Independent Operating by General Surgery Residents: An ACS-NSQIP Analysis

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OBJECTIVE: Surgical resident autonomy during training is paramount to independent practice. We sought to determine prevalence of general surgery resident autonomy for surgeries commonly performed on emergency general surgery services and identify trends with time.

DESIGN: We queried ACS-NSQIP for patients undergoing one of 7 emergency general surgery operations. We evaluated trends in independent operating (defined as a resident operating alone, without attending having scrubbed) over the study period. Other outcomes of interest: operative time, 30-day-mortality and complications.

SETTING: The ACS-NSQIP database.

PARTICIPANTS: Patients undergoing one of 7 emergency general surgery operations.

RESULTS: Data regarding resident involvement was only available for the years 2005-2010. 90,790 operations were performed, 922 (1%) by residents operating independently. Appendectomy accounted for 61% independent cases. Independent resident operating was associated with a longer operative time (65 versus 58 minutes, $p < 0.001$), but lower risk of bleeding requiring transfusion ($p < 0.001$) and progressive renal insufficiency ($p = 0.02$). Independent operating was not associated with increased risk of complications/mortality.

CONCLUSION: Independent resident operating is rare, even with increasing attention to its importance, and is not associated with increased complications or mortality. National data on this subject is old and not currently collected. There is need for a national registry on resident involvement to understand the current effect of independent operating on outcomes. (J Surg Ed 78:2001−2010. © 2021 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: Surgical training, Autonomy, Competence, Emergency general surgery, Patient safety

COMPETENCIES: Patient Care, Practice-Based Learning and Improvement

INTRODUCTION

A graduated, competency based progression towards independent operating is important for residents in surgical training[1] and there has been increasing focus on this in the surgical literature, especially in the last five years.[2] Studies cite Accreditation Council for Graduate Medical Education (ACGME) requirements for faculty supervision of trainees, faculty revenue generation, emerging technologies, patient expectations, the technical comfort of residents, and concerns about increased complications or poorer outcomes as barriers to residents operating independently.[3] Implementation of initiatives to increase independent resident operating is challenging. Efforts have included patient educational strategies[4] and assessment of resident and faculty perceptions.[5]

While the surgical education community increasingly embrace the importance of autonomy to enable successful transition to practice, the actual prevalence of independent operative experience in graduating residents is unknown. Mentoring initiatives exist to aid in the "transition to practice" for graduated residents[7] as well as

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the national Mastery in General Surgery Program delivered by the American College of Surgeons to support the transition to independent practice in general surgery.[8] Despite these resources it is important to accurately determine how much independent practice trainees experience during residency that can be built upon by these initiatives. Our aim was to determine the national experience of general surgery resident independence for operations commonly performed on an emergency general surgery service and to identify trends over time.

MATERIALS AND METHODS

We queried the American College of Surgeons – National Surgical Quality Improvement Program (ACS-NSQIP) database between 2005-2010 to identify patients undergoing one of seven operations commonly performed on an emergency general surgery (EGS) service including: partial colectomy, small bowel resection, cholecystectomy, peptic ulcer surgery, lysis of adhesions, appendectomy and exploratory laparotomy. EGS was selected as this is a specialty affording significant opportunity for resident autonomy and one that all residents will experience during their training. The operations were selected based on previous analysis in a nationally representative observational study including more than 2 million patient encounters which found these seven operations accounted for 80% of the operative volume, death, complications and costs within the specialty of EGS.[6]

We evaluated the trend of resident involvement over the study period. When evaluating the ACS-NSQIP definitions of resident involvement we defined 'independent resident operating' as a resident operating alone, without attending scrubbed in the operating room. This correlates with the ACS-NSQIP "Attending not present but available" and "Attending in OR suite" variables. The ACS-NSQIP definitions of "Attending and resident in the OR" and "Attending in the OR" were used to denote a 'supervised resident' for the purposes of this work. The "Attending alone" variable denoted no resident involvement in the case. Resident involvement was a unique, legacy variable (2005-2010), which was recorded in NSQIP between 2005 and 2012 inclusive. We also collected data to determine the effect of independent resident operating on operative time, 30-day-mortality and composite complication rate.

