WELLCOME / EPSRC CENTRE
INTERVENTIONAL AND SURGICAL SCIENCES

AUTOMATED ANALYSIS OF SURGICAL PHASE IN LAPAROSCOPIC CHOLECYSTECTOMY. A COMPARISON OF ONE ATTENDING SURGEON AND THEIR RESIDENTS.

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Introduction

- Residents are likely to have increased operating times compare to attending surgeons(1).
- Total operative time is used as a surrogate marker of performance.
- (Total) operative time alone does not identify training needs.
- Video analysis can be used to assess surgical skill and error (2).
- Validated intraoperative scores can be used to gain understanding of case severity in the absence of clinical information (3-4).
- Artificial neural networks (artificial intelligence) (ANN) can be used to automatically identify intraoperative phases in laparoscopic cholecystectomy (LC)(5).
- The aim of this study was to compare resident and attending total operative and intraoperative phase times.

	Allocated points by description		
Domain	0 Points	1 Points	2 Points
Two structures connected to the gallbladder	Unable to identify 2 structures or only 1 structure is seen	2 structures connected by some overlap	2 structures clearly seen connect to gallbladder
Cystic plate clearance	Not visible	Visible but overlapped by structures or not clearly shown	Bottom 1/3rd of gallbladder is clearly demonstrated, and cystic plate is shown
Hepatocystic triangle clearance	Tissue in triangle obscures view of structures	Some obscurement of triangle	Hepatocystic triangle cleared of all tissue except the cyst duct and cystic artery

Table 1. Critical view of safety (CVS) score adapted from Carr *et al. (2018)* A maximum of 2 points can be scored in each domain. A score of 6 indicates the CVS is clearly visible.

Description	Score
Adhesions <50% of gallbladder	1
Adhesions burying gallbladder	3
	Maximum score 3
Distension/contraction of gallbladder	1
Unable to grasp with atraumatic lap forceps	1
Stone >1cm impacted in Hartmann's pouch	1
Access	
Body Mass Index >30	1
Adhesions from surgery limiting access	1
Severe Sepsis/Complications	1
Bile/pus outside of gallbladder	1
Presence of fistula	1
TOTAL (MAXIMUM 10)	

Table 2. Intraoperative grade score adapted from Sugrue *et al.*(2019). Body mass index was not available for this study.

Methods

- Anonymised operative LC videos of an attending surgeon and supervised resident LC cases were uploaded to Touch Surgery™, a cloud-based video platform, which uses AutoPhase™ to automatically identify intraoperative phases in LC.
- Intraoperative grade and Critical View of Safety (CVS) were assessed manually by a resident and attending independently using validated scores (tables 1 and 2).

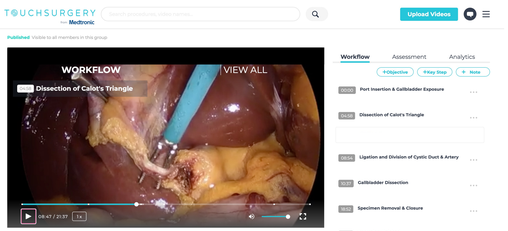


Figure 1. Touch Surgery™ cloud-based video storage platform showing AutoPhase™ generated annotations and timestamps

- Total operative and intraoperative phase times of attending and resident cases were analysed.
- Cases were matched for intraoperative grade score.
- Data was analysed in GraphPad/Prism using descriptive and non-parametric statistics.

Results

159 videos (attending = 96, resident = 63). Good interrater reliability for intraoperative grade and CVS scores.

Case selection Intraoperative grade score (maximum 9, indicating most severe) was significantly higher in attending cases (attending: median=2, IQR=2 range=0-6), resident: median=1, IQR=1, range=0-5, Mann Whitney U=2454, p=0.0372). No significant difference between attending and residents CVS scores were identified.

Resident cases Positive relationships between intraoperative grade score and CVS score (r^2=0.07158 p=0.0340), and intraoperative grade score and of dissection of HCT operative time (r^2=0.09829 p=0.0123) were found. There were no significant relationships found between CVS score and operatives times.

Attending cases No significant relationship between intraoperative grade score and CVS score. Positive relationships were found between CVS score and dissection of hepatocystic triangle (HCT) (r^2=0.1014 p=0.0016), ligation/division of cystic structures (r^2=0.1041 p=0.0013) and total operatives times (r^2=0.1349 p=0.0002). Positive relationships were found between intraoperative grade score and port insertion/exposure (r^2=0.3114 p<0.001), gallbladder dissection (r^2=0.0478 p=0.0324) and total operative times (r^2=0.1474 p=0.0001).

Case matching No significant differences in operative times for score 0, 3 and 4.
Insufficient cases to match for scores 5 and 6.

