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## Original

# Comparison of Surgeon Stress and Workload between Reduced-port and Laparoscopic Cholecystectomy: A Prospective Study

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**Abstract:** Single-port laparoscopic surgery (SPLS) has attracted attention in the field of minimally invasive surgery; however, the associated technical difficulty has delayed its adoption by all surgeons. Reduced-port laparoscopic surgery might be easier to perform than SPLS, and in this prospective study, we compared surgeon stress and workload between reduced-port laparoscopic cholecystectomy (RPLC) and conventional laparoscopic cholecystectomy (CLC). Twenty consecutive patients were assigned to undergo either RPLC or CLC between July 2016 and April 2017. Two surgeons performed the operations. The differences in surgeon workload and stress between RPLC and CLC were evaluated. Patient factors and operative outcomes were not significantly different between RPLC and CLC. In the surgeon-reported Surgery Task Load Index, the task demand subscale was significantly higher for RPLC than for CLC ( $P = 0.005$ ), although the salivary amylase levels were not significantly different between RPLC and CLC. RPLC was similar to CLC with respect to surgeon stress. Considering workload, the task demand was higher in CLC than in RPLC, which therefore might be an acceptable alternative to CLC for treating benign gallbladder disease.

**Key words:** reduced-port surgery, laparoscopic cholecystectomy, Surgery Task Load Index, salivary amylase

## Introduction

Single-port laparoscopic cholecystectomy (SPLC) is usually performed through a single incision in the umbilicus that heals into a scar similar to the original appearance of the umbilicus<sup>1,2</sup>. Although patients prefer the cosmetic outcomes of SPLC to those resulting from conventional laparoscopic cholecystectomy (CLC)<sup>3</sup>, surgeon's experience, and increased technical and workload challenges while performing SPLC are important points<sup>4</sup>. In addition, a meta-analysis of 45 studies (2,626 patients) on SPLC revealed a significantly higher rate of bile duct injury with single-port compared to four-port laparoscopic cholecystectomy (0.72% vs. 0.50%)<sup>5</sup>. On the other hand, reduced-port laparoscopic surgery (RPS) performed with thin forceps is increasingly used<sup>6</sup>, and it involves fewer or narrower ports than standard laparoscopic surgery<sup>7</sup>. To our

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knowledge, few studies have compared reduced-port laparoscopic cholecystectomy (RPLC) and CLC for treating patients with gallbladder disease in a clinical setting. Our hypothesis in undertaking this study was that RPLC would offer surgical, workload, and surgeon stress outcomes similar to those of CLC. To test this proposal, we compared surgeon stress and workload in the operating room during the performance of RPLC and CLC.

## **Materials and methods**

### *Inclusion and exclusion criteria*

Patients were included if they had undergone elective cholecystectomy for symptomatic gallstone disease. Patients with features of acute cholecystitis and those with malignancy on clinical examination were excluded from the study.

### *Data collection*

To evaluate differences in surgeon workload and stress between RPLC and CLC, we collected objective and subjective workload data for this prospective study to compare the patient outcomes.

### *Patients*

Twenty consecutive patients were prospectively assigned to undergo either RPLC or CLC between July 2016 and April 2017. All patients were scheduled for surgery, and all cases were grade I based on the Tokyo guidelines<sup>8)</sup>.

### *Participants*

The two surgeons who participated in this study had performed fewer than 20 procedures involving laparoscopic cholecystectomy. Surgeon A was a postgraduate of 9 years and surgeon B was a postgraduate of 5 years. Surgeon A performed 8 RPLC and 6 CLC. Surgeon B performed 2 RPLC and 4 CLC. Two other surgeons operated the scopes, each with 20 years of postgraduate experience. RPLC and CLC are always performed by a main surgeon and scopist.

### *Ethical considerations*

This study was conducted according to the ethical principles of the Declaration of Helsinki. Ethics approval was received from the local ethics committee (1606-01 for IRB continuation approval). The patients also provided permission for their data to be used in future analyses and informed consent before undergoing the laparoscopic cholecystectomy. The Showa University Review Board approved the study protocol prior to commencement.