Statistical Analysis

Patient characteristics and outcomes were presented as frequencies and proportions for categorical variables and as median and interquartile range (IQR) for continuous variables. Differences between groups were determined by Chi-square test for categorical variables and Kruskal Wallis test for continuous variables. Trend of independent resident operating were evaluated using the non-parametric trend test and depicted by the line graph. Multivariable logistic and linear regression analyses were conducted to determine the characteristics associated with mortality, length of operation time, any post-operative complication, and individual type of complications (surgical site infection, sepsis and sepsis shock, respiratory, renal, cardiovascular, and neurological complications). The study sample were randomly divided (50:50) into the training and validation sets. The training set was used to develop the models and the validation set was used to validate the performance of the models. The selection of variables for the multivariable logistic and linear regression models were conducted using the Stata's Lasso command with the cross-validation (CV) selection option. Models' discrimination ability was evaluated using the area under the receiver operating characteristic curve. All the analyses were performed on Stata version 16.1 (StataCorp LLC, College Station, TX, USA). A p-value of < 0.05 was considered statistically significant.

RESULTS

We found available ACS-NSQIP data pertaining to resident involvement in operations for those cases performed between 2005 and 2010. These data were missing for 44% of cases in 2011 and 77% of cases in 2012. No resident involvement data for operations between 2013 and 2016 was collected in the ACS-NSQIP database.

A total of 91,033 operations were performed in the five-year study period and 90,790 had resident involvement data available and were therefore included in analysis. Of these cases, 922 (1%) were performed by residents operating independently. Figure 1.

When patient characteristics were compared, there was a clinically meaningful difference in the following areas when patients operated on by independent residents were compared to those operations performed by a supervised resident: fewer non-Hispanic Black patients (independent residents 5.7%, supervised residents 10.2%, $p < 0.001$), more inpatients (92.5% versus 86.7%, $p < 0.001$), reduced estimated probability of morbidity (7.7% versus 8.6% $p < 0.001$), fewer diabetic patients (6.9% versus 9.2%, $p = 0.002$) and fewer patients with sepsis (36.3% versus 41.7% $p < 0.001$). Table 1. With regard to peri-operative details, the most common operation performed by independent residents was appendectomy (562 operations representing 61% of the independent cases). Table 2. Appendectomy represented 53.7% (48,709/ 90,790) of total cases examined. The number of appendectomies performed by independent residents versus other procedures we studied was

