Reduction in the Frequency of Scope Contamination During Laparoscopic Surgery Correlates with Scope Operator Experience

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Research article

Keywords: laparoscope, lens contamination, scope operator, learning curve, colorectal cancer, laparoscopic colorectomy

Posted Date: April 28th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-22997/v1

Abstract

Background As laparoscopic colorectal cancer surgery becomes more common in mid-sized municipal hospitals in Japan, young trainees have increasing opportunities to attend laparoscopic colorectomy procedures as a scope operator. However, the performance of the inexperienced scope operator may affect the operative outcome. This study aims to provide a quantitative measure of the scope operator's performance, by analyzing scope contamination events, and to determine the influence of this measure on surgical outcomes.

Methods We retrospectively analyzed the operative videos of 70 sigmoid colectomy or high anterior resection cases performed between February 2014 and July 2019 in our hospital. Twenty-four young surgeons alternated assisting with the procedure as the scope operator. To quantify the scope operators' performance, the frequency of laparoscopic lens contamination events (FLC) during surgery was determined. The FLC and operative outcomes were compared among the first, second, and subsequent procedures performed by each scope operator. We identified the cause of lens contamination and surgical situation in which contamination occurred. We examined the relationship between the FLC and experience level of the scope operator for specific types of contamination and surgical situations.

Results A total of 733 lens contaminations were observed. The median FLC was 10 (minimum: 1, maximum: 34) during each operation. The FLC and number of procedures performed by the scope operator had a negative linear correlation. Multivariate analysis showed that the experience level of the scope operator was the only independent predictor of operation time. There was also a negative linear correlation between the number of procedures performed by the scope operator and scope contamination during colorectal mobilization.

Conclusions Scope operator experience decreases scope contamination and could facilitate the laparoscopic surgical workflow. The influence of the scope operator's performance should be emphasized.

Introduction

Laparoscopic surgery is more physically and psychologically difficult for surgeons than open surgery; one explanation for this difficulty is that the surgical field of view is dependent on the scope operator [1, 2]. Clear visualization of the surgical field is critical during laparoscopic surgery [1, 3, 4]. When laparoscopic lens contamination occurs, the standard procedure is to remove the laparoscope from the abdominal cavity, wipe it with dry gauze, and then apply anti-fog solution or wash it with hot water [3]. This process disrupts the surgical workflow, prolongs operation time, and increases the risk of harm to the patient [4–6]. Lens contamination events may be avoided by a skilled scope operator. Recently, as the development of laparoscopic surgery makes laparoscopic colorectal cancer surgery more prevalent in mid-sized municipal hospitals in Japan, young trainees have increasing opportunities to attend laparoscopic colorectomy procedures as a scope operator [7].

An experienced scope operator will be able to maintain a clear view of the surgical field with fewer lens contamination incidents. On the other hand, the insufficient ability of young surgeons to properly manipulate and hold the scope could affect the operation time and operative outcome. However, no previous studies have examined laparoscopic lens contamination and scope operator experience. The aim of this study is to verify the relationship between laparoscopic lens contamination and the scope operator's experience. We further analyzed the significance of the frequency of lens contamination (FLC) as a contributor to the short-term surgical outcome.

Materials And Methods

Patient selection

Written informed consent was obtained from all patients, and the institutional review board of the Mitsui Memorial Hospital approved this retrospective study. We examined the surgical videos of 93 consecutive patients with sigmoid colon or high rectal adenocarcinoma who underwent laparoscopic sigmoid colectomy or high anterior resection between February of 2014 and July of 2019 in our hospital. Clinical records were reviewed to obtain the patients' clinicopathological characteristics and surgical data. Twenty-three patients were excluded for the following reasons: 11 procedures included extracorporeal anastomosis, 2 involved combined surgery, 5 were not attended by the author K.M., and 5 had incomplete video data. Finally, 70 patients were included in this study (Fig. 1).

Surgical team

The surgical team consisted of a primary surgeon, an assistant surgeon, a scope operator, and an instrument nurse. The author, K. M., is certified as a qualified surgeon by the Japanese Society of Laparoscopic Surgery and was involved in all the surgeries as the primary surgeon or an instructing assistant. The scope operators consisted of 24 surgical trainees with 2–7 years of surgical experience.

