



Safety of Surgical Resident Training

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Keywords

• Surgical training • Surgery • Training • Safety • Resident • Surgical outcome

Key points

- The current structure of resident participation in surgical procedures is safe, with no negative impact on mortality or major complications.
- For laparoscopic surgery, training and simulation are advisable to ameliorate potential negative effects of learning curves.
- The influence of duty-hour restriction on patient safety remains controversial.
- With the introduction of structured work shifts for residents, a focused effort to educate residents on adequate and effective communication and hand-offs is an important part of ensuring patient safety.
- Adequate training under stressful conditions can help improve resident performance in emergencies on the floor and in the Emergency Department.

INTRODUCTION

Residency training in the United States was first formalized and developed by Dr William Osler and Dr William Steward Halsted, at The Johns Hopkins Hospital, in the late nineteenth century [1]. The goal was to ensure that future physicians and surgeons mastered the necessary skills to become independent practitioners in the field. By the end of the twentieth century, residency had become an indispensable part of medical practice, with more than 80% of all surgical procedures conducted in teaching hospitals with resident participation [2,3]. Resident training and participation are thus an integral part of patient care and are of paramount importance for the sustainability of our health care system. This fact inevitably raises the question of whether participation of

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surgical residents in health care has an impact on outcome, especially in terms of safety. Several studies have attempted to study this topic, with large variation in research questions, methods, study setting, and outcome measures. In this article these studies are reviewed, and their potential implication for practice and research discussed.

SAFETY OF RESIDENT PARTICIPATION IN SURGICAL PROCEDURES

Several studies have attempted to assess the impact of resident involvement in surgical procedures on postoperative morbidity and mortality. Table 1 provides an overview of the most important studies in this regard. A recent study by Kiran and colleagues [4] provided the first direct matched comparison to assess the impact of resident involvement on a large scale. This study compared resident participation with no resident participation in surgeries performed on 60,711 patients from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP). The ACS-NSQIP database is the first validated national, outcome-based, risk-adjusted, performance-controlled platform for the measurement and subsequent improvement of medical health care delivery [2,3,5–9]. The ACS-NSQIP database collects a variety of preoperative, intraoperative, and 30-day postoperative data in patients undergoing surgical procedures [7,10–12]. Variables are collected in many national hospitals in a uniform and controlled manner, offering an opportunity to directly evaluate the effects of various factors on surgical safety, including resident involvement, while optimally correcting for potential confounders [2,3,5–8]. In their study, Kiran and colleagues [4] found that there was no difference in rate of mortality and major complications between the 2 groups. A slight increase in mild surgical complications was seen in the residents group, which was mainly driven by an increase in the rate of superficial wound infection (3.0% vs 2.2%, $P < .001$). No difference was seen in other individual complications, such as deep surgical-site infection or reoperation rate. In addition, operative time was longer when residents were involved (mean [SD] 122 [80] vs 97 [67] minutes, $P < .001$). Although a clear explanation of the difference in wound infection rate was not available, the investigators argued that the longer operative time observed in the residency group may have played a role. Of note, subgroup analyses in the same study comparing surgeries with residents of different postgraduate year (PGY) levels (PGY 1–2, PGY 3–5, and PGY ≥ 6) with matched groups without resident involvement provided results that were consistent with the main findings of the study. Superficial wound infection and operative time were significantly higher when residents were involved, whereas severe complications and mortality showed no difference. This result further strengthened the reliability of these findings. Other strengths of the study are the use of the NSQIP data, which are considered particularly reliable, and the use of extensive matching to reduce the influence of potential confounding variables on outcomes.

The main conclusion of the study was that the current form of resident involvement can be considered safe and responsible. In particular, mortality

Table 1

Overview of studies on impact of resident participation on safety of surgical procedures

Study	N	Type of analysis	Comparison	Patient selection	Mortality	Morbidity
Kiran et al [4], 2012	60,711	Matched comparison	Resident vs no resident	All surgeries in the ACS-NSQP database	No difference	No difference in major complications Slightly higher rate of SSI
Raval et al [13], 2011	607,683	Regression	Resident vs no resident	All general and vascular surgeries in the ACS-NSQP database	No difference	Increased morbidity
Tseng et al [14], 2011	37,907	Regression	Resident vs no resident	Seven general surgical procedures from the ACS-NSQP database	Slightly decreased mortality	Increased morbidity
Karatas et al [15], 2008	811	Direct comparison	Resident vs no resident	Otologic surgeries	NA	No difference
Fischer et al [16], 2006	164	Cohort	Resident vs national best-practice benchmark	Pancreaticoduodenectomy	No difference ^a	No difference ^a
Offner et al [17], 2003	1071	Historic comparison and Regression	Resident vs no resident	Level I trauma patients	No difference	No difference in complications Shorter time in ER and shorter hospital stay in resident group
Khuri et al [2], 2001	690,811	Regression	Teaching vs nonteaching hospitals	All noncardiac surgery from the VA-NSQIP database	No difference	Increased morbidity