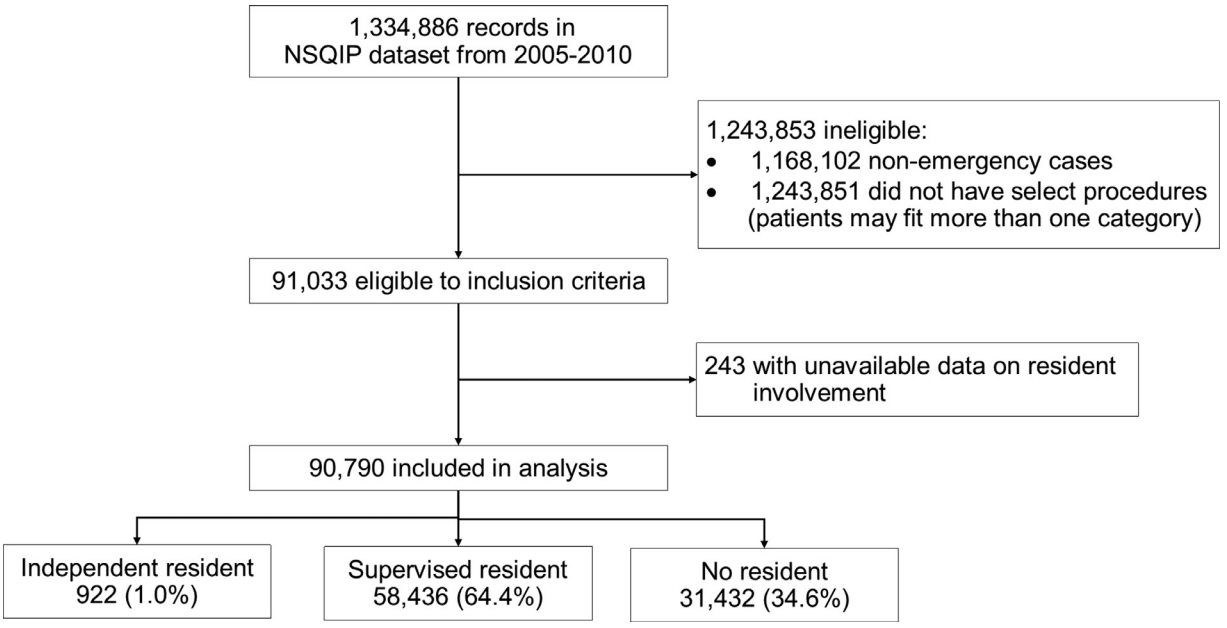

FIGURE 1. Flow chart of study population.

562 of48,709 (1.2%) and 360 of 42,081 (0.9%), respectively, $p < 0.001$. Table 4.

Considering patient outcomes, independent resident operating was significantly associated with a longer operative time (65 minutes versus 58 minutes, $p < 0.001$) but with a lower risk of progressive renal failure ($p = 0.02$) and bleeding requiring transfusion ($p < 0.001$). Table 3, Table 5. Resident independence was not associated with increased risk of composite complications or mortality. Table 5a.

There was a significant reduction in the number of cases in which there was a resident operating supervised ($p = 0.03$) and a significant increase in the number of cases performed without a resident ($p = 0.03$) during the five years between 2005 and 2010. Figure 2a. During this time, we also observed a trend towards reduced resident independent operating, $p = 0.85$. Figure 2b.

Our sample size (N = 90,790) has 86% (one-sided test) and 78% (two-sided test) power to detect a significant difference in having any complication between the 2 groups with alpha=0.05. Therefore, the possibility of type 1 and type 2 errors, if any, would be minimal.

DISCUSSION

This work demonstrates that resident independence within the operating room is rare for the most frequently performed EGS operations and may be reducing, even with increasing attention to its importance. We identified a rate of 1% for independent residents performing these procedures, which likely substantiates the concern that graduates are not sufficiently equipped for independent practice.[2,9,10] When the practices of graduating general surgery residents are considered they may go straight into independent practice or may pursue specialty training. Recent study identified 26% graduates surveyed transitioned straight into independent practice and 74% sought specialty training. Our data are important as, despite trends to increasing specialization, upon graduation approximately one quarter of residents need to be prepared to operate independently.[11]

Independent Resident Operating Does Not Increase Complications

NSQIP data demonstrates that independently operating residents were not associated with increased complications or mortality. Despite this, independent resident operating remains exceedingly rare among ACS-NSQIP participating hospitals which may reflect public concern regarding the association between resident participation in care and complications. These beliefs date back to events of the 1980s and before and still permeate patient perceptions with regard to resident training today.[12] Our results corroborate previous studies delineating no increase in complications occur when a resident is involved in surgery in a variety of specialties.[13-19] Additionally, our data demonstrate that residents are operating autonomously on patients with a lower risk of morbidity, less diabetes and less sepsis. This finding arguably represents judicious case selection by both residents and attendings of those patients appropriate for resident

