



## Factors influencing amount of guidance in the operating room during laparoscopic cases

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### ABSTRACT

**Background:** Identifying factors associated with resident autonomy may help improve training efficiency. This study evaluates resident and procedural factors associated with level of guidance needed in the operating room.

**Methods:** Intraoperative performance and yearly performance on Fundamentals of Laparoscopic Surgery (FLS) tasks from 74 general surgery residents were retrospectively reviewed. The effect of post-graduate year (PGY), procedure complexity, case difficulty, intraoperative performance, and FLS task performance were analyzed using a mixed-effects model.

**Results:** PGY level, procedure complexity, case difficulty, operative technique, and operative knowledge were significantly associated with level of intraoperative guidance. In PGY2–4 residents, ratings of medical knowledge and communication were also significantly associated with guidance. There was no significant association between FLS performance and level of guidance for any PGY level.

**Conclusions:** The amount of intraoperative guidance is influenced by many factors, including resident performance and case characteristics. FLS tasks performance was not significantly associated with intraoperative guidance.

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### Introduction

Resident autonomy is a critical component to achieve practice readiness upon graduation from general surgery residency.<sup>1</sup> Multiple surveys of both general surgery residents and fellowship program directors demonstrate a lack of resident confidence and competence in operating independently.<sup>2–4</sup> This lack of confidence is partially responsible for the decision of 80% of graduating general surgery residents choosing to enter fellowship upon graduation.<sup>2</sup> There are numerous barriers to resident autonomy including resident preparedness and technical skills, decreased clinical experience, increased supervision requirements, and time/productivity constraints.<sup>5–8</sup> Furthermore, expectations of autonomy by both residents and attending surgeons significantly surpass actual level of autonomy granted intraoperatively for common laparoscopic procedures such as laparoscopic cholecystectomy, laparoscopic

appendectomy, laparoscopic partial colectomy, and bariatric procedures.<sup>9</sup>

Less guidance provided by the attending surgeon has been used as a surrogate for more resident autonomy in prior studies.<sup>10</sup> The amount of guidance provided in the operating room is inversely proportional to resident autonomy. Multiple tools have been developed to measure intraoperative resident level of guidance.<sup>10–13</sup> Our institution assesses level of intraoperative guidance using the procedure feedback form (PFF) described by Cook et al., 2015.<sup>14</sup>

Duty hours and patient care responsibilities also limit simulation time available for residents. It is important to use simulation time efficiently in order to optimize resident performance in the operating room. Prior studies have demonstrated that performance on Fundamentals of Laparoscopic Surgery<sup>15</sup> tasks is associated with better performance in the operating room.<sup>16,17</sup> However, it is unclear whether performance on FLS tasks is associated with the level of guidance provided to residents by an attending surgeon in the operating room during laparoscopic cases. In order to optimize simulation activities, it is important to determine the modifiable

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factors that influence resident autonomy. Ultimately, senior residents need to perform core basic and advanced laparoscopic procedures with minimal guidance in order to be ready to practice without supervision upon graduation.<sup>1</sup>

## Methods

This study retrospectively reviewed two types of general surgery resident performance data from a single institution. We sought to analyze factors that were associated with the amount of attending surgeon intraoperative guidance provided, which is a surrogate marker of resident autonomy. Factors evaluated include intraoperative factors from Procedure Feedback Forms (PFFs) and laparoscopic skills lab performance from Fundamentals of Laparoscopic Surgery (FLS) tasks.

All laparoscopic procedures were evaluated from PFFs filled out by categorical and undesignated preliminary general surgery residents and attending surgeons in the operating room from 2013 to 2016. The PFF process has previously been described in detail by Cook et al., 2015.<sup>14</sup> This feedback process is initiated by the resident after an operative case, and residents are required to submit at least 20 procedure feedback forms each year. Residents may select any case for evaluation and feedback and may submit PFFs at any time during the year. Data analyzed from the PFF included procedure name, case difficulty, level of guidance, as well as attending ratings of resident medical knowledge, operative technique, operative knowledge, communication, and professionalism.

