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ORIGINAL ARTICLE

Postoperative complications at a university hospital: is there a difference between patients operated by supervised residents vs. trained surgeons?

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Abstract
Background The surgical residency system ensures supervised practices to progressively move from simple to complex surgical procedures. However, ethical dilemmas could arise if patient outcome is negatively affected by this learning methodology. The objective of this study was to evaluate whether the supervised participation of residents acting as operating surgeons influences the postoperative complication rate.
Methods Surgeries performed between June 2010 and May 2011 were analyzed. The Dindo-Clavien classification was used to stratify the severity of complications. The complication rates of patients operated by supervised residents (SR) and trained surgeons (TS) were compared considering potential confounders related to the patient and surgical procedure.
Results A total of 3697 consecutive surgical procedures were included. Age, gender, and American Society of Anesthesiologists (ASA) risk were not different between patients of both groups. The overall complication rate was 10.8 %, without significant differences between the SR and TS groups (9.8 vs. 11.4 %; P=0.14). The severity of complications was similar in both groups. Multivariate analysis adjusted for confounders confirmed that resident participation was not an independent risk factor for complications (odds ratio 1.52; 95 % CI 0.79–2.92; P=0.20).
Conclusions Supervised resident participation, as operating surgeon, does not negatively impact postoperative patient outcome. Residency training may therefore be considered as an ethical and safe learning methodology whenever implemented in the framework of an academic teaching hospital.

Keywords Postoperative complications · Residency · Training · Surgical education

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Introduction

The surgical residency system is considered the most appropriate training program to acquire the knowledge and surgical skills required to become a competent general surgeon [1, 2]. The development of surgical skills has traditionally followed a learning model mainly based on teaching in the operating room. The residency system requires supervised practices with the goal of progressively increasing the number and complexity of surgical procedures performed by the resident over a few years. However, in the current scenario, general surgery residents face the challenge of learning complex skills on a limited time frame and in a society that is increasingly aware of the efficiency and quality of the health-care system [3]. This form of education can be time consuming and even sometimes lead to an increase in health system expenses [4, 5]. Additionally, ethical dilemmas may arise in certain circumstances if the results of a surgery were affected by this learning methodology. The surgical skill learning curve of residents must be monitored so that it does not negatively influence patient outcomes. Previous studies have investigated surgical outcomes performed by residents with contradictory results [6–11]. The results of most of these studies are difficult to interpret since supervision could not be assessed in most of them due to their multicentric nature.

The aim of the current study was to evaluate whether the supervised participation of residents as operating surgeons

affects postoperative complication rates at a university hospital.

Methods

The surgical activity of the General Surgery Service of the Hospital Italiano de Buenos Aires (HIBA) was studied between June 1, 2010 and May 31, 2011. A retrospective analysis of a prospectively collected electronic database was conducted. Each surgical procedure was recorded according to the complexity established in the categorization guidelines proposed by the Argentine Surgical Association [12]. The surgical procedures included in each complexity level are described in Table 1. The complication rates of patients operated by supervised residents (SR) and trained surgeons (TS) were compared. The SR group was comprised by patients operated by residents with direct supervision from an attending surgeon who was scrubbed during the procedure (assisting the procedure but leading the intraoperative decision-making). If a resident started a procedure as operating surgeon and the supervising surgeon had to take over the procedure due to intraoperative increased severity, the procedure was still allocated in the group of SR. In the TS group, even though a resident was always scrubbed as assistant, the surgical procedure was completely performed by the attending surgeon ("gold standard").

The Hospital Italiano is a teaching hospital affiliated to the University of Buenos Aires Medical School and the HIBA University Medical School. The General Surgery Residency Program is based on a tutorial system with progressive delegation of responsibilities and is accredited by the Residences Commission of the Argentine Surgical Association. All postgraduate year (PGY) levels were included in the study analyses (five residents from each of 4 years included in the residency program). The assignment of each case was decided based on the residential curricula, the characteristics of each particular patient, and the attending surgeon decision.