Surgical procedure

The procedure for laparoscopic sigmoid colectomy and that for high anterior resection at our hospital are essentially the same with the exception of the length of the distal margin. The surgical procedure was performed using 5 hypogastric trocars and a mini incision, following the standard procedure that is performed in large, high-volume centers in Japan [8]. Surgery was performed using a 10-mm articulating laparoscope (Olympus LTF S190-10, Tokyo, Japan).

Analyses and classification of FLC

As an intrinsic measurement of the scope operator's performance, the FLC was counted by reviewing the surgical video records. The operations were recorded with a video recorder (Panasonic AG-HMR10, Osaka, Japan), output to mp4 files, and viewed using Windows Media Player.

The FLC was counted during the review of these videos, and FLC events were classified according to their cause and situation. Cleansing events without lens contamination were excluded. Causes of lens

contamination were classified into 4 types: Type 1 – surgical plume; Type 2 – contact with an intraperitoneal organ or tissue; Type 3 – trocar-related contamination; and Type 4 – failure of cleaning. Situations of lens contamination were classified according to 5 surgical events: Event 1 – preparation; Event 2 – central lymph node dissection; Event 3 – colorectal mobilization; Event 4 – dissection and anastomosis; and Event 5 – washing and placing a drain.

To compare the FLC among trainees with varying levels of experience, we first recorded the name of the trainee who attended each of the 70 procedures as the scope operator and determined the number of cases in which each trainee was the scope operator. Each of the 24 scope operators performed up to 6 procedures as the scope operator. Next, we divided the 70 procedures into 6 groups based on the level of experience of the scope operator. Group 1 comprised 24 procedures that were each of the 24 trainees' first experience as the scope operator. Group 2 (17 procedures) comprised trainees who were acting as the scope operator for the second time, Group 3 (11 procedures) included trainees who were assisting for their third time, and so on. Groups 4, 5, and 6 included 7, 7, and 4 procedures, respectively. The FLC of each procedure was compared across these 6 groups.

Statistical Analysis

Descriptive statistics were produced with SPSS ver. 21 (IBM SPSS Statistics, Tokyo, Japan). To examine the effect of scope operator experience, we performed a multiple linear regression analysis. We examined the following surgical outcomes as the dependent variables: operation time (min), blood loss (mL), hospitalization (days), and complications according to the Clavien-Dindo classification. We chose 4 explanatory variables: the experience of the scope operator (number of procedures performed), primary surgeon is K.M., BMI (kg/m^2), and history of abdominal surgery (presence or absence).

Kruskal-Wallis tests were used for multiple group comparisons. P values lower than 0.05 were considered significant.

Results

Trends of the FLC

In total, 756 lens cleansing events were observed in 70 surgical videos. Twenty-three cleansing events without lens contamination were excluded, and thus 733 lens contaminations were included in this study. The FLC and characteristics of the 70 cases are summarized in Table 1. The median FLC per one surgical operation was 10 (range 1–34). Figure 2 shows the mean FLC for groups 1 through 6. The mean FLC decreased as the experience of the scope operator increased (P = 0.023 for the trend). The learning curves of 11 scope operators who assisted with 3 or more procedures (a to k) are shown in Fig. 3. For the 7 scope operators (a to g) who assisted with 5 or more procedures, a negative linear association was observed between the FLC and the number of procedures performed. Among these 7 scope operators, 4 (a, b, e, and f) seemed to show a low plateau value after the 4th procedure. Meanwhile, 13 scope

operators performed only 1 or 2 procedures, and thus a trend could not be determined for these 13 operators.

Table 1
Profiles and surgical outcomes of 70 patients

	N = 70
Age (years)	62 (42–91)
Sex	male: 39, female: 31
BMI (kg/m^2)	22.2 (12.8–46.3)
History of abdominal surgery	presence: 22, absence: 48
ASA classification	class 1: 46, class 2: 17, class 3: 7
Location of cancer	sigmoid colon: 24, high rectum: 46
Pathological stage[a]	0: 2, I:40, II: 13, III: 12, IV: 3
Primary surgeon	resident: 28, author K.M.: 42
Experience of the scope operator (procedure number)	1st: 24, 2nd: 17, 3rd: 11, 4th: 7, 5th: 7, 6th: 4
FLC per operation	10 (1–34)
Operation time (min)	215 (114–334)
Blood loss (mL)	10 (0-218)
Hospitalization (days)	10 (7–41)
Complications[b]	Grade I: 62, Grade II: 8
Data are presented as the median (minimum-maximum).	
[a]Pathological stage based on the American Joint Committee on Cancer guidelines.	
[b]Complications based on the Clavien-Dindo Classification	
FLC: Frequency of laparoscopic lens contamination; BMI: Body Mass Index; ASA: American Society of Anesthesiologists	