### *Procedures*

Both RPLC and CLC techniques were used to perform laparoscopic cholecystectomy. For the patients who underwent RPLC, one umbilical skin incision was made, and the surgeon performed the procedure manually using a lap mini-protector (Hakko, Nagano, Japan), with

an additional port inserted in an epigastric location. We used only conventional laparoscopic instruments. For the patients who underwent CLC, three 5-mm ports and one 12-mm port (Hasson trocar) were placed in the abdominal wall.

#### *Evaluation of surgeon workload*

The surgeon's workload was measured using the Surgery Task Load Index (Surg-TLX), adapted from the National Aeronautics and Space Administration's Task Load Index<sup>9)</sup> and validated for evaluating workloads in surgery<sup>10)</sup>. Using the Surg-TLX, each surgeon rated six dimensions of workload: mental, physical, temporal, task complexity, situational awareness, and distractions on visual analog scales, where 0 is "very low" and 20 is "very high" (Appendix 1.)

#### *Surgeon stress*

Surgeon stress was quantified at three distinct time points during each case: preoperatively, intraoperatively, and postoperatively. Preoperatively was defined as the time before the surgeon washed his hands. Intraoperatively was defined as the stage during which the cystic artery and duct were clipped, and postoperatively was defined as the time of skin closure. Surgeons' stress hormone levels (salivary amylase) were sampled at each time point. At the conclusion of the study, salivary samples from both surgeons were thawed and assayed using a salivary biomarker<sup>11, 12)</sup>. The surgeons continued to eat the same breakfast during this study's enrollment period because salivary amylase level can change based on food intake and diurnal rhythm.

#### *Data analysis*

The statistical analyses were performed using JMP Pro 10 software (SAS Institute, Cary, NC). The t-test, chi-square test, and Fisher's test were used to address assumptions in variable characteristics, variance distribution, and sample size, and to compare differences in patients' age, sex, American Society of Anesthesiologists (ASA), and body mass index (BMI). Differences in the operative duration (defined as the time from skin opening to skin closure) between RPLC and CLC were tested using equal variance t-tests. Data were categorized by time point during the surgery (preoperatively, intraoperatively, and postoperatively). At the preoperative, intraoperative, and postoperative time points of RPLC and CLC, the salivary amylase levels were also compared using t-tests, as appropriate. In addition, differences in amylase levels were calculated between paired time points (e.g., preoperative amylase level minus postoperative amylase level and preoperative amylase level minus intraoperative amylase level), and RPLC and CLC were compared using unequal/equal variance t-tests, as appropriate. The impact of the RPLC and CLC techniques on each Surg-TLX subscale was compared using t-tests. Statistical significance was set at  $P < 0.05$ .

## Results

### *Patient demographics and surgical outcomes*

Data from 20 procedures (10 RPLC and 10 CLC) were collected for this study. Patient demographic characteristics (age, sex, ASA, and BMI) and surgical outcomes were not significantly different between RPLC and CLC (Tables 1, 2).

### *Surg-TLX results-surgeon workload*

The subjective ratings from the Surg-TLX are summarized in Table 2. Task demand was higher ( $P=0.005$ ) in RPLC than in CLC, but none of the other factors were significantly different between RPLC and CLC (Fig. 1).

### *Salivary amylase levels*

A summary of the amylase concentrations for RPLC and CLC during the three operative time points is shown in Figure 2. The surgeons' amylase levels were not significantly different between RPLC and CLC at the three time points, nor was there any significant difference between the paired time point levels.