	Intraoperative grade 1			Intraoperative grade 2		
	Attending n=26	Resident n=28	Mann-Whitney U	Attending n=29	Resident n=18	Mann-Whitney U
	Median, IQR (range)					
Total operative time	**30.9, 20.6 (19-80.8**	**47.4, 12.6 (26.5-73.6)**	**180 p=0.0011**	**34.8, 13.2 (16.8-72.7)**	**50.1, 17.6 (22.5-75.6)**	**99 p=0.0002**
P1 - Port insertion/exposure	6.07, 2.55 (3.92-9.92)	7.62, 4.05 (2.4-17.4)	262.5 p=0.076	**6.15, 2.09 (3.22-15)**	**8.08, 5.57 (4.23-14.5)**	**163.5 p=0.0323**
P2 - Dissection of HCT	**5.38, 4.46 (1.22-29.3)**	**11.6, 8.45 (4.2-23.9)**	**189.5 p=0.0021**	**6.98, 5.23 (3.37-31.1)**	**15.7, 13.9 (3.45-32.7)**	**105 p=0.0004**
P3 - Ligation/division of cystic structures	2.96, 4.14 (0.983-24.9)	3.06, 3.26 (1.62-18.7)	354 p=0.871	3.1, 2.43 (0.717-15.7)	3.18, 2.57 (1.4-20.0)	222 p=0.4003
P4 - Gallbladder dissection	11.8, 4.14 (5.25-21.9)	19.5, 11.8 (4.86-23.5)	186 (p=0.0017)	9.78, 8.9 (5.1-31)	13.6, 9.5 (5.7-37.2)	201 p=0.1949
P5 - Specimen out/closure	4.32, 4.22 (1.83-19.1)	4.26, 3.55 (0.833-18.6)	347.5 p=0.7802	3.02, 5.73 (1.15-13.3)	2.71, 5.34 (0.789-10.2)	236 p=0.5916

Table 3. Median, IQR and range of resident (R) and attending (A) operative times when matched for intraoperative grade scores 1 and 2. Bold text marks statistically significant differences between R and A times.

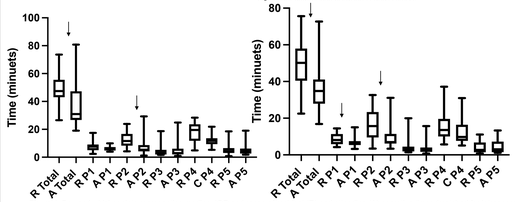


Figure 4. Box and whisker plots representing median, IQR and range of resident (R) and attending (A) operative times (matched for intraoperative grade score 1 (right) and 2 (left). Arrows mark statistically significant differences between R and A times.

Intraoperative events

Adhesionolysis (1), CD injury (1), iatrogenic gallbladder perforation (3) and aberrant cystic artery identified in outlying resident cases compared with iatrogenic gallbladder perforation (1) in outlying attending cases.

	Median, IQR (range)		
	Resident (n=63)	Attending (n=96)	Mann-Whitney U
Total operative time	**48.2, 17.1 (22.5-84.5)**	**36.4, 19.9 (16.8-106)**	**1907 p<0.0001**
P1 - Port insertion/exposure	7.87, 3.83 (2.4-17.4)	7.01, 4.38 (3.22-39.70	2775 p=0.3821
P2 - Dissection of HCT	**13.6, 9.75 (3.45-32.7)**	**7.92, 7.04 (1.22-31.1)**	**1642 p<0.0001**
P3 - Ligation/division of cystic structures	3.42, 3.49 (1.38-20)	2.96, 24.9 (0.633-24.9)	2722 p=0.2881
P4 - Gallbladder dissection	**15.9, 12.1 (4.87-47)**	**12.5, 8.33 (3.73-64.5)**	**2295 p=0.010**
P5 - Specimen out/closure	19.6, 4.35 (0.0333-18.6)	3.37, 4.14 (1.08-19.1)	3000 p=0.9335

Table 3. Median, IQR and range of resident (R) and attending (A) operative times when not matched for intraoperative grade score. Bold text marks statistically significant differences between R and A times.

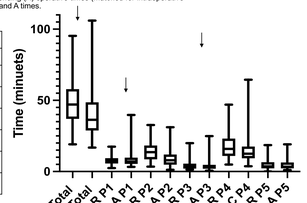


Figure 2. Box and whisker plots representing median, IQR and range of resident (R) and attending (A) operative times when not matched for intraoperative grade score. Arrows mark statistically significant differences between R and A times.

Discussion

- Residents achieved clearer visualization of CVS in more difficult cases.
- Residents took longer to complete dissection of HCT in more challenging cases, this was not found in the Attending cases.
- In attending cases longer dissection of HCT phases was associated with clearer visualization of the CVS.
- This finding could represent the experience of the attending and training need for residents.
- The more severe attending cases were associated with longer port insertion/exposure, gallbladder dissection and total times.
- Which likely reflects that intraoperative grade score is dependent on the presence of adhesions and appearance of the gallbladder wall and case selection.
- Low-severity matched cases show significantly longer operating times for residents in Insertion/exposure, dissection of HCT and total operative times.
- Unmatched cases show significantly longer operating times for residents in dissection of HCT, gallbladder dissection and total operative times.
- This suggests that improving resident dissection of HCT time could improve total operative times.
- Intraoperative events suggest that there is a surgical training need to explore to improve skill and error rate, which could improve intraoperative phase time.
- Access to resident metadata would allow more thorough analysis relating to training stage.
- This data applies to a single attending and their residents and cannot be generalized to the general population.

Conclusion

Residents' total operating time and dissection of HCT intraoperative phase times are shown to significantly exceed their Attending's in matched and unmatched cases, identifying a training need.

Artificial intelligence intraoperative phase analysis can provide the initial step to automated performance analysis.

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