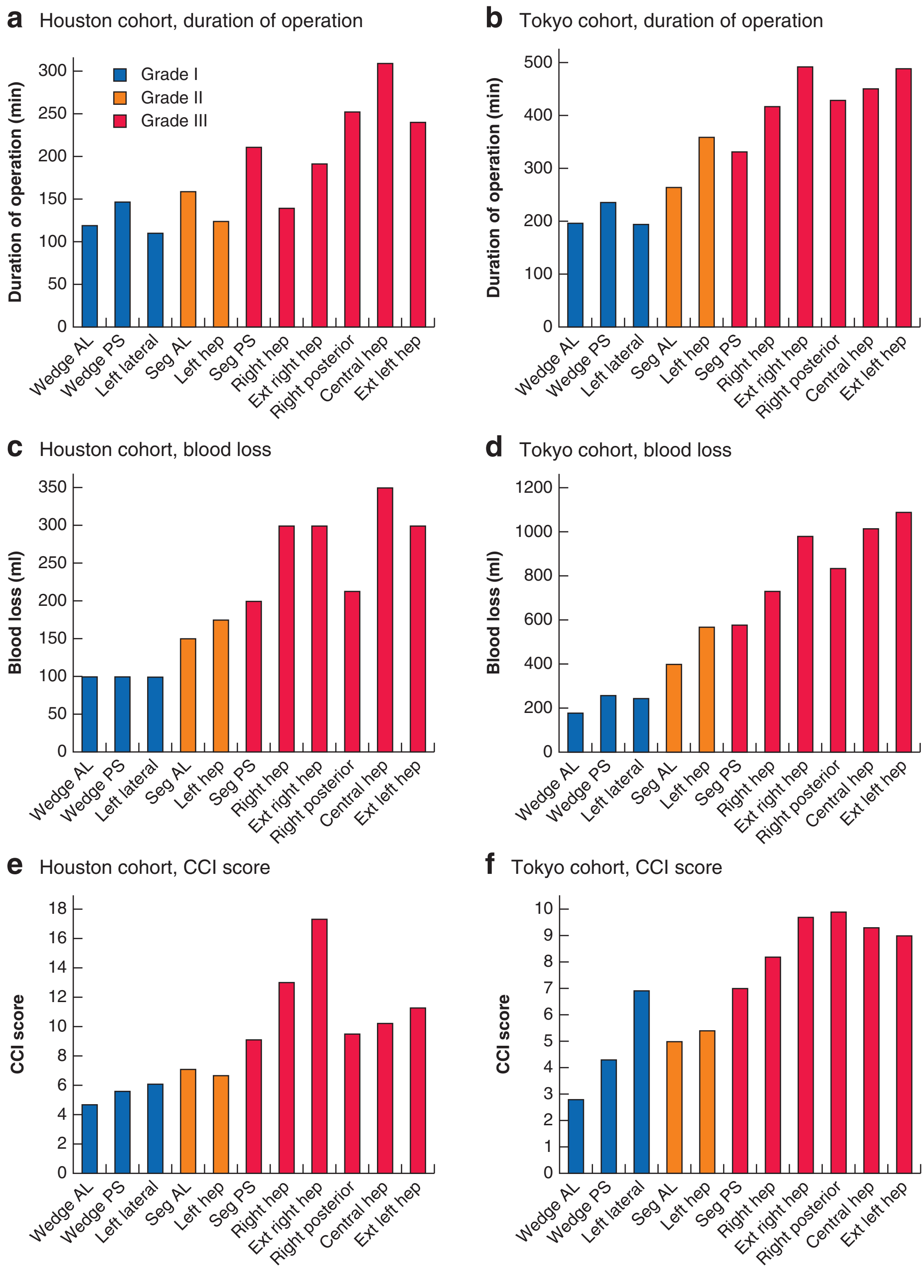
Surgical and postoperative outcomes of the 11 OLR procedures according to the modified G-K classification are shown in *Fig. 2*. The overall 90-day mortality rate was 2·2 per cent in the Houston cohort and 0·2 per cent in the Tokyo cohort.