Postoperative complications were graded according to the Dindo-Clavien classification of surgical complications, considering only those events occurring during the first 30 postoperative days [13]. A comparison of the complication rates of both studied groups (SR and TS) was conducted considering potential confounders related to the patient (age, sex, risk established by the American Association of Anesthesiologists (ASA), postoperative course in Intensive Care Unit (ICU)) and surgical procedure (timing of surgery, surgical technique, and the level of complexity of operations). Those procedures performed in patients with incomplete follow-up, outpatient procedures, reintervention in patients with complications during the same hospitalization, or high complexity surgeries (procedures performed only by attending surgeons) were excluded (level 7 as described in Table 1). In addition, those procedures initiated and finished by a trained surgeon, in which a resident had a programmed participation in a particular part of a surgical procedure, were excluded from this analysis.

Table 1 Surgical procedures included in each complexity level and resident participation

Complexity	Surgical procedures	PGY
Level 1	Benign skin lesion resection, subcutaneous abscess drainage, lymph node resection, perianal abscess drainage, wound debridement	1
Level 2	Pleural drainage, percutaneous tracheostomy, malignant skin and soft tissue tumor resection, hemorrhoidectomy, perianal fistula treatment, lateral internal sphincterotomy	1
Level 3	Appendectomy[a], hernioplasty[a], percutaneous cholecystostomy, percutaneous gastrostomy, colostomy, trans-anal rectal resection, exploratory laparotomy[a], enterolysis[a], hemithyroidectomy, submaxilectomy, thyroglossal cyst resection, percutaneous biliary drainage, percutaneous drainage of abdominal abscess, yeyunostomy	1-2
Level 4	Cholecystectomy[a], hyperparathyroidism surgery, total thyroidectomy, Zenker diverticulum surgery, small bowel resection, colostomy/ileostomy takedown, Hartman's procedure, segmental colectomy[a], duodenorrhaphy or gastrorrhaphy[a], gastroenterostomy[a], recurrent inguinal hernia repair[a], incisional hernia repair[a], thoracotomy, pulmonary segmentectomy[a], adrenalectomy[a], splenectomy[a]	2–3
Level 5	Cholecystectomy with bile duct exploration[a], hepatic cyst unroofing[a], wedge liver resection, Heller's myotomy[a], anti-reflux surgery[a], subtotal gastrectomy, right/left hemicolectomy[a], upper anterior resection[a], pelvic tumor resection, retroperitoneal tumor resection[a], pulmonary lobectomy	3–4
Level 6	Liver sectionectomy, hepaticojejunostomy[a], low and ultralow anterior resection[a], total colectomy, total proctocolectomy, Miles' procedure, total gastrectomy, sleeve gastrectomy[a], gastric bypass[a].	4
Level 7[b]	Transplant (liver, lung, intestinal, pancreas-kidney), cephalic or total pancreaticoduodenectomy, liver trisectionectomy, total esophagectomy, pelvic exenteration	

PGY postgraduate year

[a] Open or laparoscopic

[b] High complexity surgeries excluded for the study analysis

Statistical analysis Categorical variables are described using percentages and confidence intervals of 95 %, and continuous variables are expressed as mean (SD). Differences between groups were analyzed using Fisher's exact test or chi-square test, as appropriate, while for continuous variables, the *t* test was used. Odds ratios were calculated using logistic

regression in both univariate and multivariate models. A value of $P<0.05$ was regarded as statistically significant. Statistical analysis was performed with the program NCSS 2007, Pass 2005, Gess 2066 (Hintze J, 2077, Kaysville, UT).