On the procedure feedback form, the procedure performed is recorded as free text. Attending surgeons are asked to rank the case difficulty as straightforward, moderately difficult, or very difficult. Attending surgeons were then asked to rate resident intraoperative performance in five domains (medical knowledge, operative technique, operative knowledge, communication, and professionalism) on a continuous scale from 1 to 3 with numerical anchors set as: 1 = Needs Improvement, 2 = Satisfactory, 3 = Excellent. Medical knowledge relates to resident knowledge of the patient, the disease process, and the anatomy relevant to the case. Operative technique relates to resident manipulation of instruments and tissue. Operative knowledge relates to familiarity with the steps of an operation and equipment needed. Communication skills relates to communication clarity with other members of the operating team and team leadership. Professionalism relates to respect for all members of the operating room team and fostering a team-based approach to patient care. Lastly, attending surgeons were asked to rate how much guidance residents needed during the case, choosing between 3 options: little to none, moderate, and much. Only procedure feedback forms from laparoscopic cases were analyzed over the 3-year study period. Laparoscopic cases were divided into basic or advanced/complex, in accordance with ACGME case log guidelines.<sup>18</sup>

Laparoscopic skills lab data included performance on the 5 Fundamentals of Laparoscopic Surgery (FLS) tasks (peg transfer, precision cutting, ligating loop, extracorporeal suturing, and intracorporeal suturing) after completion of a yearly four-week skills lab course over the 3-year study period.<sup>15</sup> Laparoscopic skills labs are scheduled in the fall for post-graduate year (PGY)1 residents and throughout the remainder of the academic year for PGY2–4 residents. Residents in their final year were excluded from analysis, as they do not participate in a laparoscopic skills lab during their chief year. Performance of each FLS task was measured by time to complete the task plus any penalty time per FLS testing guidelines.<sup>19</sup> Each resident included in the study had one measurement of performance on each FLS task per year during the study period. We analyzed all five FLS tasks separately as well as the total normalized McGill Inanimate System for Training and

Evaluation of Laparoscopic Skills (MISTELS) score each year. The total normalized MISTELS score is a measure of overall FLS performance, equally incorporating performance on each of the 5 FLS tasks.<sup>19</sup>

All resident identifiers were removed by an independent data manager not affiliated with the residency program, assigning each resident a unique ID number in order to enable linking of laparoscopic skills to operative performance while blinding the rest of the study team to resident performance data. This study was approved by our Institutional Review Board.

To account for pseudo-replication in our dataset due to multiple intraoperative performance evaluations from PFFs from the same residents within and across post-graduate years (PGY), mixed effects regression models were used, with residents included as a random effect (number of residents = 74 with 768 procedures across four post-graduate years). We used a mixed-effects regression model to evaluate the effect of PGY level on continuous variables (attending ratings of resident intraoperative performance and resident performance on FLS tasks) and chi-squared tests to evaluate the effect of PGY level on categorical variables (level of guidance, procedure complexity, and case difficulty).

The primary analysis evaluated factors that were associated with the level of guidance needed by residents in the operating room. Both univariate analysis and multivariate analysis was performed, using F-tests from mixed-effects regression models were used to evaluate for significance in the factors evaluated. Significance level was set at the  $\alpha < 0.05$  level.

## Results

There were 106 residents with recorded data for attending ratings of operating room performance, as documented on the PFF, and of those 106, 74 residents also had laparoscopic skills lab data from FLS tasks. In total, there were 768 PFFs with data for level of guidance, intraoperative performance ratings, procedure complexity, and case difficulty. The number of PFFs per resident per year varied, ranging from 1 to 21. There was variation in the number of PFFs per resident per year due to residents being able to submit more than 20 PFFs per year and the fact that not all cases submitted on PFFs were laparoscopic cases. Across all PGYs, residents required much guidance in 13% of cases, moderate amounts of guidance in 56% of cases, and little to no guidance in 31% of cases. In regard to case difficulty, 49% were straightforward, 42% were moderately difficult, and 9% were very difficult. Basic laparoscopic procedures (diagnostic laparoscopy, laparoscopic cholecystectomy, and laparoscopic appendectomy) comprised 77% of the PFF entries. Descriptive statistics are summarized in [Table 1](#).