FLC trends according to cause

Regarding the cause of lens contamination, a nonsignificant negative linear trend was observed between the experience of the scope operator and FLC (Fig. 4).

FLC trends according to surgical situations

Regarding the situations in which lens contamination occurred, there was a negative linear correlation between the experience of the scope operator and FLC during colorectal mobilization (P = 0.04 for the trend) and a nonsignificant trend during other situations (Fig. 5)

Predictors of surgical outcome

Multiple linear regression analyses to predict surgical outcomes (operation time, blood loss, hospitalization, and complications) according to the explanatory variables (experience of the scope operator, primary surgeon is K.M, BMI, and history of abdominal surgery) are summarized in Table 2. Only the experience of the scope operator was a significant predictor of operation time. No other associations were significant (Table 2).

Table 2
Multiple regression analyses

	Operation time		**Blood loss**		**Hospitalization**		**Complications[a]**	
Explanatory variable	β	P value	β	P value	β	P value	β	P value
Experience of scope operator	-0.315	0.018	0.022	0.871	-0.124	0.376	-0.033	0.811
Operator is K.M.	-0.176	0.169	0.164	0.215	-0.002	0.988	0.019	0.886
BMI	0.203	0.09	0.21	0.09	-0.041	0.746	-0.117	0.357
History of abdominal surgery	0.074	0.539	-0.03	0.81	0.072	0.575	0.04	0.753
R^2	0.138		0.076		0.017		0.016	

[a]Complications based on the Clavien-Dindo Classification; BMI: body mass index.

Discussion

In this study, we found that a young trainee's level of experience as a scope operator was closely related to the FLC and was the only independent predictor of operation time. This study objectively demonstrates the importance of the scope operator's performance during laparoscopic surgery. Previous ergonomic reports support our results, suggesting that instrument exchange, such as cleansing the laparoscopic lens, disrupts the surgical workflow [6, 9, 10]. However, there were no objective assessments for lens contamination and the performance of the scope operator. A strength of our study is that the FLC represents a quantitative assessment of the scope operators' performance.

In a previous report, the surgeons' procedure time stabilized after the performance of 15 sigmoidectomy procedures as the primary operator [11]. Although the experience of the scope operator should be considered an important contributor to a meticulous laparoscopic surgery, the learning curve of the scope

operator may plateau after a relatively small number of times assisting with sigmoidectomy or anterior resection (approximately 4 procedures). This number could be used as an index for advancing to the next role, such as a first assistant or primary operator.

Previously, reports describing laparoscopic or thoracoscopic lens contamination focused on anti-fog solution [12–14], the cleansing device [15], cleaning technique [16], or surgical plume [1, 17]. There are no studies that focused on the scope operator's performance and learning curve.

Lens contamination has been classified according to the type of contamination materials or cleaning method [5, 17]. However, there is no objective, widely usable classification. In our study, lens contamination was classified by the 4 causes of contamination during the surgical procedure. This causal analysis could be used to improve surgical trainees' scope manipulation technique. In addition, this classification can be used objectively during retrospective video observation.

Because our laparoscopic sigmoid colectomy and high anterior resection followed a standardized procedure, we were able to classify five types of surgical situations. During colorectal mobilization, manipulation of the laparoscope was limited by the narrow working space. Outcomes during this situation may be particularly affected by the experience level of the scope operator. Recognition of these causes and situations could aid in improving the technique of scope operators.

This study was limited by the relatively small number of patients. Another possible bias is that the first assistant was different for each operation. In addition, the type of laparoscope used (forward-viewing or forward-oblique viewing) was not considered. The laparoscope used in this study, the Olympus LTF S190-10, includes an antifog heating solution; if another laparoscope that does not include this feature is used, the number of contamination events due to fogging would likely be increased and the results may differ. Finally, the study is limited by the single institution nature of the study so that further studies across multiple institutions are needed to confirm our findings.