TABLE 1. Patient characteristics

	Total (N = 90790)	Resident Autonomy (*n* = 922)	Supervised Resident (*n* = 58436)	No Resident (*n* = 31432)	Overall p-Value
Age (years), median (IQR)	47.0 (30.0, 64.0)	46.0 (30.0, 61.0)	46.0 (30.0, 64.0)	47.0 (31.0, 64.0)	0.01
Gender					0.04
Female	47443 (52.4)	458 (49.8)	30435 (52.2)	16550 (52.9)	
Male	43096 (47.6)	462 (50.2)	27892 (47.8)	14742 (47.1)	
Race/Ethnicity					<0.001
Non-Hispanic White	59912 (66.0)	557 (60.4)	37516 (64.2)	21839 (69.5)	
Non-Hispanic Black	7838 (8.6)	53 (5.7)	5975 (10.2)	1810 (5.8)	
Hispanic	10180 (11.2)	128 (13.9)	6612 (11.3)	3440 (10.9)	
Asian or Pacific Islander	3449 (3.8)	61 (6.6)	2253 (3.9)	1135 (3.6)	
American Indian or Alaska Native	980 (1.1)	1 (0.1)	645 (1.1)	334 (1.1)	
Unknown	8431 (9.3)	122 (13.2)	5435 (9.3)	2874 (9.1)	
Inpatient					<0.001
No	13313 (14.7)	69 (7.5)	7778 (13.3)	5466 (17.4)	
Yes	77477 (85.3)	853 (92.5)	50658 (86.7)	25966 (82.6)	
Estimated probability of mortality (%), median (IQR)	0.2 (0.0, 2.2)	0.2 (0.1, 1.5)	0.2 (0.1, 2.6)	0.2 (0.0, 1.5)	<0.001
Estimated probability of morbidity (%), median (IQR)	8.0 (4.0, 26.4)	7.7 (4.3, 22.1)	8.6 (4.1, 28.6)	7.1 (3.8, 22.2)	<0.001
Diabetes					0.002
No	82589 (91.0)	858 (93.1)	53035 (90.8)	28696 (91.3)	
Yes	8201 (9.0)	64 (6.9)	5401 (9.2)	2736 (8.7)	
Functional health status Prior to Surgery					<0.001
Independent	79683 (87.8)	824 (89.4)	50682 (86.8)	28177 (89.7)	
Partially dependent	6321 (7.0)	55 (6.0)	4107 (7.0)	2159 (6.9)	
Totally dependent	4743 (5.2)	43 (4.7)	3611 (6.2)	1089 (3.5)	
> 10% loss body weight in last 6 months					<0.001
No	88780 (97.8)	907 (98.4)	56979 (97.5)	30894 (98.3)	
Yes	2010 (2.2)	15 (1.6)	1457 (2.5)	538 (1.7)	
Systemic sepsis					<0.001
No	53626 (59.4)	587 (63.7)	33920 (58.3)	19119 (61.2)	
Yes	36681 (40.6)	334 (36.3)	24248 (41.7)	12099 (38.8)	
Prior Operation within 30 days					<0.001
No	81728 (95.6)	841 (95.1)	51311 (95.0)	29576 (96.8)	
Yes	3722 (4.4)	43 (4.9)	2692 (5.0)	987 (3.2)	

independence. This is important to recognize as it is adherent to recommendations that trainers should make decisions regarding resident supervision based upon: the level of skill of the resident, the complexity of the patient's condition and surgical technique and the residents' confidence and comfort with the operation in question.[20] These are important findings that work to combat the purported long standing stigma with regard to resident participation in surgical care. It is also interesting to note that significantly fewer non-Hispanic Black patients were operated on by independent residents which may suggest that there is no significant racial or ethnic bias regarding "practicing" on non-white patients.

Independent Resident Operating is Limited to Appendectomy

The most common operation general surgery residents are performing independently is appendectomy, representing 61% of the independent cases. When the 6 other EGS operations studied are considered; partial colectomy accounts for 12% of the independent cases, small bowel resection 8%, surgery for peptic ulcer disease 7%, lysis of adhesions 5% and exploratory laparotomy 4%. Therefore, for seven EGS operations that account for 80% of EGS practice, general surgery residents are only gaining significant independent