### *Analysis of the effect of PGY level*

Analysis revealed a significant association between PGY level and level of guidance ( $p < 0.01$ ) with increasing PGY level associated with less guidance needed in the operating room. There was also a significant association between PGY and procedure complexity, with higher PGY level associated with a higher percentage of complex laparoscopic procedures ( $p = 0.04$ ). There were also significant associations between PGY level and attending ratings of medical knowledge ( $p < 0.01$ ), operative technique ( $p < 0.01$ ), operative knowledge ( $p < 0.01$ ), communication ( $p < 0.01$ ), and professionalism ( $p = 0.04$ ), with higher PGY level associated with higher performance ratings. PGY level was significantly associated with performance on the FLS tasks of peg transfer ( $p < 0.01$ ), pattern cutting ( $p < 0.01$ ), ligating loop ( $p < 0.01$ ), extracorporeal suturing ( $p < 0.01$ ), and intracorporeal suturing, with higher PGY level associated with better performance on FLS

**Table 1**  
Descriptive statistics for PFF and FLS tasks performance by post-graduate year (PGY).

	PGY1	PGY2	PGY3	PGY4	All
<i>Attending Ratings (mean, sd)</i>					
Number of Procedures	87	264	231	186	768
Medical Knowledge (1–3)	2.55 (0.48)	2.81 (0.35)	2.90 (0.25)	2.92 (0.19)	2.83 (0.33)
Operative Technique (1–3)	2.13 (0.57)	2.38 (0.49)	2.63 (0.41)	2.76 (0.31)	2.52 (0.48)
Operative Knowledge (1–3)	2.19 (0.61)	2.58 (0.45)	2.76 (0.38)	2.85 (0.27)	2.66 (0.46)
Communication (1–3)	2.80 (0.37)	2.91 (0.26)	2.93 (0.22)	2.92 (0.21)	2.91 (0.26)
Professionalism (1–3)	2.95 (0.20)	2.98 (0.15)	2.99 (0.11)	3.00 (0.04)	2.98 (0.13)
<i>Laparoscopic Lab Skills (mean, sd)</i>					
Number of Residents*	37	39	22	19	74
Normalized MISTELS Score	464 (35)	492 (26)	499 (20)	496 (18)	485 (31)
Peg Transfer (sec)	74 (20)	63 (17)	64 (9)	64 (12)	67 (17)
Precision Cutting (sec)	73 (32)	58 (25)	52 (16)	63 (14)	62 (26)
Ligating Loop (sec)	40 (14)	37 (11)	35 (6)	46 (15)	39 (13)
Extracorporeal Suturing (sec)	82 (14)	88 (20)	94 (17)	110 (31)	90 (22)
Intracorporeal Suturing (sec)	127 (45)	98 (31)	95 (20)	93 (19)	106 (36)
<i>Procedure Complexity (n, %)</i>					
Basic	62 (71%)	223 (84%)	173 (75%)	135 (73%)	593 (77%)
Complex	25 (29%)	41 (16%)	58 (25%)	51 (27%)	175 (23%)
<i>Case Difficulty (n, %)</i>					
Straightforward	47 (55%)	133 (52%)	110 (48%)	82 (44%)	372 (49%)
Moderately Difficult	32 (37%)	103 (40%)	101 (44%)	82 (44%)	318 (42%)
Very Difficult	7 (8%)	22 (9%)	20 (9%)	21 (11%)	70 (9%)
<i>Guidance Needed (n, %)</i>					
Little to None	3 (3%)	42 (16%)	99 (43%)	98 (53%)	242 (32%)
Moderate	43 (49%)	194 (73%)	113 (49%)	77 (41%)	427 (56%)
Much	41 (47%)	28 (11%)	19 (8%)	11 (6%)	99 (13%)

NOTE: N = 74 residents who participated in 768 total procedures across four post-graduate years; \*some residents have data for more than one PGY year. PFF – Procedure Feedback Forms; FLS – Fundamentals of Laparoscopic Surgery; MISTELS – McGill Inanimate System for Training and Evaluation of Laparoscopic Skills.

tasks. There was no significant association between PGY level and case difficulty ( $p = 0.98$ ).