This study could help improve laparoscopic surgery outcomes because the influence of the scope operator on laparoscopic surgical workflow has often been overlooked and is difficult to quantify.

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Declarations

Disclosures

Drs. Ryota Ito, Keisuke Minamimura, Yusuke Tanaka, Yoshiharu Kono, Kazuhiko Mori, Toru Hirata, Takashi Kobayashi, and Seiji Kawasaki have no conflicts of interest or financial ties to disclose.

Funding information:

No funding was obtained for this study.

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Figures

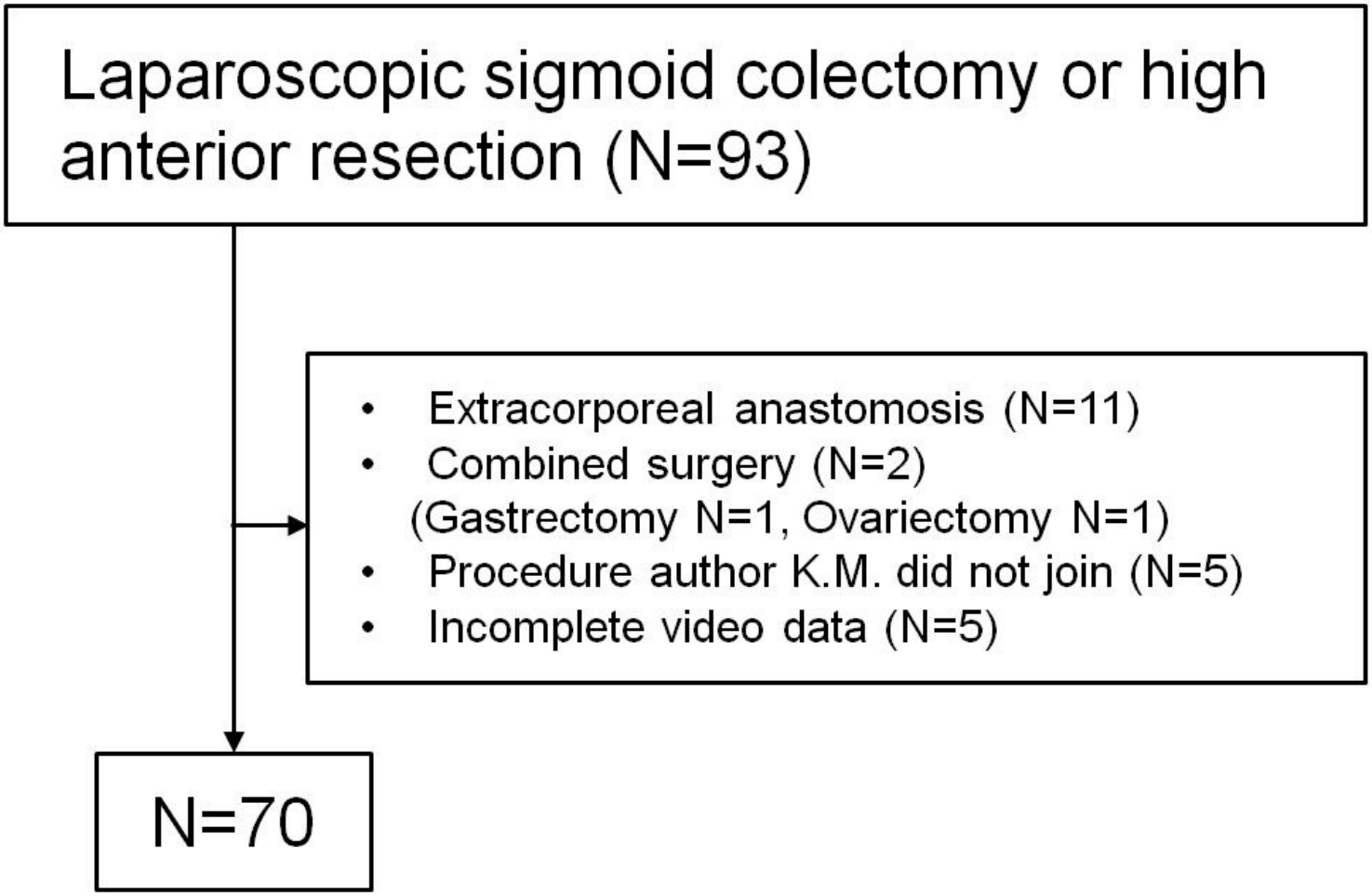

Figure 1

The exclusion criteria for study patients. Out of 93 patients who underwent laparoscopic sigmoid colectomy or high anterior resection, 70 were included in this study.