Performance of the modified G-K classification

Demographic and clinical characteristics of the Houston and Tokyo cohorts by OLR grade in the modified G-K classification are summarized in *Table S2* (supporting information). Surgical and postoperative outcomes in the two cohorts by grade in the modified G-K classification are shown in *Fig. 3*. In both cohorts, duration of operation and estimated blood loss were higher for grade III than for grade I, for grade III than for grade II, and for grade II than for grade I ($P < 0{\cdot}001$). In both cohorts, the CCI score was higher for grade III than for grade I ($P < 0{\cdot}001$) and for grade III than for grade II ($P < 0{\cdot}001$), but the CCI score did not differ between grades I and II (Houston cohort, $P = 0{\cdot}320$; Tokyo cohort, $P = 0{\cdot}426$). In both cohorts, duration of operation, estimated blood loss and CCI score increased in stepwise fashion from grade I to grade III ($P < 0{\cdot}001$) (*Fig. 3*; *Table S3*, supporting information). In both cohorts, the rates of major complication, bile leak and pulmonary complications were associated with a stepwise increase from grade I to grade III ($P < 0{\cdot}001$) (*Table S3*, supporting information).

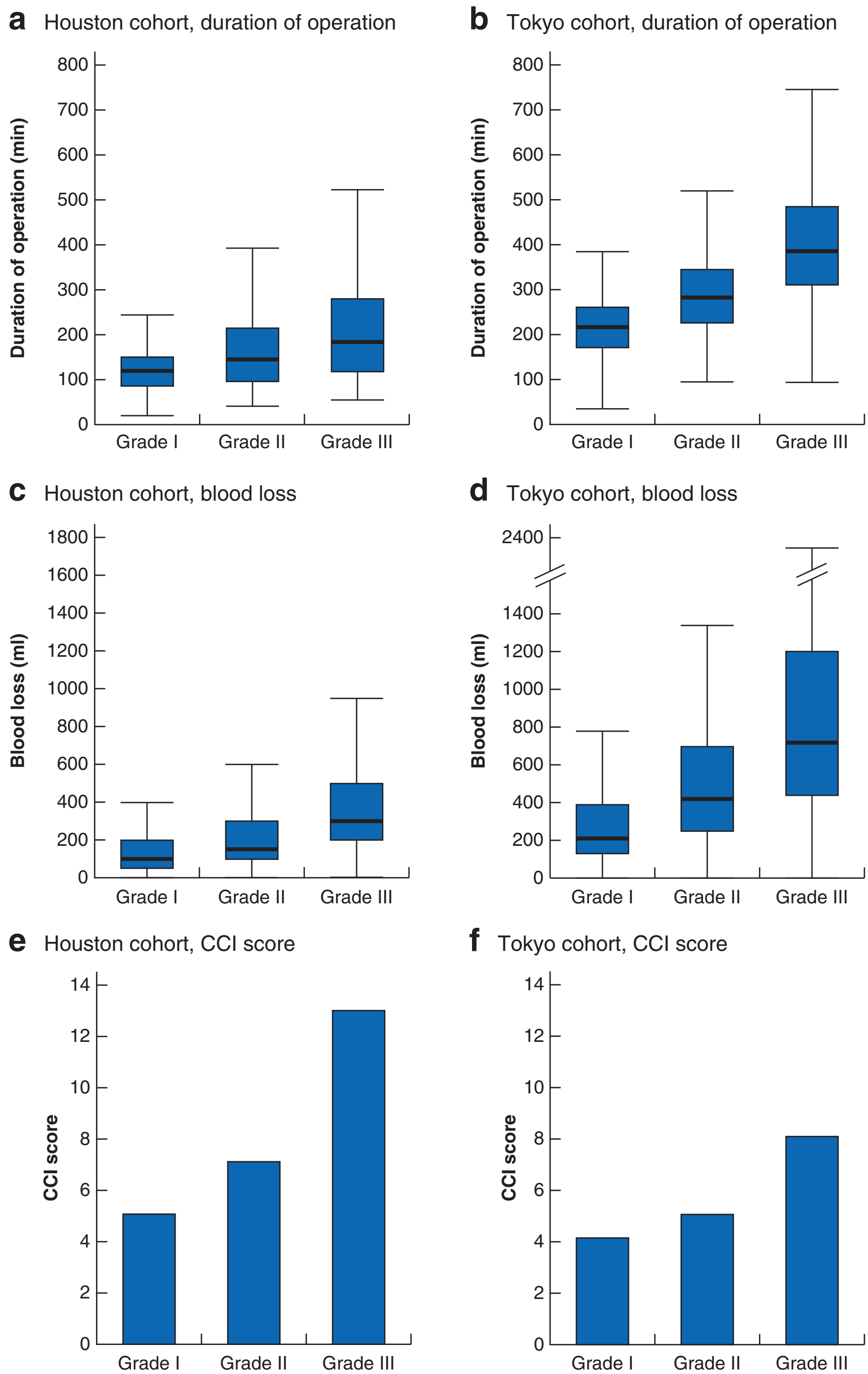
In the Houston cohort, minor resection accounted for all 415 grade I resections, 157 of 353 grade II resections and 85 of 1110 grade III resections. In the Tokyo cohort, minor resections accounted for all 244 grade I resections, 151 of the 206 grade II resections and 438 of 752 grade III resections (*Tables S2* and *S4*, supporting information). When OLR procedures classified as minor in the minor/major classification were categorized by grade in the present three-level classification, duration of operation and estimated blood loss differed between the grades in both cohorts ($P < 0{\cdot}001$) (*Table S4*, supporting information). The CCI score was higher for grade III than for grade I ($P < 0{\cdot}001$) and for grade III than for grade II ($P = 0{\cdot}011$) in the Tokyo cohort.