*Univariate analysis of factors associated with level of guidance*

Since PGY level was significantly associated with level of guidance, separate univariate mixed-effects regression analyses were performed for each PGY level. Attending surgeon ratings of resident medical knowledge, operative technique, and operative knowledge, as well as procedure complexity and the case difficulty, were significantly associated with the level of guidance needed in the operating room for PGY 2–4 levels ( $p < 0.01$ ). Higher ratings of medical knowledge, operative technique, and operative knowledge were associated with less guidance. Higher procedural complexity (complex vs basic) and higher level of case difficulty were associated with more guidance needed in the operating room. For PGY 4 residents, higher attending ratings of communication skills were significantly associated with less guidance needed ( $p = 0.035$ ).

For PGY1 residents, level of guidance was only significantly associated with operative technique ( $p < 0.01$ ) and operative knowledge ( $p < 0.01$ ), with higher ratings of operative technique and operative knowledge associated with less guidance. For the PGY1 level, procedure complexity and case difficulty were not significantly associated with level of guidance ( $p = 0.96$  and  $p = 0.85$ , respectively). There was no significant association between performance on any of the 5 FLS tasks or total normalized MISTELS score and level of guidance at any PGY level ( $p = ns$  for all). Univariate analysis test results are reported in Table 2.

*Multivariate analysis of factors associated with level of guidance*

A multivariate, mixed-effects regression analysis was performed to account for interactions between factors evaluated, including all factors that were significantly associated with guidance in the univariate analysis as well as performance on all FLS tasks. Significant factors from the univariate analysis included PGY level,

procedure complexity, case difficulty, and attending surgeon ratings of medical knowledge, operative technique, operative knowledge, and communication. A second multivariate analysis was conducted, replacing total times to complete the five FLS tasks with the normalized MISTELS score since the MISTELS score is derived from the FLS tasks. All other factors were also included in the second analysis.

The multivariate analysis showed no significant association between resident performance on the 5 FLS tasks and level of guidance needed ( $p = ns$  for all tasks). Factors that were significantly associated with level of guidance included operative

**Table 2**  
Univariate Analysis: Factors associated with level of guidance in the operating room using a mixed-methods model.

Factors Evaluated	Test for significant association with level of guidance by PGY level			
	PGY1	PGY2	PGY3	PGY4
<i>Attending Ratings</i>				
Medical Knowledge	0.18	<b>&lt;0.01</b>	<b>&lt;0.01</b>	<b>&lt;0.01</b>
Operative Technique	<b>&lt;0.01</b>	<b>&lt;0.01</b>	<b>&lt;0.01</b>	<b>&lt;0.01</b>
Operative Knowledge	<b>&lt;0.01</b>	<b>&lt;0.01</b>	<b>&lt;0.01</b>	<b>&lt;0.01</b>
Communication	0.08	0.26	0.61	<b>0.03</b>
Professionalism	0.05	0.12	0.26	0.31
<i>Procedure</i>				
Procedure Complexity (Basic or Complex)	0.96	<b>&lt;0.01</b>	<b>&lt;0.01</b>	<b>&lt;0.01</b>
Case Difficulty	0.85	<b>&lt;0.01</b>	<b>&lt;0.01</b>	<b>&lt;0.01</b>
<i>Laparoscopic Lab Skills</i>				
Normalized MISTELS Score	0.66	0.96	0.25	0.83
Peg Transfer (sec)	0.07	0.62	0.26	0.31
Precision Cutting (sec)	0.30	0.81	0.20	0.70
Ligating Loop (sec)	0.21	0.85	0.11	0.87
Extracorporeal Suturing (sec)	0.46	0.74	0.54	0.80
Intracorporeal Suturing (sec)	0.32	0.71	0.83	0.31