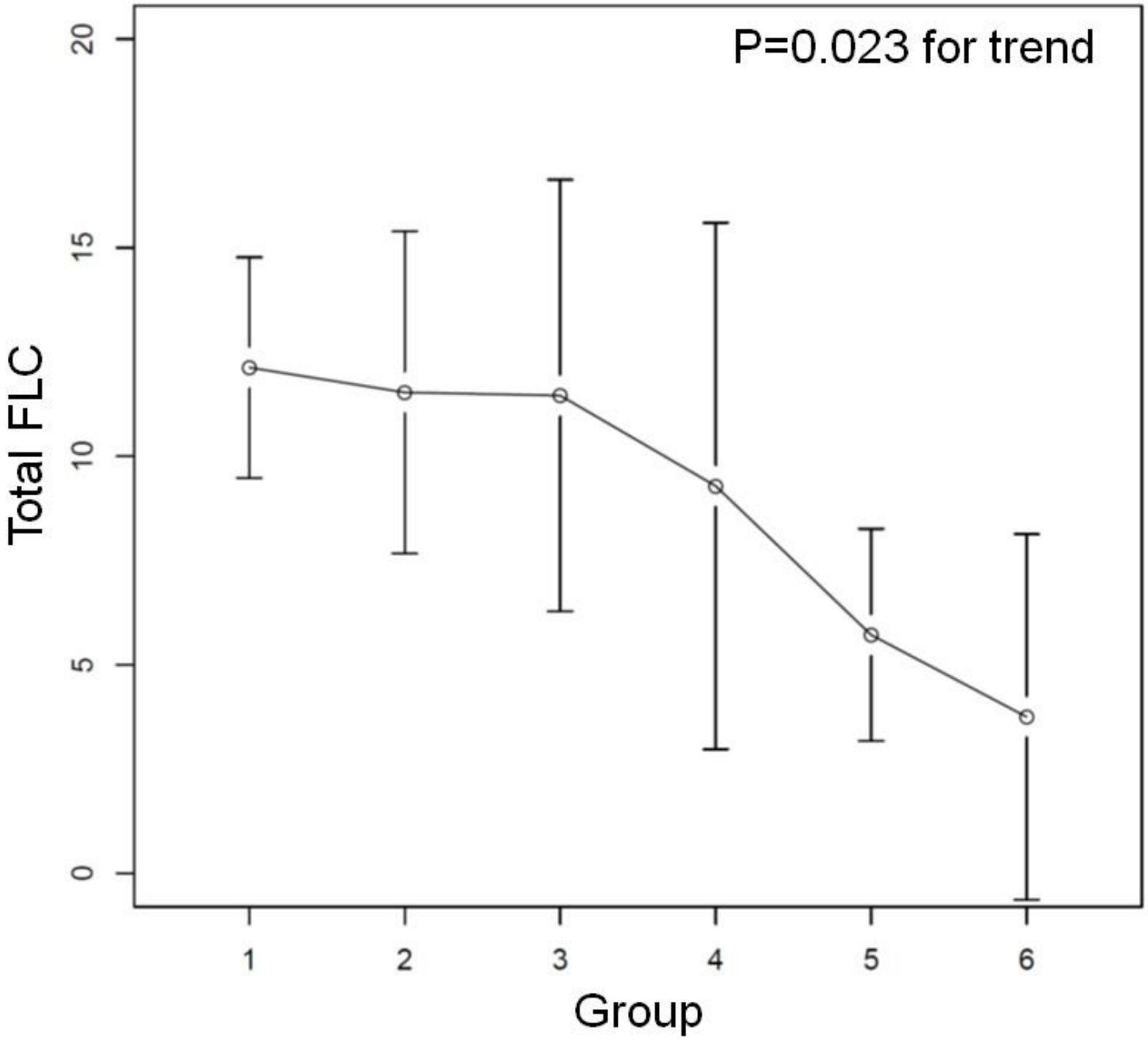

Figure 2

The relationship between the frequency of laparoscopic lens contamination events (FLC) and groups 1 to 6. The filled shapes indicate the means, and the bars represent the 95% confidence intervals. The plot shows a negative linear correlation between the FLC and the number of procedures performed by the scope operator (Kruskal-Wallis test, P=0.023 for the trend).

