# Safety in Allowing Residents to Independently Perform Appendectomy: A Retrospective Review

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**BACKGROUND:** In an era of competency-based education and concern about graduating resident readiness for practice, early resident autonomy and the ability to safely teach junior residents is becoming increasingly important. In this study, we aimed to understand the effect of "teaching resident" (2 residents operating under the supervision of an attending physician) appendectomy cases on outcomes.

**STUDY DESIGN:** We performed a single-center retrospective review of 928 patients who underwent appendectomy within the University of Wisconsin hospital system, from October 2014 to December 2017. We examined how 2 residents (compared with 1 resident with an attending) attempting a case affected operation time, surgical site infection (SSI) rate, conversion to open rate, postoperative CT scanning, and readmission rate, while controlling for sex, age, American Society of Anesthesiologists (ASA) class, BMI, previous lower abdominal surgery, acuity, perforation, and presence of a junior attending.

**RESULTS:** We identified 597 1-resident cases and 331 2-resident or "teaching resident" cases. We performed multiple logistic regression to assess teaching resident cases as a predictor of postoperative outcomes. There were no significant differences in postoperative surgical site infection (superficial or organ space) odds ratio (OR) = 0.83 (95% CI, 0.47, 1.45); p = 0.51, conversion to open OR = 1.10 (95% CI, 0.46, 2.60); p = 0.84, postoperative CT scanning OR = 0.82 (95% CI, 0.48, 1.35); p = 0.42, or readmission within 30 days OR = 0.76 (95% CI, 0.40, 1.44); p = 0.40. However, teaching resident operative times were more likely to be classified as prolonged OR = 1.44 (95% CI, 1.03, 2.01); p = 0.03.

**CONCLUSIONS:** Senior surgical trainees can safely supervise more junior trainees performing appendectomy procedures, and training programs should encourage faculty to allow residents to not only manage operative appendicitis as independently as possible, but to supervise junior residents in the intraoperative management of appendicitis. (J Am Coll Surg 2019;229:621–625. Published by Elsevier Inc. on behalf of the American College of Surgeons.)

A recent survey of fellowship directors reported multiple perceived deficits in graduates of general surgery programs in domains of independent practice ability, patient responsibility, and motor skills.[1] The ACGME, American Board of Surgery, and the American College of Surgeons (ACS) have been working to address these deficits in order to improve the caliber of GME graduates, specifically promoting competency through entrustable professional activities (EPAs). An EPA has been defined as "a unit of professional practice that can be fully entrusted to a trainee, as soon as he or she has demonstrated the necessary competence to execute this activity unsupervised." Intraoperative trainee autonomy, as assessed by the EPA approach, typically involves 1 trainee and 1 attending physician, with autonomy being assessed based on the degree to which the technical conduct of the procedure and intraoperative decision-making are performed by the trainee rather than the attending.[2]

"Teaching resident" procedures represent an important extension of the entrustment concept. During such procedures, a senior trainee assumes the role of attending

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by guiding a more junior trainee through the technical and decision-making steps of the operation. Although such procedures remain subject to the supervision of an actual attending surgeon, the "once-removed" nature of this supervision represents a natural fulfillment of the "see one, do one, teach one" concept, which has long characterized surgical training and is critical for ensuring a next generation of competent surgical teachers. Although evidence can be found in the literature supporting unsupervised trainee performance of certain surgical procedures,[3-7] the safety of "teaching resident" procedures has not been extensively assessed.[8]

## METHODS

Patients aged 18 years or older, who underwent appendectomy for acute appendicitis at a tertiary academic medical center, from October 2014 through December 2017, were included for analysis. Internal Review Board approval for this study was obtained. Procedures that did not include a surgical trainee, or those that were performed under the supervision of a fellowship-level trainee, were excluded from the analysis.

The primary predictor variable for our analysis was teaching resident status. Procedures were classified as "teaching resident" if the operative note for those procedures identified 2 surgical trainees as being scrubbed. Additional predictor variables included patient sex, age (<65 years vs ≥65 years), BMI (<30 kg/m$^2$ vs ≥30 kg/m$^2$), previous lower abdominal surgery (defined as any intra-abdominal procedure below the level of the umbilicus), American Society of Anesthesiologists Physical Status Classification (Class 1−2 vs 3−5), attending surgeon practice experience (with junior attending surgeons defined as those within 5 years of residency or fellowship training), and presence of perforated appendicitis (as determined by intraoperative findings detailed in the operative report).

Outcome variables for our analysis included the need for conversion to an open procedure, prolonged operative time (defined as ≥75th percentile operative duration, or 76.5 minutes), postoperative surgical site infection (including incisional and/or organ/space infection), need for abdominal CT scan in the first 30 days after operation, and 30-day hospital readmission. Need for abdominal CT scan was included as an outcome because it suggests deviation from a normal expected postoperative course.