NOTE: N = 74 residents with 768 total procedures across four post-graduate years. Test results were from F-tests from mixed-effects models fit by post-graduate year. P-values in bold indicate statistically significant values.

technique ( $p < 0.01$ ), operative knowledge ( $p < 0.01$ ), PGY level ( $p < 0.01$ ), procedure complexity ( $p < 0.01$ ), and case difficulty ( $p < 0.01$ ). Higher PGY level and higher ratings of operative technique and operative knowledge were associated with less guidance while increased procedure complexity and case difficulty were associated with more guidance.

The significance level of the effect of other factors and the direction of their effect remained unchanged when MISTELS replaced the five FLS tasks in the model. There was no significant association between total normalized MISTELS score and level of guidance ( $p = 0.33$ ). Multivariate test results are reported in Table 3. The effect of resident statistically significant intraoperative factors and laparoscopic skills lab performance on level of guidance are shown in Figs. 1 and 2, respectively.

## Discussion

Results of this study show that the amount of intraoperative guidance needed, which is a surrogate for intraoperative autonomy,<sup>10</sup> is associated with the resident's technical skills, knowledge of the procedure, PGY level, and case characteristics (procedure complexity and case difficulty), but not FLS task performance. More factors are associated with level of guidance for senior residents as they transition from moderate guidance towards little to no guidance, as demonstrated by the significant contribution of medical knowledge and communication skills in addition to technical skills and operative knowledge. This is in contrast to junior residents where the data indicates that level of guidance in the operating room is associated primarily with technical skills and knowledge of the procedure.

A number of factors may explain the absence of an association of FLS performance and intra-operative guidance. First, even in tasks that correlate well, FLS tasks may not sufficiently simulate intra-operative conditions. A recent study by Crochet et al., 2017 demonstrated that residents after structured FLS training performed the same on the FLS intracorporeal suturing task as

experienced surgeons but took significantly longer to complete intraoperative intracorporeal suturing. Also, these residents and had significantly lower Global Objective Assessment of Laparoscopic Skills (GOALS) scores than experienced surgeons despite similar performance on the FLS intracorporeal suturing task.<sup>20</sup> FLS performance may reflect the ability to perform the specific tasks in ideal conditions through goal setting and deliberate practice, rather than reflect true improvement in intra-operative performance.

Second, not all FLS tasks are directly relatable to tasks performed in the operating room; it may be difficult for residents to translate grasping gauze and plastic triangular prisms to providing tension on tissues and seeing planes in the operating room. Previous work by Cook et al., 2015 identified major themes of operative flow, technical skill, outcomes, synthesis and decision-making, knowledge base, and communications/attitudes in the comments listed on the feedback portion of the PFF.<sup>14</sup> The most common sub-themes within operative technique included dissection technique, instrument handling, suture placement/location, use of left hand, and tissue handling. Dissection technique and tissue handling do not correspond well to the materials used in FLS tasks.

Third, resident performance continues to improve on FLS tasks since it was first developed, and it may be that the FLS tasks no longer have sufficient discriminatory power for resident technical skills. The mean normalized MISTELS score at our institution for PGY1 level residents was 464, which is greater than the mean of 372 in the competent group described in the initial MISTELS validation cohort.<sup>19</sup> It is possible that a new, improved performance baseline has been established with the routine use of laparoscopic skills labs. As the technical demands of surgeon skill level increase, FLS may need to be modified to more closely reflect the current technical requirements of a practicing surgeon performing laparoscopy. Other certifications such as the Advanced Trauma Life Support (ATLS) course and the Advanced Cardiac Life Support (ACLS) courses are also required for board eligibility.<sup>21</sup> However, ATLS and ACLS have been modified over time to reflect current evidence-based practices while FLS has yet to undergo changes since its inception. Furthermore, residents at this institution complete ACLS training prior to residency and ATLS training prior to their trauma rotation. The optimal time to complete FLS may be prior to performing any laparoscopic surgeries, not after hundreds of laparoscopic cases.