Fig. 2 Surgical and postoperative outcomes by surgical procedure



a,**b** Median duration of operation, **c**,**d** median estimated blood loss and **e**,**f** mean comprehensive complication index (CCI) score in the Houston (**a**,**c**,**e**) and Tokyo (**b**,**d**,**f**) cohorts. Procedure grades refer to the modified G-K classification. Wedge AL, wedge resection of anterolateral segment; wedge PS, wedge resection of posterosuperior segment; left lateral, left lateral sectionectomy; seg AL, anterolateral segmentectomy; left hep, left hepatectomy; seg PS, posterosuperior segmentectomy (includes resection of segment IV); right hep, right hepatectomy; ext right hep, extended right hepatectomy; right posterior, right posterior sectionectomy; central hep, central hepatectomy; ext left hep, extended left hepatectomy.

Fig. 3 Surgical and postoperative outcomes by grade in the modified G-K classification



a,**b** Median duration of operation, **c**,**d** median estimated blood loss in the Houston (**a**,**c**) and Tokyo (**b**,**d**) cohorts. Median (bold line), i.q.r. (box) and range (error bars) are shown. Values increased in stepwise fashion from grade I to grade III ($P < 0{\cdot}001$, Jonckheere–Terpstra trend test). **e**,**f** Mean comprehensive complication index (CCI) score in the Houston (**e**) and Tokyo (**f**) cohorts also increased in stepwise fashion from grade I to grade III ($P < 0{\cdot}001$, Cochran–Armitage trend test). **a**–**d** $P < 0{\cdot}050$, grade I *versus* grade II, grade I *versus* grade III, and grade II *versus* grade III, for all variables in both cohorts (Wilcoxon rank-sum test with adjustment of Holm's method). **e**,**f** $P < 0{\cdot}050$, grade I *versus* grade III and grade II *versus* grade III in both cohorts (Student's *t* test with adjustment of Holm's method).

Table 1 Surgical and postoperative outcomes by surgical procedure

	Left hepatectomy	Right hepatectomy	*P*§	Extended right hepatectomy	*P*§	Right posterior sectionectomy	*P*§
Houston cohort							
No. of patients	195	604		285		28	
Duration of operation (min)*	125 (85–207)	140 (108–240)	< 0·001¶	192 (117–295)	< 0·001¶	253 (215–309)	< 0·001¶
Blood loss (ml)*	175 (100–300)	300 (200–500)	< 0·001¶	300 (200–600)	< 0·001¶	213 (150–475)	0·068¶
CCI score†	6·7(13·9)	13·0(20·7)	< 0·001#	17·3(22·0)	< 0·001#	9·5(20·4)	0·353#
All complications (%)	24·0	44·0	< 0·001	58·0	< 0·001	32	0·362
Bile leak	1·5	5·0	< 0·001	8·4	< 0·001	0	0·369
Hepatic insufficiency	1·0	7·3	0·021	12·2	< 0·001	4	0·345
Abscess/biloma	4·1	10·2	0·004	11·2	0·004	4	0·896
Pulmonary	5·1	8·1	0·147	8·4	0·158	4	0·715
Major complication (%)	9·7	13·4	0·164	18·5	0·006	7	0·654
90-day mortality‡	3 (1·5)	19 (3·1)	0·203	13 (4·6)	0·057	1 (4)	0·492
Tokyo cohort							
No. of patients	55	109		52		83	
Duration of operation (min)*	360 (310–445)	418 (368–503)	< 0·001¶	493 (361–558)	< 0·001¶	430 (342–495)	0·013¶
Blood loss (ml)*	570 (395–900)	730 (518–1310)	0·026¶	980 (595–1541)	< 0·001¶	835 (500–1312)	0·015¶
CCI score†	5·4(9·7)	8·2(12·5)	0·147#	9·7(19·1)	0·142#	9·9(13·4)	0·031#
All complications (%)	26	31·2	0·474	31	0·667	39	0·141
Bile leak	7	10·1	0·775	4	0·679	11	0·564
Hepatic insufficiency	0	0	–	2	0·486	1	1·000
Abscess/biloma	2	2·8	1·000	6	0·354	2	1·000
Pulmonary	2	7·3	0·275	8	0·197	12	0·050
Major complication (%)	4	6·4	0·719	8	0·429	8	0·316
90-day mortality‡	0 (0)	0 (0)	–	1 (2)	0·486	0 (0)	–