TABLE 2. Peri-Operative Details

	Total (N = 90790)	Resident Autonomy(*n* = 922)	Supervised Resident (*n* = 58436)	No Resident (*n* = 31432)	p-Value
Wound classification					<0.001
1-Clean	4174 (4.6)	45 (4.9)	2913 (5.0)	1216 (3.9)	
2-Clean/ Contaminated	32484 (35.8)	225 (24.4)	20815 (35.6)	11444 (36.4)	
3-Contaminated	32355 (35.6)	423 (45.9)	20500 (35.1)	11432 (36.4)	
4-Dirty/Infected	21777 (24.0)	229 (24.8)	14208 (24.3)	7340 (23.4)	
ASA classification					<0.001
1-No disturb	20583 (22.7)	230 (24.9)	13277 (22.7)	7076 (22.6)	
2-Mild disturb	38877 (42.9)	393 (42.6)	24105 (41.3)	14379 (45.8)	
3-Severe disturb	20128 (22.2)	200 (21.7)	13103 (22.5)	6825 (21.8)	
4-Life threat	9773 (10.8)	86 (9.3)	6915 (11.8)	2772 (8.8)	
5-Moribund	1297 (1.4)	13 (1.4)	965 (1.7)	319 (1.0)	
Procedure type					
Partial colectomy					0.26
No	78368 (86.3)	813 (88.2)	50430 (86.3)	27125 (86.3)	
Yes	12422 (13.7)	109 (11.8)	8006 (13.7)	4307 (13.7)	
Small bowel resection					<0.001
No	83289 (91.7)	850 (92.2)	53056 (90.8)	29383 (93.5)	
Yes	7501 (8.3)	72 (7.8)	5380 (9.2)	2049 (6.5)	
Cholecystectomy					<0.001
No	81798 (90.1)	853 (92.5)	52782 (90.3)	28163 (89.6)	
Yes	8992 (9.9)	69 (7.5)	5654 (9.7)	3269 (10.4)	
Peptic ulcer disease					<0.001
No	82438 (90.8)	858 (93.1)	52357 (89.6)	29223 (93.0)	
Yes	8352 (9.2)	64 (6.9)	6079 (10.4)	2209 (7.0)	
Lysis of adhesions					0.03
No	85976 (94.7)	876 (95.0)	55252 (94.6)	29848 (95.0)	
Yes	4814 (5.3)	46 (5.0)	3184 (5.4)	1584 (5.0)	
Appendectomy					<0.001
No	42081 (46.3)	360 (39.0)	28303 (48.4)	13418 (42.7)	
Yes	48709 (53.7)	562 (61.0)	30133 (51.6)	18014 (57.3)	
Exploratory laparotomy					<0.001
No	85694 (94.4)	883 (95.8)	54681 (93.6)	30130 (95.9)	
Yes	5096 (5.6)	39 (4.2)	3755 (6.4)	1302 (4.1)	

experience with one of these. This is perhaps unsurprising as appendicitis is a common pathology (with an estimated 400,000 cases of appendicitis diagnosed in North America in 2015[21]) and as such residents gain exposure and the opportunity to develop proficiency with this operation earlier in their training. However, these findings represent an issue for graduating residents who must also demonstrate competency in more complex EGS procedures. It is unknown how independence during a challenging appendectomy may translate to competency in more complex procedures; for example, dissection during retrocaecal appendectomy may require mobilization of the right colon and may facilitate competency in colectomies. There is evidence that residents are not prepared for independent practice, often using their first years in practice or fellowship as additional training time.[22]

Strategies to Appropriately Improve Rates of Independent Resident Operating

Ensuring graduated independent practice is challenging and while graduate medical education moves towards competency-based paradigms like entrustable professional activities (EPA), the actual effect on resident independence remains unknown. Independent resident operating is low at 1% for EGS operations and with a recent, worrying trend towards reduced independent cases and significantly reduced supervised resident involvement. It is important to develop programs of EPA use with the dual goal of supervision to ensure patient safety and to promote an appropriate, graded development of resident autonomy.[23,24] Key to this is the development and utilization of validated evaluation tools.[25] It may not be sufficient to simply insist on graduated autonomy and assess for milestones indicative of readiness for practice, rather volume metrics are needed to track