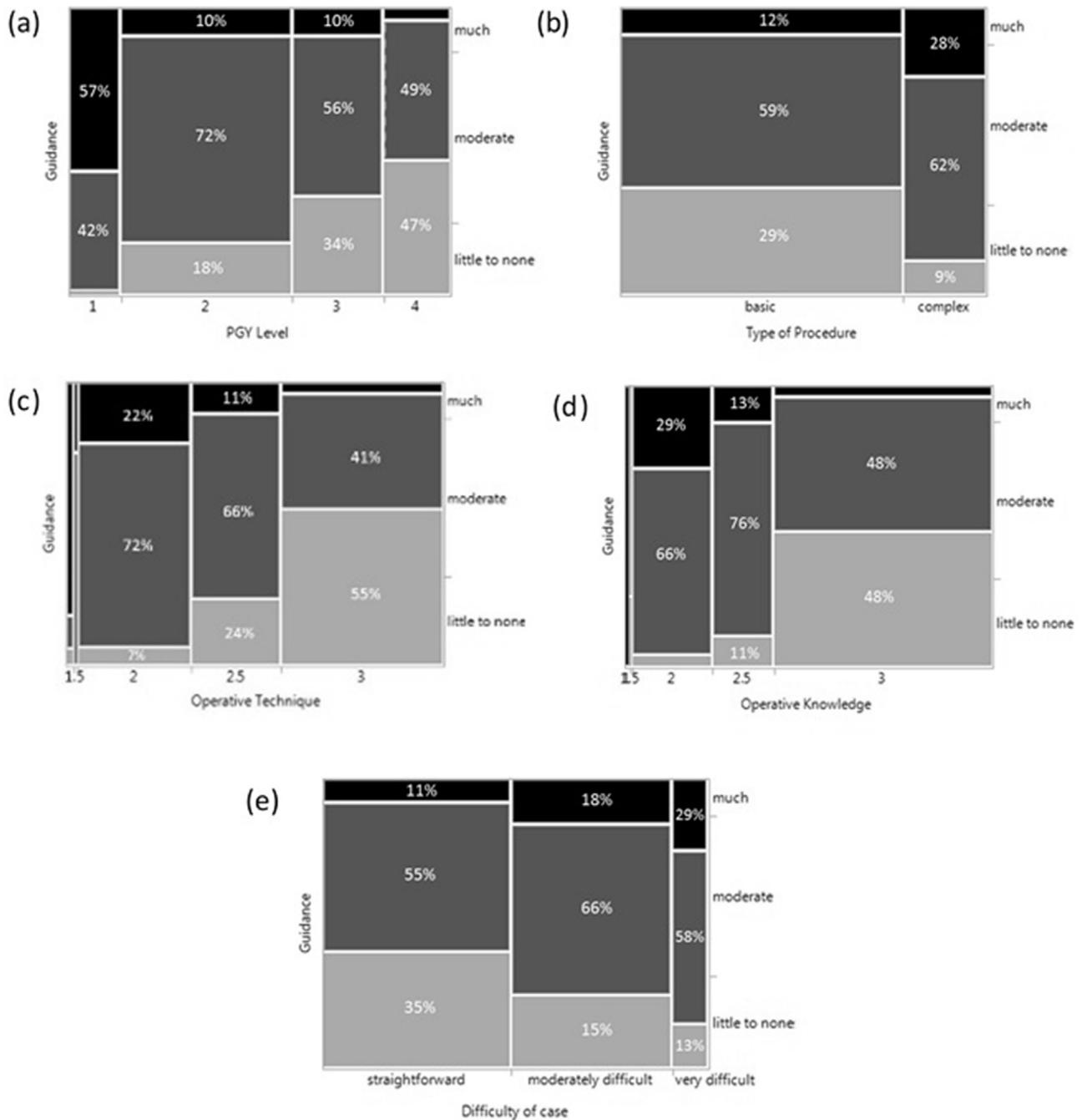
Lastly, FLS does not incorporate other aspects of operating room performance such as operative knowledge, case setup, and communication skills in order to improve resident confidence and preparedness, which also affect level of resident guidance in the operating room.<sup>22,23</sup> Simulation may need to focus on more complex activities that incorporate higher fidelity tissue such as cadaver or porcine labs, especially for senior residents. Cadaver and live-animal models have a higher perceived value to surgical trainees and faculty, yet are less utilized than physical models, SCORE, and virtual reality simulators<sup>24</sup> FLS is the foundation of laparoscopic simulation training but may need to be emphasized more in junior residents that still need to hone basic technical skills. Results of this study and other recent studies (Crotchet et al., 2017) that show a disconnect between FLS task performance and intra-operative performance provide evidence that FLS should be primarily used for junior residents with minimal previous laparoscopic intraoperative experience.<sup>20</sup> For senior residents, it may be more effective to utilize valuable skills lab time for more complex simulation integrating medical knowledge, case setup, technical skills, intra-operative decision making, and communication skills.