Abbreviations: ACS-NSQIP, American College of Surgeons National Surgical Quality Improvement Program; ER, emergency room; NA, no data available; SSI, superficial surgical infection; VA-NSQIP, Veteran Affairs National Surgical Quality Improvement Program.

^aBased on conclusion of investigators. No formal comparison performed (ie, no *P* value provided).

and major morbidity were similar when residents participated in surgical operations. The investigators advised surgeons to be more aware of the potential association of longer operative time and higher rates of wound infection. Where possible, surgeons should prevent prolongation of operative time beyond what is needed for patient care and essential resident training, although the investigators acknowledged the difficulty of implementing this in practice.

Two recent studies using the same ACS-NSQIP database to examine the impact of resident involvement on surgical outcome found slightly different results (see Table 1) [13,14]. These studies did not compare surgeries with and without resident involvement, but rather used regression analysis to correct for potential differences between these groups. Raval and colleagues [13] included all general surgical and vascular procedures from 2006 to 2009 for a total sample of 607,683 surgical cases. Tseng and colleagues [14] included a total of 37,907 patients undergoing a selected number of general surgical procedures from 2005 to 2007. The results of both studies were similar. Resident participation in surgical procedures was associated with slightly higher morbidity rates but slightly decreased mortality rates. Tseng and colleagues [14] were not able to provide a clear explanation of these seemingly conflicting results, despite performance of various post hoc analyses in an attempt to do so. Raval and colleagues [13] also conducted several post hoc analyses, with interesting results. When an analysis was performed accounting for hospital-level variation, the difference in morbidity was minimized and mortality no longer reached significance. None of the studies examined individual complications to further specify the cause of the increased morbidity. Both studies concluded that patients and other stakeholders can be reassured that resident involvement in surgical care is safe, because the differences observed were small.

In a different approach, Khuri and colleagues [2] studied the differences in outcome between teaching and nonteaching hospitals, using the Veterans Affairs National Surgical Quality Improvement Program (VA-NSQIP) to obtain data from 690,811 noncardiac operations performed in 128 hospitals. Based on logistic regression, the study examined the relationship between teaching and nonteaching hospitals and 30-day postoperative mortality and morbidity. It was found that in teaching hospitals the residents were the primary surgeons in more than 90% of the operations. As expected, the patient populations in teaching hospitals had a higher prevalence of risk factors, underwent more complex operations, and had longer operation times. Therefore, unadjusted mortality and morbidity rates were higher in teaching hospitals. After correction for differences in patient severity, no difference was observed in mortality between teaching and nonteaching hospitals. However, differences in morbidity persisted. The investigators explained this by the poor performance of the regression-risk adjustment, as evidenced by the low c-index associated with these models in their analysis [2].

This finding might offer an explanation for the differences observed in the 2 studies by Raval and colleagues [13] and Tseng and colleagues [14] discussed

earlier. The limitation of regression analysis in not fully correcting for confounders may be related to the difference in case mix between teaching (ie, with residents) and nonteaching (ie, without residents) hospitals. It can be expected that there is a group of patients that is almost exclusively treated in either of these settings. For example, patients who need simple procedures and do not have many comorbidities are more likely to be treated in a nonteaching hospital, whereas patients with complex surgeries or with many comorbidities are almost exclusively treated in teaching hospitals. Because no adequate controls are available for these patients, regression will not be able to fully correct for such differences. When matching is used, patients without appropriate controls are excluded, effectively avoiding this problem.

Certain studies have also investigated the impact of resident involvement in specific types of surgery. Karatas and colleagues [15] examined the effect of resident participation in otologic procedures in 811 patients, and observed no difference in complications or success rates after surgery. Similarly, Fischer and colleagues found no difference in morbidity or mortality when comparing outcomes of Whipple procedures performed by residents vs the national best-practice benchmark [16]. Offner and colleagues [17] reported on the impact of resident involvement in the management of level I trauma patients. Of interest, they found that resident participation does not affect outcome in terms of morbidity or mortality, but did significantly improve the efficiency of trauma care delivery, as evidenced by shorter time in the emergency room and shorter hospital stay. The results of these studies are summarized in Table 1.