TABLE 3. Patient Outcomes

	Total (N = 90790)	Supervised or No Resident (*n* = 89868)	Resident Autonomy (*n* = 922)	p-Value
Total operation time, median (IQR)	58.0 (40.0, 90.0)	58.0 (40.0, 89.0)	65.0 (47.0, 96.0)	<0.001
Return to OR				0.47
No	85581 (94.3)	84717 (94.3)	864 (93.7)	
Yes	5209 (5.7)	5151 (5.7)	58 (6.3)	
Length of total hospital stay, median (IQR)	2.0 (1.0, 8.0)	2.0 (1.0, 8.0)	2.0 (1.0, 7.0)	0.09
Mortality within 30 days				0.31
No	85982 (94.7)	85102 (94.7)	880 (95.4)	
Yes	4808 (5.3)	4766 (5.3)	42 (4.6)	
Postoperative Complications				
Any post-operative complication	16834 (18.5)	16670 (18.5)	164 (17.8)	0.55
Surgical site infections (without sepsis)	6070 (6.7)	6005 (6.7)	65 (7.0)	0.66
Superficial surgical site infection	3075 (3.4)	3046 (3.4)	29 (3.1)	0.68
Deep Incisional SSI	784 (0.9)	771 (0.9)	13 (1.4)	0.07
Occurrences of Organ Space SSI	2464 (2.7)	2441 (2.7)	23 (2.5)	0.68
Sepsis	2893 (3.2)	2867 (3.2)	26 (2.8)	0.52
Septic Shock	2928 (3.2)	2903 (3.2)	25 (2.7)	0.37
Wound Dehiscence	986 (1.1)	980 (1.1)	6 (0.7)	0.20
Respiratory complications	8163 (9.0)	8092 (9.0)	71 (7.7)	0.17
Pneumonia	3108 (3.4)	3082 (3.4)	26 (2.8)	0.31
Unplanned Intubation	2513 (2.8)	2487 (2.8)	26 (2.8)	0.92
Ventilator > 48Hours	6323 (7.0)	6269 (7.0)	54 (5.9)	0.18
Renal and urinary tract complications	3054 (3.4)	3030 (3.4)	24 (2.6)	0.20
Progressive Renal Insufficiency	519 (0.6)	519 (0.6)	0 (0.0)	0.02
Acute Renal Failure	1064 (1.2)	1056 (1.2)	8 (0.9)	0.39
Urinary Tract Infection	1695 (1.9)	1678 (1.9)	17 (1.8)	0.96
Cardiovascular complications	2560 (2.8)	2538 (2.8)	22 (2.4)	0.42
Cardiac Arrest Requiring CPR	857 (0.9)	852 (0.9)	5 (0.5)	0.20
Myocardial Infarction	458 (0.5)	455 (0.5)	3 (0.3)	0.44
Pulmonary embolism	411 (0.5)	406 (0.5)	5 (0.5)	0.68
DVT/Thrombophlebitis	1077 (1.2)	1068 (1.2)	9 (1.0)	0.55
Neurological complications	487 (0.5)	482 (0.5)	5 (0.5)	0.98
Stroke/CVA	264 (0.3)	260 (0.3)	4 (0.4)	0.42
Coma >24h	228 (0.3)	227 (0.3)	1 (0.1)	0.38
Bleeding requiring transfusion	2047 (2.3)	2041 (2.3)	6 (0.7)	<0.001

cases where residents were truly afforded operative autonomy.

In addition to these competency based programs, it is important to address the other barriers to resident independence including: patient stigma related to perceived increased complications with resident involvement,[3,13-19] reduced training hours, Centers for Medicare and Medicaid Services mandate for the attending

TABLE 4. Level of Resident Supervision for the Most Commonly Performed EGS Operations

Procedure Type n, %	Level of Resident Supervision			
	Independent resident	Supervised resident	No resident	Total
Partial colectomy	109 (0.88)	8,006 (64)	4,307 (35)	12,422
Small bowel resection	72 (0.96)	5,380 (72)	2,049 (27)	7,501
Cholecystectomy	69 (0.77)	5,654 (63)	3,269 (36)	8,992
Peptic ulcer disease	25 (0.77)	2,324 (71)	907 (28)	3,256
Lysis of adhesions	46 (0.96)	3,184 (66)	1,584 (33)	4,814
Appendectomy	562 (1.15)	30,133 (62)	18,014 (37)	48,709
Exploratory laparotomy	39 (0.77)	3,755 (74)	1,302 (25)	5,096

TABLE 5. Relationship Between 30-Day Mortality, Risk of Any Complication, Length of Operation and Independent Resident Operating

a) Resident autonomy and 30-day mortality - multivariable logistic regression (N=59,767)		
Level of resident supervision	Adjusted OR (95% CI)	p-Value
Supervised or no resident	(reference)	
Resident autonomy	0.89 (0.55, 1.44)	0.64
b) Resident autonomy and risk of any complication - multivariable logistic regression (N=54,120)		
Level of resident supervision	Adjusted OR (95% CI)	p-value
Supervised or no resident	(reference)	
Resident autonomy	0.96 (0.72, 1.29)	0.80
c) Resident autonomy and length of operation - multivariable linear regression ((N=54,252)		
Level of resident supervision	Adjusted beta coefficient (95% CI)	p-value
Supervised or no resident	(reference)	
Resident autonomy	9.85 (5.93, 13.77)	<0.001