Limitations of this study include the fact that residents select the cases in which to receive evaluation and feedback via the procedure feedback form, causing a selection bias. Residents who are

**Table 3**  
Multivariate Analysis: Factors associated with level of guidance in the operating room using a mixed-methods regression model.

Explanatory Variable	Influence on Guidance	p-value
<i>Attending Ratings</i>		
Medical Knowledge	–	0.28
Operative Technique	–	<b>&lt;0.01</b>
Operative Knowledge	–	<b>&lt;0.01</b>
Communication	–	0.56
Professionalism	–	0.38
<i>Post-Graduate Year</i>		
PGY2 compared to PGY1	–	0.45
PGY3 compared to PGY1	–	<b>&lt;0.01</b>
PGY4 compared to PGY1	–	<b>&lt;0.01</b>
<i>Procedure Complexity</i>		
Complex compared to Basic procedure	+	<b>&lt;0.01</b>
<i>Case Difficulty</i>		
Very Difficult compared to Straightforward	+	<b>&lt;0.01</b>
Moderately Difficult compared to Straightforward	+	0.27
<i>Laparoscopic Lab Skills</i>		
Normalized MISTELS Score	–	0.33
Peg Transfer (sec)	+	0.48
Precision Cutting (sec)	+	0.68
Ligating Loop (sec)	–	0.75
Extracorporeal Suturing (sec)	+	0.12
Intracorporeal Suturing (sec)	+	0.75

NOTE: A "+" indicates that the factor evaluated is associated with more guidance needed and "-" indicates less guidance needed. P-values in bold indicate statistically significant values.



**Fig. 1.** (a) Effect of RGY level on guidance ( $p < 0.001$ ) (b) Effect of procedure complexity on guidance ( $p < 0.001$ ) (c) Effect of operative technique on guidance ( $p < 0.001$ ) (d) Effect of operative knowledge on guidance ( $p < 0.001$ ) (e) Effect of case difficulty on guidance ( $p < 0.001$ ).

concerned about their laparoscopic performance may select more straightforward cases for evaluation compared to their peers. Additionally, if residents struggled or received negative feedback on a case, they may not choose to submit the procedure feedback form. Conversely, residents that perform better than their PGY-matched peers may have opportunities to perform more complex or difficult cases, which may lead to decreased autonomy compared to their peers. However, this study provides content validity for the procedure feedback form, as the PFF is able to discriminate between performance of residents at each PGY level. Another limitation of the study is common source bias due to attending intraoperative ratings of resident performance occurring in conjunction with

attending determination of the level of guidance the resident needed intraoperatively, as both data are collected on the same form. Additionally, the database of procedure feedback forms included multiple laparoscopic procedures, varying in complexity and skills needed to complete the operation. Lastly, this study highlights resident and procedural factors that affect guidance in the operating room. However, attending factors are also present; this study does not account for attending factors that affect resident autonomy, such as time and productivity constraints, attending confidence, patient outcomes, malpractice concerns, and increased supervision requirements by attending surgeons.<sup>5–8</sup> Evaluating attending factors associated with level of guidance as well as