Values are *median (i.q.r.) and † mean(s.d.); ‡values in parentheses are percentages. CCI, comprehensive complication index. §*Versus* left hepatectomy (χ^2 or Fisher's exact test, except ¶Wilcoxon rank-sum test and #Student's *t* test).

Comparison of the modified G-K and S-L classifications

In both cohorts, duration of operation was shorter for left hepatectomy than for right hepatectomy (both cohorts $P < 0{\cdot}001$), extended right hepatectomy (both $P < 0{\cdot}001$) and right posterior sectionectomy (Houston cohort, $P < 0{\cdot}001$; Tokyo cohort, $P = 0{\cdot}013$). Estimated blood loss was less for left hepatectomy than for right hepatectomy (Houston cohort, $P < 0{\cdot}001$; Tokyo cohort, $P = 0{\cdot}026$) and extended right hepatectomy (both $P < 0{\cdot}001$) (*Table 1*). The CCI score was lower for left hepatectomy than for right hepatectomy ($P < 0{\cdot}001$) and extended right hepatectomy ($P < 0{\cdot}001$) in the Houston cohort. It was lower for left hepatectomy than for right posterior sectionectomy in the Tokyo cohort ($P = 0{\cdot}031$).

Areas under the curve for the modified G-K, minor/major and segment-based classifications

In the Houston cohort, the AUCs for duration of operation, blood loss and CCI score were higher for the modified G-K classification than for the minor/major (duration of operation and blood loss, $P < 0{\cdot}001$; CCI score, $P = 0{\cdot}010$) and segment-based (duration of operation and blood loss, $P < 0{\cdot}001$; CCI score, $P = 0{\cdot}012$) classifications (*Table 2*). In the Tokyo cohort, the AUC for duration of operation was higher for the modified G-K classification than for the minor/major classification ($P = 0{\cdot}003$), and the AUC for blood loss was higher for the modified G-K classification than for the minor/major ($P < 0{\cdot}001$) and segment-based ($P = 0{\cdot}029$) classifications.

Comparisons of outcomes of wedge resection and segmentectomy between anterolateral and posterosuperior segments

In both cohorts, median duration of operation was longer for wedge resection of PS segments than for wedge resection of AL segments (Houston cohort, $P = 0{\cdot}006$; Tokyo cohort, $P < 0{\cdot}001$) (*Table S5*, supporting information). Additionally, in the Tokyo cohort, estimated blood loss was greater ($P < 0{\cdot}001$) and the overall complication rate was

Table 2 Comparison of classifications using logistic regression and receiver operating characteristic curve analyses

	Modified G-K classification	Minor/major classification		Segment-based classification	
	AUC	AUC	P*	AUC	P*
Houston cohort					
Duration of surgery	0·596	0·540	< 0·001	0·549	< 0·001
Blood loss	0·719	0·673	< 0·001	0·677	< 0·001
CCI score	0·623	0·596	0·010	0·598	0·012
Tokyo cohort					
Duration of surgery	0·748	0·702	0·003	0·728	0·203
Blood loss	0·701	0·647	< 0·001	0·665	0·029
CCI score	0·619	0·588	0·252	0·607	0·671

AUC, area under the curve; CCI, comprehensive complication index. **Versus* modified G-K classification.

higher ($P = 0·009$) for wedge resection of PS segments than for wedge resection of AL segments. In both cohorts, segmentectomy for PS segments was associated with a longer operating time (both $P < 0·001$), greater estimated blood loss (Houston cohort, $P = 0·013$; Tokyo cohort, $P < 0·001$) and a higher major complication rate (Houston cohort, $P < 0·001$; Tokyo cohort, $P = 0·046$) than segmentectomy for AL segments. In the Tokyo cohort, segmentectomy for PS segments was associated with a higher CCI score ($P = 0·026$).