Results

Residents performed 1426 (38.6 %) out of 3697 consecutive surgical procedures analyzed during the study period, 86 of which (6 %) required a transitory or definitive take over by the supervising surgeon. Table 2 summarizes the demographic characteristics of the studied population and the surgical procedures performed. There were no significant differences among age, sex, and ASA risk between patients operated in both groups. Regarding the characteristics of the procedures, the SR group had a smaller proportion of elective procedures, a higher proportion of laparoscopic surgery, and a less highly complex procedures compared with the TS group. The overall complication rate was 10.8 % (398 patients), with no significant differences when comparing surgeries performed by SR and TS (9.8 vs. 11.4 %; $P=0.14$). The analysis of the complication rates in relation to the operating surgeon and variables related to both the patient and the procedure performed is detailed in Table 3. Although the participation of TS as operating surgeons was associated with a higher rate of complications in elective procedures ($P<0.01$), when stratified by complexity level, the difference remained only in the levels 3–4, with a marginal P value ($P=0.049$) and a no clinically relevant difference (8.3 vs. 5.5 %) (Fig. 1).

Table 2 Patient's demographics and surgical procedure characteristics

Characteristics	Residents ($N=1426$)	Trained surgeons ($N=2271$)	P
Age (mean±SD)	55.1±19.26	56.4±17.1	0.6
Gender (female), *n* (%)	692 (48.5)	1085 (47.8)	0.14
ASA, *n* (%)			
1–2	1030 (72.2)	1642 (72.3)	0.96
3–4	396 (27.8)	629 (27.7)	
Opportunity, *n* (%)			
Elective	716 (50.2)	1823 (80.3)	<0.001
Emergency	710 (49.8)	448 (19.7)	
Surgical technique, *n* (%)			
Laparoscopic	696 (48.8)	779 (34.3)	<0.001
Conventional	730 (51.2)	1492 (65.7)	
Complexity, *n* (%)			
1–2	243 (17)	320 (14.1)	0.01
3–4	1038 (72.8)	1359 (59.8)	<0.001
5–6	145 (10.2)	592 (26.1)	<0.001
Need of ICU, *n* (%)	191 (13.4)	416 (18.3)	<0.001

ASA operative risk according to American Society of Anesthesiologists, *ICU* intensive care unit

Table 3 Complications rates with respect to patient-related variables and surgical procedure

Variable	Residents	Trained surgeons	P
Opportunity, *n* (%)			
Elective	52 (7.3)	191 (10.5)	0.01
Emergency	88 (12.4)	67 (15)	0.21
Complexity, *n* (%)			
1–4	116 (9.1)	163 (9.7)	0.54
5–6	24 (16.6)	95 (16)	0.88
ASA, *n* (%)			
1–2	96 (9.3)	178 (10.8)	0.20
3–4	44 (11.1)	80 (12.7)	0.44
Age≥80 years, *n* (%)	35 (21.3)	38 (21)	0.93
Need of ICU, *n* (%)	41 (21.5)	91 (21.9)	0.90

ICU intensive care unit

The severity rates of complications were similar in both groups (Table 4). The overall postoperative mortality rate was 1.3 %. The group of patients operated by the SR showed a mortality rate significantly higher than the group operated by TS (1.9 vs. 0.9 %; $P=0.01$). However, in the multivariate analysis, the participation of the residents as operating surgeons was not independently associated with an increased risk of complications (Tables 5 and 6).

Discussion

The present study demonstrates that participation of supervised residents as operating surgeons in surgical procedures of varying complexity does not negatively impact patient safety. The complication rate of supervised residents was not higher than that of trained surgeons, demonstrating that our training system is suitable because it does not increase the surgical risk.

Modern medicine focused on improving the quality and efficiency of the health-care services. There is still debate

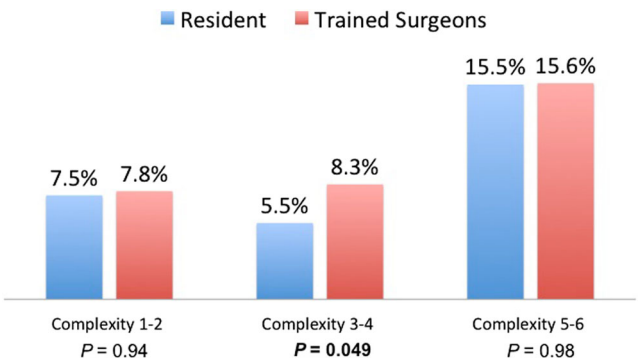

Fig. 1 Postoperative complications in elective surgery according to the level of complexity