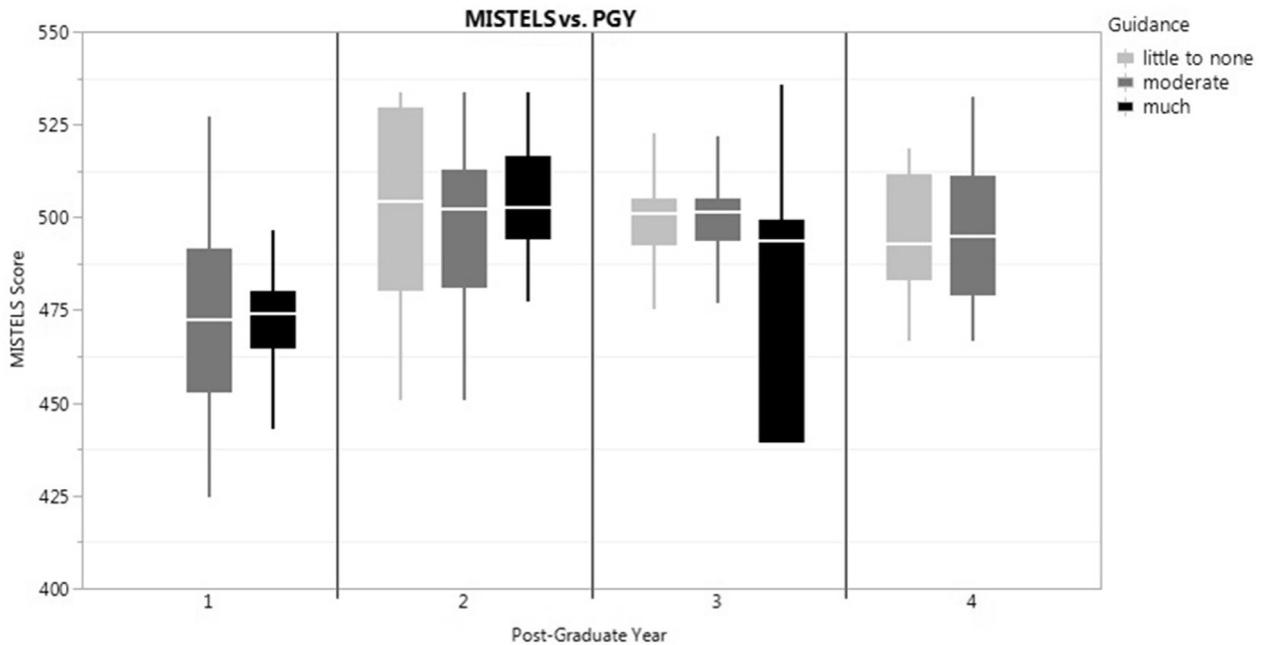


Fig. 2. Effect of FLS task performance on level of guidance by PGY year ( $p =$  non-significant for all PGY levels).

gender differences between residents and attending surgeons may help identify other factors that may need to be addressed to optimize resident autonomy during training.

## Conclusions

Operative technical skills, operative knowledge, PGY level, procedure complexity, and case difficulty are all associated with level of guidance provided to residents by attending surgeons in the operating room. However, FLS task performance was not associated with guidance. FLS is the foundation of laparoscopic simulation, but performance above a certain level may not affect the level of guidance residents need in the operating room. Further work is needed to elucidate factors associated with operating room guidance and autonomy and to develop resident simulation curricula targeted at improving resident operative autonomy.

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