Discussion

In this study, the modified G-K classification effectively stratified 11 OLR procedures with respect to surgical and postoperative outcomes in Western and Eastern cohorts. Duration of operation and estimated blood loss, markers of surgical complexity, differed between grades in the modified G-K classification and increased in a stepwise fashion from grade I to grade III. Furthermore, postoperative morbidity as indicated by CCI score increased from grade I to grade III. These findings indicate that the modified G-K classification provides an overview of three different grades associated with surgical complexity and postoperative morbidity. Thus, the (modified) G-K classification may be useful in future analyses of OLRs and LLRs at Western and Eastern centres.

The S-L classification of OLR procedures is based on surgeons' perceptions of procedural complexity[5,16], whereas the modified G-K classification shows the association with objective indicators of surgical complexity (operating time and estimated blood loss) and postoperative outcomes (CCI score and morbidity rates). The modified G-K classification and the S-L classification partially overlap: both categorize wedge resection and left lateral sectionectomy as being of low complexity, left hepatectomy as being of intermediate/medium complexity, and central hepatectomy and extended left hepatectomy as being of high complexity. However, the S-L classification categorizes right hepatectomy without caudate resection, right posterior sectionectomy and right trisectionectomy without caudate resection as being of medium complexity, whereas the modified G-K classification categorizes these procedures as being of high complexity. The categorization of the present study is supported by the findings that these three OLR procedures, which require major parenchymal removal or entail a large resection surface, were associated with worse surgical and postoperative outcomes than left hepatectomy.

The S-L classification does not have a category including resection less extensive than sectionectomy except 'peripheral wedge resection less than 3 cm' and 'isolated caudate resection'. As a result, 11·4 per cent of OLR procedures in the Houston cohort and 42·1 per cent of those in the Tokyo cohort were not classified according to the S-L classification.

Laparoscopic resection of PS segments is considered more difficult than laparoscopic resection of AL segments[27,28]. Interestingly, in OLR, wedge resection and segmentectomy of PS segments were associated with worse surgical and postoperative outcomes than wedge resection and segmentectomy of AL segments. Thus, similar to previous studies[6,27,28,34] on classification of LLR procedures, the present classification of OLR procedures showed that tumour location is important. The outcomes of wedge resection of PS segments were worse than the outcomes of wedge resection of AL segments, but better than the outcomes of segmentectomy of AL segments. Thus, it is reasonable to classify wedge resection of AL segments and wedge resection of PS segments as grade I, and segmentectomy of AL segments and left hepatectomy as grade II. The tumour location factor is not really implemented in the other three classifications.

Taken together, the present findings indicate that the modified G-K classification is better than the minor/major classification for stratifying OLR procedures with respect to surgical and postoperative outcomes. These findings include: surgical and postoperative outcomes differed between 'minor' liver resections categorized as grade I, II and III in the modified G-K classification; surgical and postoperative outcomes were better for left hepatectomy than for the other four 'major' liver resections; and the AUCs for surgical outcomes were higher for the modified G-K classification. In addition, the higher AUCs for the modified G-K classification indicate that it predicts surgical complexity better than the segment-based classification. Given the fact that the original G-K classification was associated with surgical and postoperative outcomes after LLR[6], the original/modified G-K classification may be useful for a training pathway of LLR and OLR, and for tailoring management after liver resection.

This study has several limitations. It is a retrospective analysis covering a long period in two high-volume Western and Eastern centres. Nonetheless, the modified G-K classification performed well in both Houston (Western) and Tokyo (Eastern) cohorts, which differed in terms of demographic and clinical characteristics, and types of liver disease. The original and modified G-K classifications are based on a single criterion (resection procedure only), and may represent a clinically useful replacement for classification based on a survey, minor/major nomenclature and number of resected segments in future analyses of OLR and LLR. Instead of classifying hemihepatectomy or more with excision of segment I and/or the portal vein in separate categories, as in the S-L classification (*Fig. 1*), all hemihepatectomy or more extensive procedures were grouped in a single category, irrespective of concomitant resection of segment I and/or the portal vein. However, this should not be a major limitation as only 0·9 per cent of the OLR procedures in the present study were hemihepatectomy or more with excision of segment I. Finally, to simplify classification, patients with biliary reconstruction, repeat hepatectomy, concomitant surgical procedures or multiple wedge resections and/or segmentectomies were excluded. Therefore, the present findings may not be applicable to patients who require such procedures.