## Discussion

This study suggested that RPLC is similar to CLC in terms of surgeon stress. Based on the

Table 1. Patient demographics

	RPLC	CLC	P < 0.05
Age(y)	51 (47-68)	50 (42-77)	0.75
Sex			0.65
Male	5	5	
Female	5	5	
ASA			0.30
1	10	9	
2	0	1	
BMI	21.4 (20.3-28.4)	23.4 (19-26.4)	0.41

Table 2. Surgical outcome

	RPLC	CLC	P < 0.05
Operative time (min)	83 (44-207)	55 (47-144)	P = 0.39
Intraoperative complications			
Liver parenchymal bleeding	2	0	P = 0.46
Gallbladder perforation	1	1	P = 1.00
CV Exposure	9	10	P = 0.30

CV; Critical View

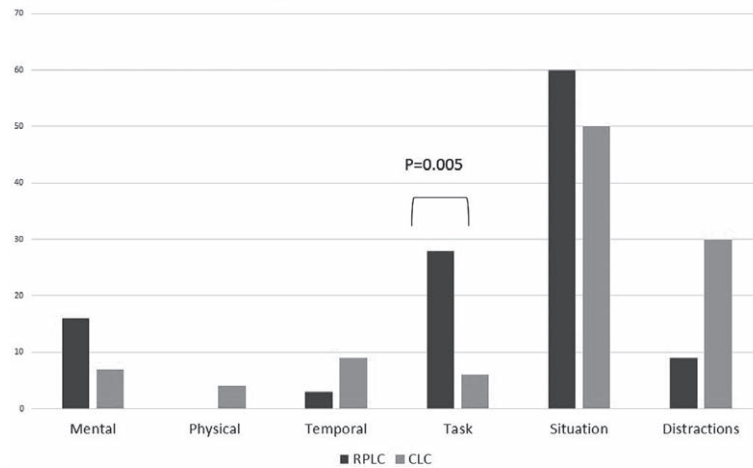


Fig. 1. Surgery Task Load Index subscales

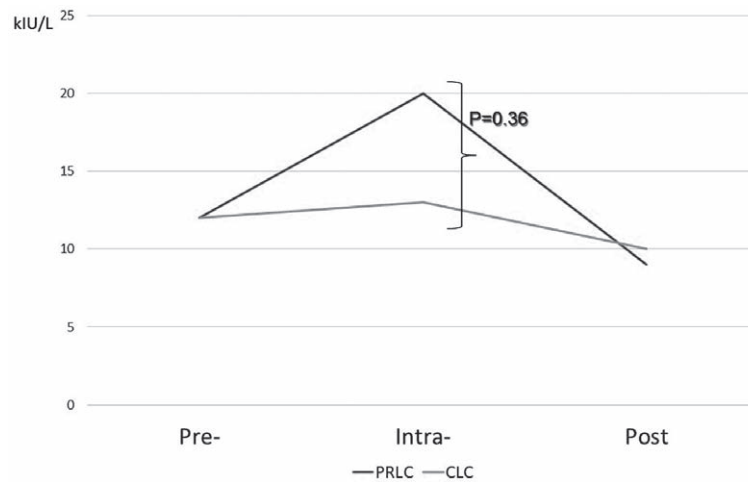


Fig. 2. Salivary amylase levels at the three time points

Surg-TLX assessment, the workload task demand was higher in CLC than in RPLC, but the operative outcomes were similar and there was no significant difference in salivary amylase levels between the procedures.

A previous study reported that RPS is safe and feasible, but that it is also technically difficult, even in expert hands, because of the limited operative field<sup>13)</sup>, and this conclusion is supported by our current results. In the present study, surgeon stress and Surg-TLX ratings, excluding task demand, were not significantly different between RPLC and CLC; however, although SPLC achieves patient satisfaction comparable to that reported with CLC, it is physically more demanding for the surgeon than CLC<sup>14)</sup>. In addition, two previous meta-analyses found that SPLC requires a significantly longer procedure time than does CLC<sup>14,15)</sup>, while others claimed that single-incision techniques are more challenging than the conventional laparoscopic model<sup>16,17)</sup>. Furthermore, our previous study found that dry box single-incision laparoscopic surgery is more difficult than conventional surgery<sup>18)</sup>, and a recent study showed that the average operative cost

was significantly higher for SPLC than for CLC<sup>19)</sup>.

Recently, RPS has been in the spotlight. RPLC includes both two-port laparoscopic cholecystectomy and mini-laparoscopic cholecystectomy, and its development has been reported in the field of RPS. Two-port mini laparoscopic cholecystectomy results in reduced pain and improved cosmesis without increased operative times and complication rates compared to four-port laparoscopic cholecystectomy<sup>20-22)</sup>; however, the main advantage of two-port mini laparoscopic cholecystectomy, as described in the present study, is the ease of performing the technique, while maintaining the surgical principles of conventional four-port laparoscopic cholecystectomy. Sisir Kr. Nath<sup>23)</sup> also reported similar patients safety rates between the procedures.