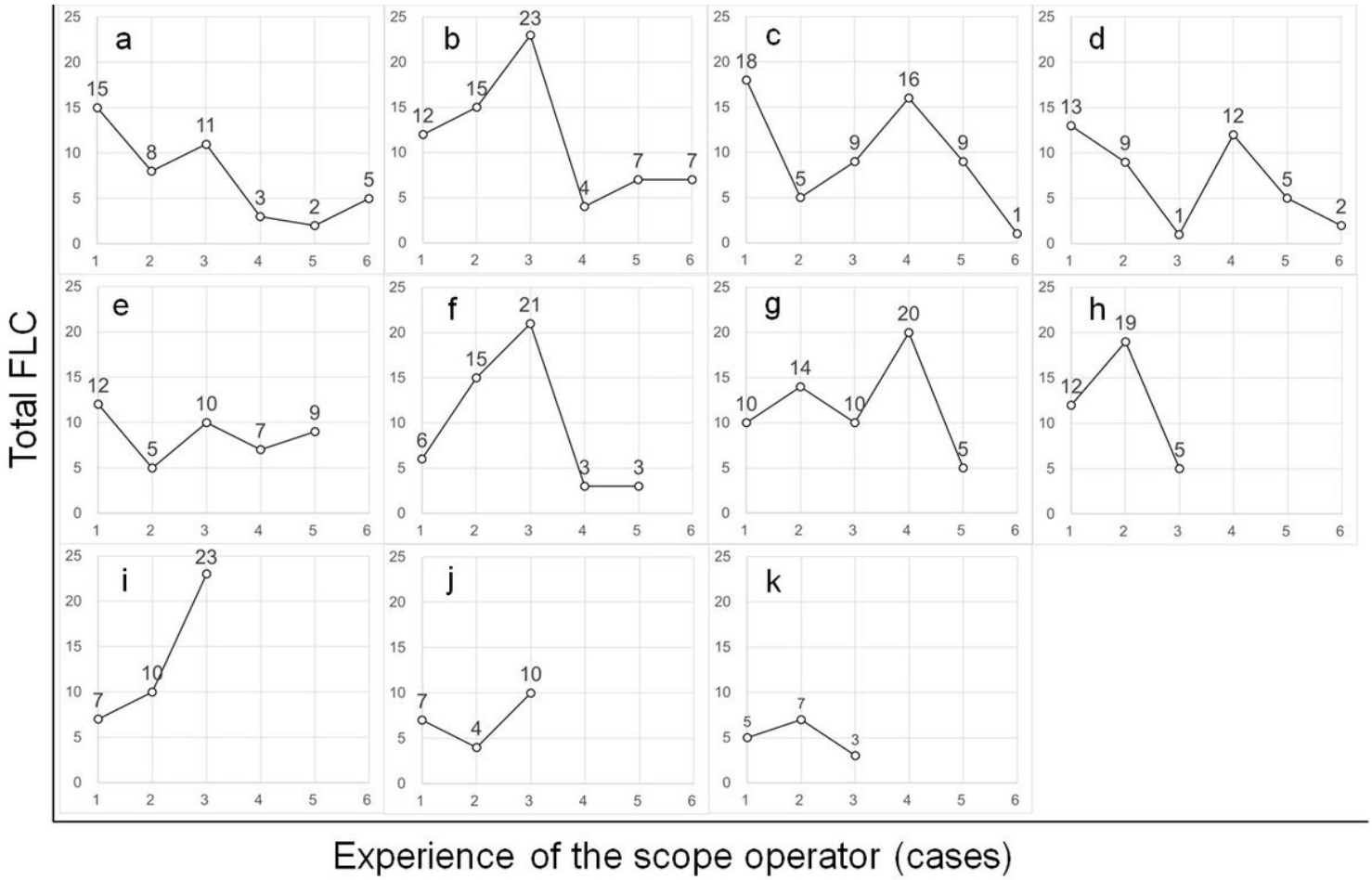

Figure 3

The learning curves of the 11 scope operators (a to k) who assisted with 3 or more procedures. Four scope operators (a, b, e, f) displayed a plateaued low frequency of laparoscopic lens contamination events (FLC) after their 4th procedure.