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Supporting information

Additional supporting information can be found online in the Supporting Information section at the end of the article.

European Colorectal Congress

28 November – 1 December 2022, St.Gallen, Switzerland

Monday, 28 November 2022

09.50
Opening and welcome
Jochen Lange, St.Gallen, CH

10.00
It is leaking! Approaches to salvaging an anastomosis
Willem Bemelman, Amsterdam, NL

10.30
Predictive and diagnostic markers of anastomotic leak
Andre D'Hoore, Leuven, BE

11.00
SATELLITE SYMPOSIUM
ETHICON

11.45
Of microbes and men – the unspoken story of anastomotic leakage
James Kinross, London, UK

12.15
LUNCH

13.45
Operative techniques to reduce anastomotic recurrence in Crohn's disease
Laura Hancock, Manchester, UK

14.15
Innovative approaches in the treatment of complex Crohn Diseases perianal fistula
Christianne Buskens, Amsterdam, NL

14.45
To divert or not to divert in Crohn surgery – technical aspects and patient factors
Pär Myrelid, Linköping, SE

15.15
COFFEE BREAK

15.45
Appendiceal neoplasia – when to opt for a minimal approach, when and how to go for a maximal treatment
Tom Cecil, Basingstoke, Hampshire, UK

16.15
SATELLITE SYMPOSIUM
Medtronic
Further, Together

17.00
Outcomes of modern induction therapies and Wait and Watch strategies, Hope or Hype
Antonino Spinelli, Milano, IT

17.30
EAES Presidential Lecture - Use of ICG in colorectal surgery: beyond bowel perfusion
Salvador Morales-Conde, Sevilla, ES

18.00
Get-Together with your colleagues
Industrial Exhibition

Tuesday, 29 November 2022

9.00
CONSULTANT'S CORNER
Michel Adamina, Winterthur, CH

10.30
COFFEE BREAK

11.00
SATELLITE SYMPOSIUM
INTUITIVE

11.45
Trends in colorectal oncology and clinical insights for the near future
Rob Glynne-Jones, London, UK

12.15
LUNCH

13.45
VIDEO SESSION

14.15
SATELLITE SYMPOSIUM
BD

15.00
COFFEE BREAK

15.30
The unsolved issue of TME: open, robotic, transanal, or laparoscopic – shining light on evidence and practice
Des Winter, Dublin, IE
Jim Khan, London, UK
Brendan Moran, Basingstoke, UK

16.30
SATELLITE SYMPOSIUM
Takeda

17.15
Lars Pahlman lecture
Søren Laurberg, Aarhus, DK

Wednesday, 30 November 2022

9.00
Advanced risk stratification in colorectal cancer – choosing wisely surgery and adjuvant therapy
Philip Quirke, Leeds, UK

09.30
Predictors for Postoperative Complications and Mortality
Ronan O'Connell, Dublin, IE

10.00
Segmental colectomy versus extended colectomy for complex cancer
Quentin Denost, Bordeaux, FR

10.30
COFFEE BREAK

11.00
Incidental cancer in polyp - completion surgery or endoscopy treatment alone?
Laura Beyer-Berjot, Marseille, FR

11.30
SATELLITE SYMPOSIUM

12.00
Less is more – pushing the boundaries of full-thickness rectal resection
Xavier Serra-Aracil, Barcelona, ES

12.30
LUNCH

14.00
Management of intestinal neuroendocrine neoplasia
Frédéric Ris, Geneva, CH

14.30
Poster Presentation & Best Poster Award
Michel Adamina, Winterthur, CH

15.00
SATELLITE SYMPOSIUM
OLYMPUS

15.45
COFFEE BREAK

16.15
Reoperative pelvic floor surgery – dealing with perineal hernia, reoperations, and complex reconstructions
Guillaume Meurette, Nantes, FR

16.45
Salvage strategies for rectal neoplasia
Roel Hompes, Amsterdam, NL

17.15
Beyond TME – technique and results of pelvic exenteration and sacrectomy
Paris Tekkis, London, UK

19.30
FESTIVE EVENING

Thursday, 1 December 2022

Masterclass in Colorectal Surgery
Proctology Day

Information & Registration **www.colorectalsurgery.eu**