Unadjusted comparison of patient- and procedure-related characteristics and outcomes of procedures performed with and without a teaching resident were performed using Pearson's chi-square tests. In order to determine the independent association between teaching resident status and outcomes, a nonparsimonious logistic regression model was developed for each outcome variable, using all of the previously mentioned patient- and procedure-related characteristics, including teaching resident status, as potential predictor variables. STATA Version 14 (STATA Corp) was used for all statistical analyses.

## RESULTS

A total of 928 adult patients undergoing appendectomy for acute appendicitis were included for analysis. Of these procedures, 331 (35.7%) included 2 scrubbed residents and were therefore classified as "teaching resident" cases, while 597 (64.3%) included only 1 scrubbed resident and were classified as "nonteaching resident" cases. Table 1 demonstrates the distribution of resident pairings in teaching resident cases. Table 2 demonstrates patient- and procedure-related characteristics of the study population stratified by teaching resident status. The only significant difference between the 2 groups on univariate analysis was the experience level of the supervising attending surgeon, with a significantly lower proportion of teaching resident cases being supervised by junior-level attendings, compared with nonteaching resident cases.

Of the 928 procedures included in our study, 27 (2.9%) required conversion to an open approach. The median (interquartile range [IQR]) operative time for the procedures included in our study was 60 minutes (IQR 45 to 76.5 minutes), with teaching resident procedures lasting a median of 65 minutes (IQR 5 to 79 minutes) and nonteaching resident procedures lasting a median of 56 minutes (IQR 43 to 73 minutes). A total of 71 (7.7%) patients developed a postoperative surgical site infection (SSI) and 86 (9.3%) required a postoperative abdominal CT scan, while 50 (5.4%) required hospital readmission within 30 days after their procedure. Table 3 demonstrates postoperative outcomes stratified by teaching resident status of the procedures. The only outcome that differed significantly between the 2 groups after adjusting for other patient- and procedure-related characteristics was operative time, which was more likely to be classified as prolonged in cases that involved a teaching resident. Of note, there were no significant differences

**Table 1.** Number and Percent of Cases by Type of Resident Pairing

| | 5, 2 | | 5, 1 | | 4, 2 | | 4, 1 | | Other | |
|---|---|---|---|---|---|---|---|---|---|---|
| PGY pairing | n | % | n | % | n | % | n | % | n | % |
| Teaching resident case | 110 | 33.2 | 73 | 22.5 | 56 | 16.9 | 62 | 18.7 | 30 | 9.1 |

PGY, postgraduate year.

**Table 2.** Patient and Procedure-Related Characteristics of 928 Adult Patients Undergoing Appendectomy for Acute Appendicitis, Stratified by Teaching Resident Status

| | Teaching resident case | | | | |
|---|---|---|---|---|---|
| | No (n = 597) | | Yes (n = 331) | | |
| Characteristic | n | % | n | % | p Value |
| Female | 288 | 48.2 | 154 | 46.5 | 0.62 |
| Age ≥ 65 y | 44 | 7.4 | 18 | 5.4 | 0.26 |
| BMI ≥ 30 kg/m$^2$ | 183 | 30.7 | 121 | 36.6 | 0.07 |
| Previous lower abdominal surgery | 102 | 17.1 | 58 | 17.5 | 0.87 |
| ASA Class 3 or 4 | 48 | 8.0 | 32 | 9.7 | 0.40 |
| Junior-level attending surgeon | 215 | 36.0 | 88 | 26.6 | 0.003 |
| Perforated appendicitis | 108 | 18.2 | 48 | 14.5 | 0.16 |

ASA, American Society of Anesthesiologists.

in outcomes based on trainee combination on univariate analysis.

## DISCUSSION

The results of this study suggest that "teaching resident" appendectomy procedures are safe. Specifically, appendectomy procedures performed by a junior trainee and directly supervised by a senior trainee appear to have postoperative outcomes that are similar to those that involve a single trainee who is directly supervised by an attending surgeon. The only significant difference identified between the 2 groups was the higher proportion of "teaching resident" procedures that were classified as prolonged (27.8% vs 23.5% in nonteaching resident procedures), which translates into an increased median operative time of only 9 minutes. Taken together, these findings suggest that "teaching one" appears to be as safe as "doing one," and supports the use of "teaching resident" procedures within academic medical centers.

That teaching resident appendectomies are safe is not a surprising finding, given evidence from previous international studies that these procedures can be safely performed by trainees without attending surgeon supervision.[3-7] Although subject to medico-legal barriers, there appears to be increasing recognition of the safety of trainee-only appendectomy within the United States as well. The Children's Hospital of Philadelphia currently permits pediatric surgery trainees to perform unsupervised laparoscopic appendectomies in their last year of fellowship in order to "promote independent operative decision-making skills," and has demonstrated this practice to have no impact on patient outcomes.[9] Similarly, military general surgery programs in the United States have implemented a "highly-structured program of graduated autonomy that culminates in senior residents being allowed to perform highly select cases under varying levels of attending supervision, including the attending being immediately available but not present in the operating room."[8]

Contrary to these findings, several analyses of data from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database have suggested an increased risk of postoperative complications in procedures that involve surgical trainee participation.[10-13] For example, in a review of 54,467 laparoscopic appendectomy procedures contained in the ACS NSQIP database, intraoperative trainee participation was associated with a small, but statistically significant, increase in the incidence of postoperative surgical site infection.[14] The ACS NSQIP does not capture information about the number of trainees who participated in its included procedures, so analyses that derive from that dataset are not directly comparable with this study. Nevertheless, such findings do emphasize the importance of ensuring that teaching residents are sufficiently adept at "doing one" before they are allowed to proceed to "teaching one."