Table 4 Complication rates according to the severity of the event

Grade	Resident (*N*=140/1426)	Non-resident (*N*=258/2271)	*P*
I, *n* (%)	14 (1)	35 (1.5)	
II, *n* (%)	59 (4.1)	130 (5.7)	
III, *n* (%)			
IIIa	9 (0.6)	16 (0.7)	0.07
IIIb	16 (1.1)	28 (1.2)	
IV, *n* (%)			
IVa	13 (0.9)	26 (0.1)	
IVb	2 (0.1)	2 (0.1)	
V, *n* (%)	27 (1.9)	21 (0.9)	

% are given in relation to the total number of procedure in each group

D-C Dindo-Clavien classification of surgical complications [13]

about whether the participation of residents in surgical procedures may influence postoperative outcomes, with potential ethical and economic implications in the health system [5]. Over last two decades, the development of training models based on surgical simulation offered the opportunity for training in a structured environment that does not compromise patient safety and allows educators to recreate experiences that promote deliberate practice, evaluation, and resident feedback [14]. However, these learning methods have limitations as they are only based on laparoscopic models and do not allow reproducing stress situations that may be experienced in the operating room.

The results of our study raise a discussion on important issues related to the education of residents and their influence on patient outcomes. One of the main concerns is the potential ethical implication that this learning methodology can generate both to the patient (who in many cases is not aware that he/she is going to be operated by a resident) and the operating surgeon (who is not certain whether this methodology is harmless) [15]. On the other hand, residents may suffer moral dilemmas when being exposed to conflictive surgical scenarios (first surgery, inadequate or absent supervision, unexpected complication during or after a surgical procedure, etc.) [16]. The results of this study endorse the decision of a trained surgeon to act as assistant letting a resident to participate as operating surgeon. It is important to remark that in this study, all the procedures were either performed or supervised by trained surgeons. The lack of attending supervision, known as "ghost surgery," should be discouraged since it may have a different impact that requires a thorough evaluation before being implemented [17].

Although there are studies concerning the participation of residents in surgical procedures, the results remain contradictory and are still a topic of debate in many teaching institutions. Offner et al. [18] did not find differences related to the participation of general surgery residents in a level 1 trauma hospital. Another study compared the results of surgeries where residents were supervised, without finding any differences in adjusted mortality and morbidity between groups, suggesting that the surgeons who supervised the procedures properly selected the cases according to the performance and experience of the resident involved [6]. A recent study analyzing a US national database showed that, although there was an increase in the complication rate when patients were operated by residents, this was mainly due to wound infections (3 vs. 2.2 %, $P<0.001$) without significant clinical implications and therefore concludes that supervised participation is safe for the patient [19]. Most of these studies do not clarify the level of surgical complexity of the surgeries performed by residents. In contrast, Scarborough et al. [20] analyzed the activity of 250 hospitals in the USA, including a total of 54,467 appendectomies and showed that resident participation was an independent risk factor for major complications. However, those residents were not properly supervised and the authors did not take into account the comorbidities or intraoperative variables of the patients treated. Similarly, Kauvar et al. [11] showed increased rates of intraoperative complications during laparoscopic cholecystectomy among junior residents, compared to senior residents and trained surgeons. This study included a small population of patients (n=315), and the results belong to a single type of surgery, which in