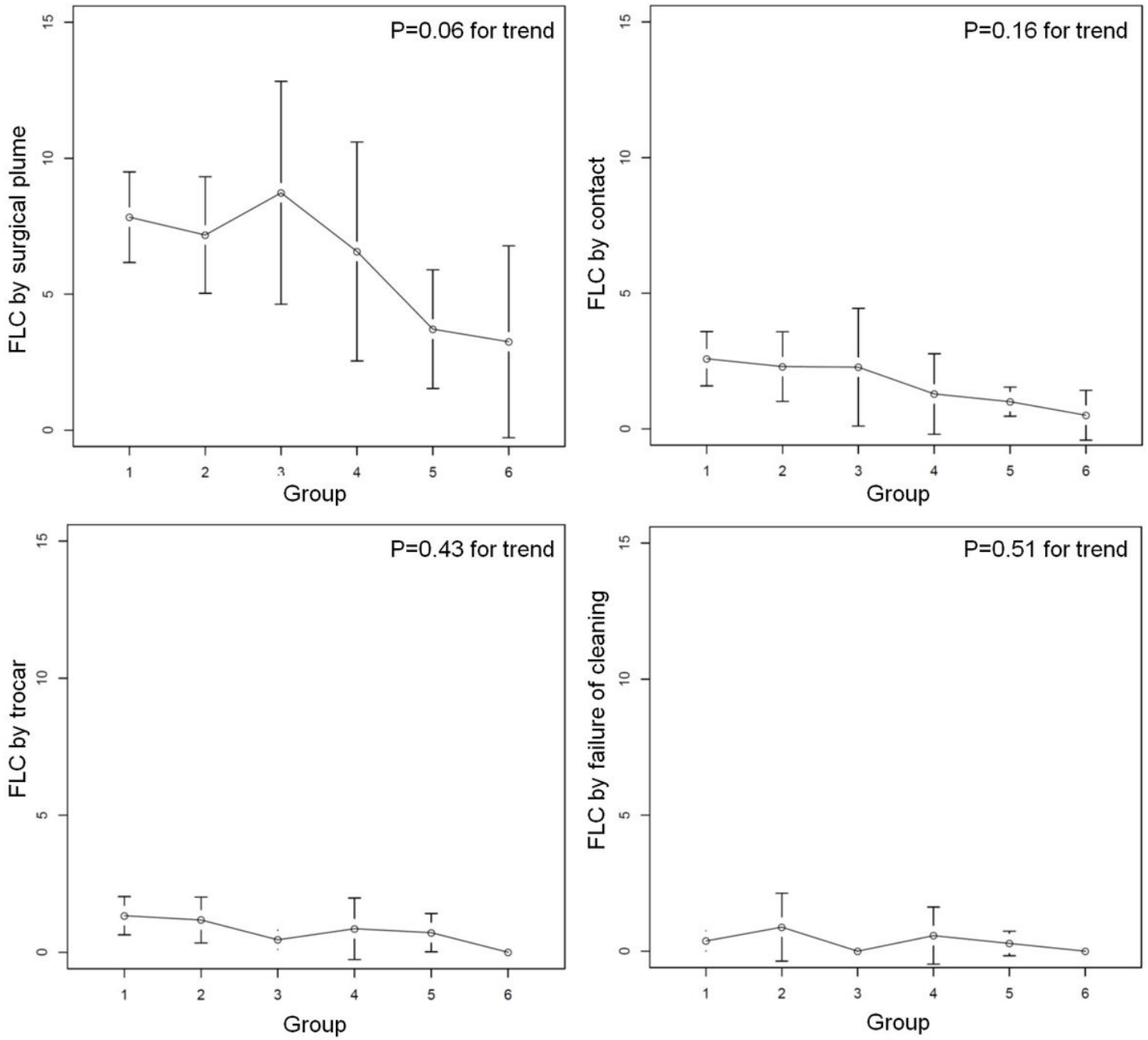

Figure 4

Trends for the 6 groups in the frequency of laparoscopic lens contamination events (FLC) according to the cause of contamination: surgical plume, contact with an organ or tissue, trocar-related contamination, and failure of cleaning.