Several studies also investigated the impact of varying levels of supervision on resident performance and safety [18–20]. None of these studies identified a difference in outcome for varying levels of resident supervision, or between operations performed by residents alone or by residents and attending surgeons. However, this does not mean that supervision is not important. An important limitation of these studies is that supervision is often selected based on the assessment of the attending. Therefore, the conclusion of these results is that physicians seem to appropriately select the level of supervision needed based on a resident's competence and skills, without compromising patient outcome.

In summary, the majority of current studies support the notion that resident participation in surgical procedures is safe. None of the studies showed an increase in mortality. Some studies showed a small increase in complication rate when residents were involved. The best available evidence shows that this is probably caused by a small increase in mild surgical complications such as superficial wound infection, and may be related to the longer operative time when residents are involved.

SAFETY OF RESIDENT PARTICIPATION IN LAPAROSCOPIC SURGERY

Laparoscopic surgery has now become the standard technique for many common operative procedures such as cholecystectomy and appendectomy.

The use of laparoscopy for other, more complex operations is on the increase, meaning that residents are expected to participate in these types of surgeries at an early stage of their training. Because learning curves are more pronounced in laparoscopic surgery, the safety of resident participation in this type of surgery warrants a more focused discussion. Methods and findings of studies addressing safety of resident involvement in laparoscopic cholecystectomy and appendectomy are summarized in Table 2.

Several studies addressed the safety of resident participation in laparoscopic cholecystectomy, but all had important methodological limitations, making it difficult to draw a reliable conclusion. A recent large study compared the outcome of laparoscopic cholecystectomy performed by residents and attending surgeons [21]. Mortality was similar in both groups, but the resident group showed lower morbidity and shorter hospital stay. Unfortunately, the baseline characteristics of both groups were not equal. The rate of urgent surgery, body mass index, and American Society of Anesthesiologists (ASA) classification were higher in the attending group. A matched study by Bencini and colleagues [22] showed no difference in mortality and morbidity after laparoscopic cholecystectomy procedures performed by residents versus experienced staff surgeons. Again, the matching was not extensive and differences existed in important confounding variables. In this case the ASA classification was higher in the group operated on by experienced surgeons, effectively favoring the resident group. In addition, fewer patients in the resident group required additional concomitant procedures (3% vs 7%, respectively; $P = .009$). Kauvar and colleagues [23] compared outcomes after laparoscopic cholecystectomy performed by junior residents (PGY 1–3) and senior residents (PGY >3), and observed a higher rate of overall postoperative complications in the junior resident group (5.6% vs 0.78%, $P < .05$) [23]. The investigators explained that their residents, up to that point, learned to perform laparoscopic cholecystectomy solely through observation in the operating room, and did not participate in simulation training or other teaching methods specifically aimed at laparoscopic skills. The investigators suggested that these educational techniques might improve outcome, and concluded that the results of their study may help surgical educators maximize both resident learning and operative efficiency and safety.

Two recent studies addressed the safety of resident participation in laparoscopic appendectomy. Again, results were somewhat conflicting. Mahmoud and colleagues [18] performed a randomized controlled trial comparing outcomes of laparoscopic appendectomy performed by either junior residents under supervision of a senior resident (residents only group) or junior residents under supervision of an attending surgeon (resident and attending group). The trial showed no difference between both groups regarding complications and mortality. It was concluded that senior surgical residents can act safely as teaching assistants for junior residents. This trial was limited by the fact that residents performed the operations in both groups, making a direct evaluation of the role of residents impossible. Lin and colleagues [24], on the other hand,

Table 2

Overview of studies on impact of resident participation on safety of selected laparoscopic surgical procedures

Study	N	Type of analysis	Comparison	Patient selection	Mortality	Morbidity
Fahrner et al [21], 2012	1747	Direct comparison	Resident vs no resident	Laparoscopic cholecystectomy	No difference	Fewer complications in residents group ^a
Bencini et al [22], 2008	342	Matched	Resident vs staff surgeons	Laparoscopic cholecystectomy	No difference	No difference ^b
Kauvar et al [23], 2006	315	Regression	Junior vs senior residents	Laparoscopic cholecystectomy	NA	Higher complications in junior residents group
Mahmoud et al [18], 2012	120	Randomized controlled trial	Residents only vs residents and attending	Laparoscopic appendectomy	NA	No difference
Lin et al [24], 2010	306	Direct comparison	First 20 vs subsequent 20 surgeries for each resident	Laparoscopic appendectomy	No difference	Higher complications in less experienced residents

Abbreviation: NA, no data available.