**Table 3.** Outcomes of 928 Adult Patients Undergoing Appendectomy for Acute Appendicitis, Stratified by Teaching Resident Status

| | Teaching resident case | | | | | |
|---|---|---|---|---|---|---|
| | No (n = 597) | | Yes (n = 331) | | | |
| Outcome | n | % | n | % | AOR* (95% CI) of teaching resident presence | p Value |
| Conversion to open | 17 | 2.9 | 10 | 3.0 | 1.10 (0.46, 2.60) | 0.84 |
| Prolonged operation | 140 | 23.5 | 92 | 27.8 | 1.44 (1.03, 2.01) | 0.03 |
| Surgical site infection | 49 | 8.2 | 22 | 6.7 | 0.83 (0.47, 1.45) | 0.51 |
| Postoperative CT scan | 59 | 9.9 | 27 | 8.2 | 0.82 (0.48, 1.35) | 0.42 |
| 30-d readmission | 35 | 5.9 | 15 | 4.5 | 0.76 (0.40, 1.44) | 0.40 |

*Adjusted for patient sex, age, BMI, previous abdominal surgical history, American Society of Anesthesiologists Physical Status Classification, presence of perforated appendicitis, and attending surgeon seniority.
AOR, adjusted odds ratio.

Beyond simply being entrusted to perform these procedures autonomously, however, allowing senior trainees to serve as teaching residents provides them an opportunity to develop those skills relevant to intraoperative surgical instruction (such as emphasizing anatomic landmarks, instructing learners with regard to visual and tactile procedural elements, promoting early independence, demonstrating confident competence, maintaining a calm demeanor, exhibiting a willingness to accept responsibility for mistakes and consequences, and knowing when to ask for help) while simultaneously allowing the junior trainee further operative experience.[15] Therefore, in this respect, teaching resident procedures go 1 step beyond the current maximum level of autonomy that is included in the general surgery EPA assessment tools that are undergoing pilot testing.[2] At least at our academic center, the attending surgeon remains physically present during the critical portions of these procedures and is therefore able to intervene when surgical technique or decision-making are deemed to fall below an acceptable standard. This extra layer of supervision, although ideally consisting of silent observation, further bolsters the safety of teaching resident procedures and promotes autonomy, while alleviating the patient safety, medico-legal liability, and billing requirement concerns surrounding unsupervised trainee-performed procedures.

The inclusion of 25 "teaching assistant" procedures by the American Board of Surgery in its requirements for graduating general surgical residents, and the more general expectation of establishing competency in practice-based learning by the ACGME represent implicit endorsement by these regulatory bodies of the concept of teaching resident procedures.[16-18] These procedures can also simultaneously serve as "chief" cases for junior trainees. Until recently, such cases could be counted as teaching assistant cases only if the senior resident was in his or her fifth year. Given that 36% of the teaching assistant cases in our cohort were performed by fourth year residents, these data support the recent change by the ACGME to allow fourth year residents to log teaching assistant cases. In the current era of work hour limitations, which has been associated in some studies with a reduction in cumulative operative volume for surgical trainees,[19-21] the increased use of a "teaching resident" model will therefore have the added benefit of maximizing the educational reach of each individual procedure.

This study has several important limitations. Most importantly, the extent to which attending surgeon presence during the included cases might have surpassed the ideal of silent observation is not known. The assumption that the senior trainee served as teaching resident when 2 trainees were reported as scrubbed is consistent with the culture of the institution where these procedures were performed. It is possible, however, that attending surgeons may have become actively participatory in some of the procedures, either with their technical conduct or with decisions such as need for conversion to open. Any conclusions about the safety of teaching resident procedures must therefore be drawn within the context of some allowance for attending surgeon intervention. Additionally, the sample size was not large enough to conduct a subset analysis of the different resident pairings in order to determine which postgraduate year levels optimize or otherwise affect patient outcomes.

## CONCLUSIONS

Senior surgical trainees can safely supervise more junior trainees in performing appendectomy procedures. Given the valuable experience in surgical instruction that teaching resident cases afford to senior trainees, their safety for other procedure types should be assessed.

### Author Contributions

Study conception and design: Barrett, O'Rourke, Scarborough
Acquisition of data: Barrett, Drezdzon, Monawer
Analysis and interpretation of data: Barrett, Scarborough
Drafting of manuscript: Barrett, Scarborough
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