Salivary amylase was used as an objective physiological measure of surgeon stress during the procedures, although variability in such biological levels can occur due to external and internal factors that affect salivary cortisol<sup>24)</sup>. Furthermore, amylase reactivates earlier than does the cortisol response<sup>25)</sup>. During RPS and CLC, there was no significant difference in the salivary amylase levels. Previous studies reported that high mental stress could decrease surgeons' performance<sup>26)</sup> and decision-making ability<sup>27)</sup>, which in turn may increase the duration of the operation and rate of surgical errors, potentially affecting patient outcomes<sup>16)</sup>. Our results thus indicate that performing RPS is just as stressful as performing CLC.

In our study, the Surg-TLX results demonstrated that RPLC is significantly more demanding than CLC in terms of workload, supporting a previous study showing that SPLC is more demanding than conventional laparoscopy, as demonstrated by Surg-TLX results<sup>17)</sup>. In addition, Reyes *et al*<sup>28)</sup> found that SPLC caused greater mental strain than conventional laparoscopy. The higher physical workload with SPLC might increase the surgeon's fatigue, muscular symptoms, and injuries<sup>29)</sup>, which might in turn affect overall surgical productivity by increasing the surgeon's days of absence and decreasing their years of practice. Additionally, the combination of data from validated objective and subjective measures of stress and workload together in one study follows the recommendations of many reviews in ergonomics research in surgery<sup>26)</sup>.

A limitation of this study is that only two surgeons were used. In addition, the number of cases was small. We did attempt to reduce selection bias in this current study by prospectively assigning patients to undergo either RPLC or CLC.

In conclusion, RPLC was similar to CLC in terms of surgeon stress, but with regard to workload, the task demand was higher in CLC than in RPLC. We propose that RPLC provides an acceptable alternative to CLC for treating benign gallbladder disease. To our knowledge, this is the first study to compare surgeon stress and workload between RPLC and CLC in a clinical setting; however, large-scale trials will be necessary to prove the benefit of RPLC.

#### **Acknowledgements**

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### Conflict of interest disclosure

The authors declare that there are no conflicts of interest.

### Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

## Appendix 1: The SURG-TLX

### Weighted rating

There are six rating scales for evaluating your experience during the procedure. Please evaluate the procedure by marking an “X” on each of the six scales at the point which best fits your experience. The scale ranges from “low” on the left to “high” on the right. Please read the descriptions carefully.

**Mental Demands**  
How mentally fatiguing was the procedure?

Very Low Very High

**Physical Demands**  
How physically fatiguing was the procedure?

Very Low Very High

**Temporal Demands**  
How hurried or rushed was the pace of the procedure?

Very Low Very High

**Task Complexity**  
How complex was the procedure?

Not Very Complex Very Complex

**Situational Stress**  
How anxious did you feel while performing the procedure?

Not Very Anxious Very Anxious

**Distractions**  
How distracting was the operating environment?

Not Very Very

*Pairwise comparisons*

The followings are sets of titles listed in boxes within a grid. From these boxes, you will choose which title you deem more applicable to your experience of workload in the procedure.

Circle the title that you deem fitting of your experience. Please consider your choices carefully and make them consistent with how you used the rating scales. We are not looking for a right or wrong answer, and we are only interested in your opinion.

Task Complexity Or Mental Demand	Distractions Or Situational Stress	Task Complexity Or Distractions
Task Complexity Or Temporal demand	Mental demand Or Situational Stress	Physical Demand Or Distractions
Mental demand Or Physical demand	Situational Stress Or Physical demand	Situational Stress Or Task Complexity
Temporal demand Or Mental demand	Distractions Or Mental demand	Temporal demand Or Distractions
Physical demand Or Temporal demand	Physical demand Or Task Complexity	Temporal demand Or Situational Stress

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