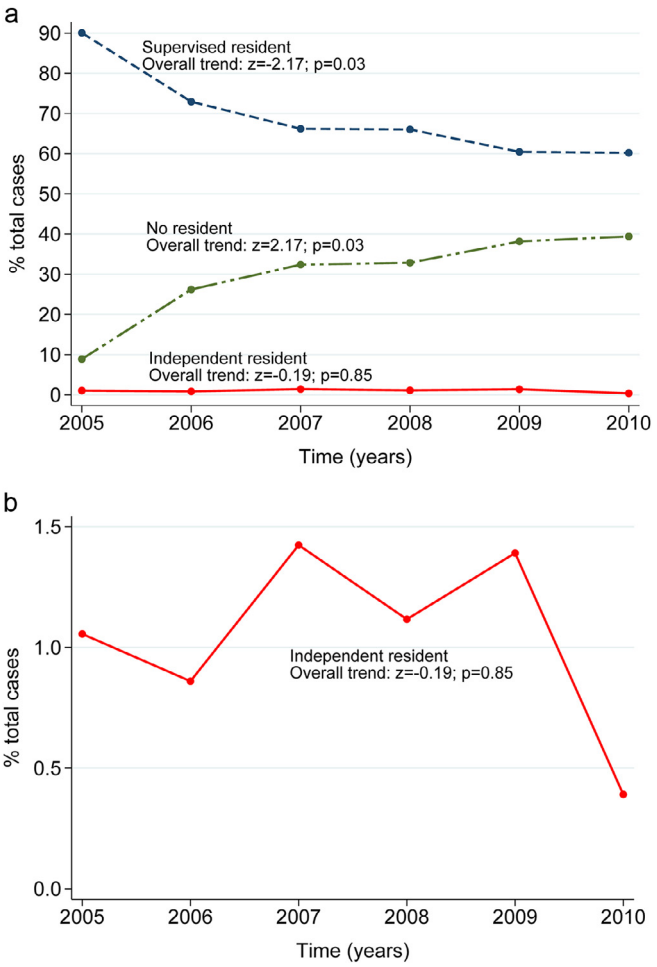

FIGURE 2. Trends in general surgery resident autonomy with time (a) trends comparing cases with supervised residents, no residents and those with independently operating residents (b) trends in cases with resident independence over time.

surgeon to be present for the critical portion of the case, disparity between resident and attending perceptions of autonomy[5,10] and financial pressures in terms of relative value unites (RVUs). In fact, our observation of a reduction in resident independent operating during the period of 2005 to 2010 corelates with the ACGME mandate for the 80-hour work week. We can postulate that in this time EGS operations may have been handed over to the new on call team in the morning in order to reduce duty hour violations and as such attending presence may have increased during these cases as a result. Our study highlights the discrepancy between our desire to allow autonomy and real life practice. Although not the goal of this study, nor answerable by this data, the reason behind the lack of independence in this national database is unknown.

Legal and policy related implications also affect resident autonomy. Our work highlights that current national data collection regarding resident participation in surgery via the ACS-NSQIP database has ceased. Interestingly, the ACGME uses the term "graduated authority" rather than independence or autonomy. Within the existing ACGME structure, the 3 different levels of supervision are direct supervision (attending is physically present and scrubbed for the entire procedure), indirect supervision (attending is immediately available to provide direct supervision, i.e., on site of care or attending is available, i.e., not on site of care but available telephonically or electronically to provide supervision), and oversight (where attending is available to give feedback and advice regarding patient care encounter after care is rendered). Although not expressly stated in the ACS NSQIP definition, independence would map to indirect supervision. This is an important aspect of training residents for autonomous practice. Reinstating the ACS-

NSQIP resident involvement variable, with a more granular definition of "independence" may focus the educational lens on this issue, potentially leading to favorable change in some institutional resident supervision policies and procedures.