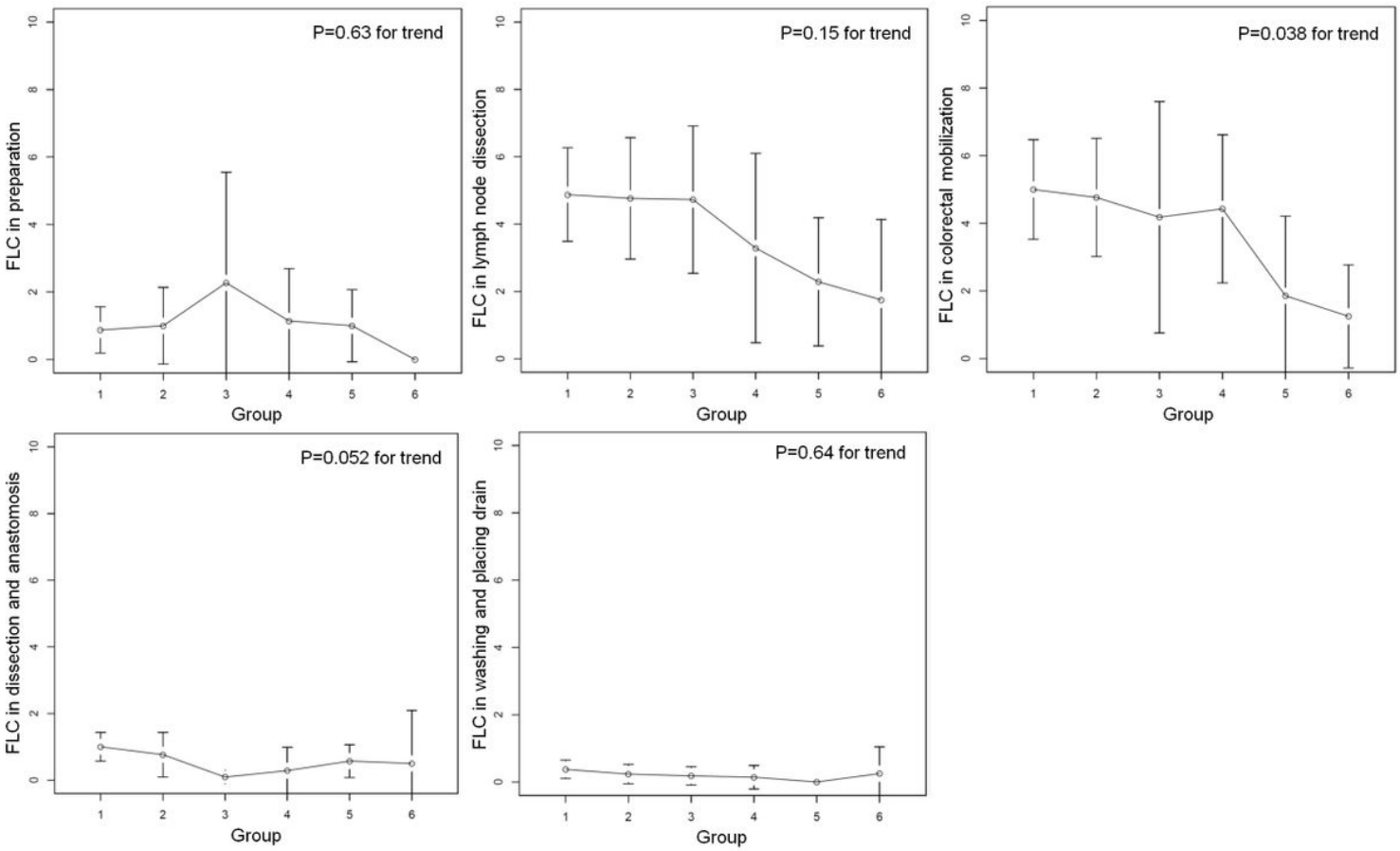

Figure 5

Trends for the 6 groups in the frequency of laparoscopic lens contamination events (FLC) for individual surgical situations.

Supplementary Files

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