^aNonresident group included patients with higher American Society of Anesthesiologists (ASA) classification.

^bNonresident group included patients with more urgent surgeries, higher body mass index, and higher ASA classification.

compared the outcome of laparoscopic appendectomy for 6 residents during their first 20 surgeries versus their subsequent 20 procedures. Higher complication rates were observed for residents during their first 20 procedures. Residents in this study attended a certified laparoscopic surgery workshop, and used simulation to practice laparoscopic surgery. Residents also assisted in several procedures, and were evaluated and found to be proficient and safe by a consulting surgeon before operating independently. The investigators concluded that operative duration and complication rate were significantly reduced with increasing experience of residents, and that stringent supervision is required in the initial phase of the learning curve.

In summary, studies regarding this topic have important limitations, but do demonstrate that mortality is similar in the groups that were studied while the impact of resident participation on morbidity was variable. Better designed studies correcting for potential confounders and aiming to directly evaluate the role of resident participation are needed, especially in the case of laparoscopic cholecystectomy and appendectomy, because these are often the first types of laparoscopic surgeries that residents embark on. It does seem that with improved supervision and specific teaching approaches directed toward laparoscopic skills, the safety of early resident participation in laparoscopic surgery can be improved. The benefit of such training programs has been shown in several studies that included other surgical approaches such as colectomies and gastric bypass surgery [25–28].

RESIDENT WORK RESTRICTION AND SAFETY

In a recent article, Van Eaton and colleagues [29] identified 3 key current challenges for surgical resident training. The first of these was a new restriction of duty hours proposed in 2011. The aim of these restrictions can be easily deduced from the name of the committee formed for this purpose: “Optimizing Graduate Medical Trainee Hours and Work Schedules to Improve Patient Safety” [29]. The proposed changes do not alter the maximum permitted work hours per week (remaining at 80 hours), but do put some restrictions on durations of shifts, on-call frequency, minimum time off between scheduled shifts, and the maximum frequency of in-hospital night shifts. The most notable change may be the 5-hour protected sleep period between 10 PM and 8 AM during a 30-hour duty period. The recommendation of a 48-hour off-duty period after 3 or 4 consecutive nights may prove to be challenging for many programs, because they are currently relying on night-shift teams to comply with the 2003 restriction of on duty hours.

There has been great controversy about whether the previous 2003 restriction of work hours has improved patient safety. A large number of studies have shown a decrease in mortality rate after implementation of these restrictions [30–32]. However, similar decreases have been observed in nonteaching hospitals over the same period [30]. This finding has raised doubts about the relationship between the restriction of working hours and the decrease in mortality. In addition, most studies were retrospective in nature, limiting the

studies' ability to reliably identify causal relationships. The effect of restriction of work hours on morbidity and medical errors also remains unclear. Some studies show higher rates of complications and errors before the implementation of the 80-hour work schedule, whereas other reports show an increase in such events after the implementation of these restrictions [30]. A recent meta-analysis found no difference between pooled complications in both periods (odds ratio [OR] 1.03, 95% confidence interval [CI] 0.67–1.57) [33]. This finding has led a recent review to conclude that as a result of methodological concerns and the lack of hard evidence linking fatigue and underperformance in medical practice, it is unclear whether the goals of the reductions in work hours have been achieved [30].

In general, the sentiments of both surgical residents and program directors seem to be against any further restriction of work hours. Both seem to think that further reduction of work hours will not improve patient safety [34,35]. In addition, they raise the concern that further reductions may jeopardize adequate surgical training, affect the quality of the learning environment, and further complicate program administration, all of which ultimately could negatively affect patient outcomes [35,36].

Although controversy regarding this topic is likely to continue, careful evaluation of the actual impact of any further restriction seems warranted. Such assessment includes better studies to evaluate the relationship between restriction of working hours and safety. Pilot studies in which work-hour restrictions are implemented in a limited number of hospitals or departments, and the outcomes compared with those of adequate controls, may be the best next step.