Our work has limitations. The major limitation is that the ACS-NSQIP database only reports resident involvement from 2005-2010, with limited data available for the years 2011 and 2012, with no information recorded thereafter. Our work focuses therefore on data collected 10-15 years ago. Interestingly, this was a similar period of time when resident supervision came to the forefront of surgical education and across all residencies, perhaps demands for more resident supervision may have further negatively influenced independent practice during residency. Arguably national educational efforts and the recent research focus on surgical resident autonomy highlighting the importance of entrustable activities may have increased the prevalence of resident independent operative practice. Despite this, we were able to identify concerning findings such as only 1% of operations were performed independently by residents and the fact that operations without a resident were increasing and those with independent residents were decreasing in the period where data was available. To observe these findings and to have no contemporaneous data with which to determine whether these trends have continued, worsened or improved is very worrying. The lack of current data is important as this highlights the need for us as educators to identify modern trends of resident independent operating. An effective initiative that could be used as a template for this data collection is the UK National Emergency Laparotomy Audit project.[26]

The ACS-NSQIP database is a large national database with retrospective data collection and may not accurately represent local prospectively collected data regarding patterns of independent resident operating. In order to determine whether our data accurately reflect that of other studies of autonomy during the 2005-2010 time period we searched PubMed using the following search terms *["2005"[Date - Create]: "2010"[Date - Create]) and (surgical or surgery) and (resident or residency) and autonomy].* This identified only 22 studies, none of which detailed the prevalence of surgical resident autonomy. To demonstrate the increased attention to this subject over the last 15-20 years, when we repeated this search to cover 2015-2020 there were 255 studies. Although this current work is based upon a large national database, this is the largest data set available for the time period in question and indeed for any time after 2011. While previous studies using ACS-NSQIP data have examined resident involvement in operations either in a limited scope of EGS practice (such as appendectomy alone,[27] or appendectomy, laparoscopic cholecystectomy and inguinal hernia repair[28,29]) or in general surgery as a whole specialty,[30] our work includes assessment of all 7 common EGS operations. This arguably provides a more complete picture of a resident's training experience. Our work also highlights issues with inadequate and historical documentation within the ACS-NSQIP database regarding trainee involvement in cases.

ACS-NSQIP defines resident independence as a resident operating alone, without attending scrubbed in the operating room (as defined by NSQIP). This is in line with the indirect supervision ACGME definition of graduated authority (which includes direct supervision, indirect supervision with direct supervision immediately available, indirect supervision with direct supervision available, and oversight). We therefore do not capture those events in which the resident was operating with the trainer in the "Passive help" role.[31] Despite this, we feel that when considering a graduating chief's comfort with transition to independent operative practice, having operated successfully independently before graduation is an important component of confidence. In this scenario the resident has an opportunity to safely rehearse their future role with an attending surgeon in range. We argue that for those cases in which "Passive help" is given, it is impossible to truly determine whether the resident could perform the operation alone, perhaps with an inexperienced assistant, as may be required for independent practice. In addition, from the ACS-NSQIP data we are not able to ascertain the training level of the resident involved. It is, however, reasonable to assume that a significant percentage of these EGS operations were performed by senior or chief residents.

It is possible that, within the "supervised resident" group we have missed some independent practice. In this group there is likely to be a range of resident supervision levels based upon the educator preferences and styles and the resident experience level, competence and relationship with their trainer. In this group we likely have a heterogenous spectrum of supervision from intern to PGY-5 level. A limitation of this work is that the granularity of this data is not discernable from that currently accessible within the ACS-NSQIP database.

We recognize the selection bias in patients operated on by independent residents and this may contribute to the finding of no increase in patient morbidity or mortality associated with independent resident operating. This may also contribute to the lack of difference seen between length of stay of patients operated on by independent residents. However, we believe that these data represent real clinical practice. Anecdotally educators want to set their residents up for success and are unlikely to leave a resident to operate independently on a patient that is inappropriately selected. The findings of no increase in mortality or morbidity are testament to

the effective selection practices of educators of patients appropriate for this part of the learners curve.

CONCLUSIONS

There have been important advances in our appreciation of the importance of graded resident independence in the last 10 years, however, rates of residents operating alone lies at 1% for the most frequently performed operations on an EGS service and is decreasing in recent years. These data and identified trends illustrate the importance of prospective assessment of more recent data to evaluate modern interventions that seek to enhance resident independence. Understanding the factors that contribute to the competency-dependent independent operative practice of general surgery residents is important to allow cultural or policy changes to promote and develop a resident's readiness for practice.

DECLARATION OF COMPETING INTEREST

None.

FUNDING

None.

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