Table 5 Analysis of variables related to postoperative complications

Risk factors	Univariate analysis			Multivariate analysis	
	Yes vs. no (%)	OR (95 % CI)	*P*	OR (95 % CI)	*P*
Resident	9.8 vs. 11.4	0.84 (0.68–1.05)	0.14	0.81 (0.63–1.03)	0.09
Complexity 5–6	16.1 vs. 9.4	1.85 (1.46–2.33)	<0.001	1.94 (1.51–2.51)	<0.001
≥ 80 years	21.2 vs. 9.7	2.49 (1.88–3.31)	<0.001	2.32 (1.74–3.12)	<0.001
ASA 3–4	12.1 vs. 10.3	1.20 (0.96–1.50)	0.10	1.13 (0.89–1.42)	0.31
Emergency	13.4 vs. 9.6	1.46 (1.17–1.80)	<0.001	1.70 (1.33–2.17)	<0.001
ICU	21.7 vs. 8.6	2.95 (2.34–3.71)	<0.001	2.62 (2.07–3.32)	<0.001

ASA operative risk according to American Society of Anesthesiologists, *ICU* intensive care unit

Table 6 Analysis of variables related to postoperative mortality

Risk factors	Univariate analysis			Multivariate analysis	
	Yes vs. no (%)	OR (95 % CI)	*P*	OR (95 % CI)	*P*
Resident	1.9 vs. 0.9	2.06 (1.16–3.67)	0.01	1.52 (0.79–2.92)	0.20
Complexity 5–6	1.9 vs. 1.1	1.66 (0.88–3.12)	0.10	3.37 (1.61–7.02)	0.001
≥ 80 years	4.1 vs. 1	4.12 (2.19–7.76)	<0.001	2.83 (1.45–5.53)	0.002
ASA 3–4	1.9 vs. 1.1	1.72 (0.96–3.08)	0.06	1.48 (0.81–2.72)	0.2
Emergency	2.8 vs. 0.6	4.93 (2.67–9.12)	<0.001	5.39 (2.59–11.19)	<0.001
ICU	4.3 vs. 0.7	6.24 (3.51–11.08)	<0.001	5.28 (2.93–9.51)	<0.001

*AS*A operative risk according to American Society of Anesthesiologists, *ICU* intensive care unit

many cases represent the first surgical procedure of a junior resident.

As noted above, even though there are previous studies analyzing the safety of the residency training in patients, they mainly include US residency programs. As far as we are concerned, the present study is the first one from South America including a large single center study population. It is worth noting that in our analysis, unlike others reports to date, those patients operated by residents had a trend towards a lower postoperative complication rate than those operated by trained surgeons (9.8 vs. 11.4 %; $P=0.14$), although it failed to reach neither statistical nor clinical significance.

The group of patients operated by trained surgeons showed a higher rate of complications in elective surgery. This could be explained due to the patient selection by the surgeon at the time of surgery, based on criteria not included in this study, such as body mass index, body surface area, anatomical characteristics of the patient, tumor stage in malignant disease, etc. However, we do not know whether a greater sense of responsibility and commitment by residents, in monitoring a patient when acting as operating surgeon instead of assistant, could have had a positive implication in postoperative outcomes. Likewise, when we differentiated complications by complexity level in elective surgery, we found significance in the levels 3–4, with a marginal *P* value ($P=0.049$) and a difference that we consider not clinically relevant (3 %). Although the group of patients operated by supervised residents had a higher mortality, multivariate analysis showed that resident participation as operating surgeon is not an independent risk factor. The increased mortality could be explained by other variables that influence postoperative results (complexity 5–6, emergency surgery, age≥80 years, and the need of postoperative ICU) or even others that were not covered in our analysis [21].

The main limitations of this study are its retrospective nature, as well as the potential patient selection bias by the attending surgeon when selecting each case. This last aspect is difficult to evaluate, as in most previous retrospective studies, and will require future prospective randomized assessment. In addition, since a heterogeneous group of 3697 consecutive surgical procedures was included in the present analysis, it is difficult to be confident that there might not be differences if the same sophisticated analysis was undertaken over a longer period of time but in more specific surgical procedure categories.

In summary, the results of our study demonstrate that the morbidity and mortality of surgical procedures performed by residents under supervision are similar to the surgeries performed by trained surgeons. The participation of a resident as operating surgeon is not an independent risk factor and may be considered ethical, safe, and responsible whenever implemented in the framework of a residency-training program with continuous supervision and national accreditation.

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