CONTINUATION OF CARE AND HAND-OFFS

One of the consequences of the modern organization of health care is the increased number of caregivers for each patient. This situation is related to the growing size of health care institutions and the recent restriction of work hours necessitating frequent switches between caregivers. Hand-off refers to the process of communication that takes place when a primary caregiver transfers this responsibility to another person [37]. Hand-offs are critical in patient care, as they constitute opportunities for important information to become lost or be misunderstood. Several studies have investigated the effect of switching of primary caregivers on outcomes of care. A case-control study at an urban tertiary center showed that potential preventable adverse events were strongly associated with cross-coverage by a physician from another team (OR 6.1; 95% CI 1.4–26.7) [38]. Other studies have also shown that cross-coverage and gaps in communication can lead to ordering more (duplicate) tests and longer hospital stays [39,40]. Moreover, an analysis of litigation cases showed that teamwork breakdowns were a leading contributing factor for litigation (70% of all litigation cases) [41]. Hand-off problems were one of the most prevalent types of teamwork problem, and were found to be disproportionately more common among errors that involved trainees [41]. This issue is, therefore, of great importance in ensuring the safety of resident participation in care.

To be able to prevent these deleterious effects of poor communication, there needs to be a more deliberate and focused effort to educate residents on adequate and effective hand-offs [37]. Several examples of such efforts have been described, and have been shown to improve the outcome of care. A recent study showed that simply agreeing on a set of policies aimed at increasing effective and consistent resident-attending communication can substantially reduce potentially harmful communication breakdowns [42]. These policies were agreed on internally and were reinforced by simple measures, such as a pocket information card for residents and periodic reminders. After implementation of these measures, the proportion of critical events not conveyed to an attending surgeon decreased from 33% to 2% [42]. These results were corroborated by another study, which showed that simplifying and standardizing the hand-off instrument results in substantial increases in accuracy, completeness, and number of tasks transferred during hand-off at a surgical department [43]. Others have described the use of computerized systems to aid in ensuring complete and effective communication. Van Eaton and colleagues [44] describe a centralized, Web-based computerized rounding and sign-out system in a surgical department, developed specifically as a consequence of the recent restriction on residents' work hours. This system was shown to significantly reduce the number of patients missed during rounds, and increase the quality of reporting and the continuity of care. It also was able to save residents up to 3 hours per week, facilitating meeting the 80-hour work week.

Regardless of the approach used, implementing some form of structure for hand-offs seems an obvious necessity in surgical practice in the twenty-first century. Recently, a checklist containing 10 essential points for an efficient and safe hand-off has been formulated by the surgical services at the Johns Hopkins Hospital [45]. This list might provide an appropriate guideline for the formulation of such systems in other services.

IMPACT OF STRESS ON PERFORMANCE OF RESIDENTS

An important part of surgical training is preparing residents to deal with emergencies. Knowledge and skills in such stressful situations might not be sufficient if residents cannot cope with the associated stress. Studies have shown that residents tend to perform less effectively when faced with a stressful situation. One study compared surgical and trauma residents with experts in 12 basic emergencies [46]. The study found that in simple clinical scenarios, residents had significant deficits in cognitive performance when compared with experts in the areas of secondary evaluation, follow-up of the presenting problem, and total performance [46]. The investigators suggested the need for the development of educational systems to enhance performance of residents under such stressful conditions. A second study compared performance of residents in simulated trauma scenarios under low and high stress conditions [47], and found that performance scores and postscenario recall were significantly lower in the high-stress situation. The investigators concluded that these findings highlight a potential threat to patient safety that needed to be addressed.

There is no doubt that experience is an important factor for developing competence in stressful situations. However, adequate teaching and training have been shown to improve residents' skills and performance. A study investigated the effect of a single 8-hour period of intensive simulation resuscitation training, and found that this significantly improved self-assessed theoretical knowledge and procedural skill competence for residents [48]. Another study showed that simulation training can reduce levels of anxiety, and improve clinical performance and nontechnical skills [49]. Implementation of adequate training under stressful conditions is therefore an important part of ensuring the safety of resident participation.

SUMMARY

The current structure of residency training allows for safe participation of residents in the care of surgical patients. In part, this is likely due to the ability of attending-level surgeons and educators to adequately select and provide the supervision needed for different levels of residents. Nonetheless, efforts have to be made to ensure the optimal safety of patients in several settings of modern health care. For laparoscopic surgery, training and simulation are highly advisable in preparing residents to perform well in the early stage of their learning curves. Attention has to be given to safe and complete hand-offs, especially with the increased focus on restricting work hours and the increased number of changing shifts. Measures to ensure optimal preparation of surgical residents to perform well in stressful situations should also be taken, because such situations are an intrinsic part of this specialty. It is only by focusing on all these aspects that we can ensure the safety for our patients and provide the best possible training for the next generation of surgeons.

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