Article

Appendectomy in the Training Program of General Surgery: Entrustable Professional Activity?

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AIM: The training of medical specialists is a decisive issue for the quality of medical practice. Autonomization in simple procedures and applying the peer education concept seem promising, particularly for general surgery. With this work, we wanted to assess whether there are differences between appendectomy operations performed by differently composed teams with the active involvement of resident doctors at a university centre.
METHODS: We retrospectively analyzed the laparotomies and laparoscopic appendicectomies carried out at the Udine Surgery Clinic over a period of 10 years. The interventions were divided into groups according to the experience of the surgical team that performed them: G1 (consultant), G2 (senior resident + consultant), G3 (junior resident + consultant), and G4 (junior resident + senior resident).
RESULTS: 510 appendectomy procedures were considered for the present analysis. 214 (42.0%) were performed by G1, 139 (27.3%) by G2, 79 (15.5%) by G3 and 78 (15.3%) by G4 group. No difference between the groups was shown in terms of complications, reinterventions, readmissions, length of stay, and duration of surgery. A statistically significant difference was shown in the age of the observed population with respect to the degree of experience of the surgical teams: younger patients were mainly operated on by more experienced teams, and in particular, pediatric laparoscopic appendectomy was performed mainly by consultants.
CONCLUSIONS: Appendectomy surgery can be performed by teams with varying levels of experience and is an example of an activity that can be used in Peer Education. It allows for the empowerment of younger residents and the autonomization of older residents in maintaining a medically, ethically, and legally correct standard of safe clinical practice.

Keywords: appendectomy; residents; education; outcomes

Introduction

The acquisition of practical skills is an essential step in the training program of resident doctors, particularly for surgeons. Recent American studies have highlighted a perceived deficiency in this area, noting inadequate quality and safety worldwide. This so-called ‘chasm of quality’ is unacceptable for the expected possibilities of care in the 21st century. Potential pathways have been identified by the American Board of Surgery and the American College of Surgeons that can fill these gaps.

The Halstedian learning model of ‘see one, do one, teach one’, which has governed surgical training for almost 100 years, has been replaced by a new model focused on the attainment of competencies and the acquisition of skills through the identification of entrustable professional activities (EPAs), in line with ethical, legal, safety, and even economic requirements [1–3]. EPAs are units of professional practice that encapsulate several essential skills that trainees acquire proficiency in before undertaking them independently [4].

The two-century-old concept of ‘peer education’ proposed the abolition of obsolete teaching/learning methods. Social and cognitive congruence between learner and teacher has demonstrated, in many areas, a benefit in qualitative terms of teaching/learning activities but also in terms of empowerment and motivation of older students and teamwork by younger ones [5,6].

In our work, we wanted to compare any differences in results between surgical procedures performed by teams with different levels of experience. Since appendectomy surgery, whether laparoscopic or laparotomic, is one of the simplest and most common surgical procedures, we chose it as our study model.

The aim of the present study was to analyze the training program for doctors in specialist training at the School of General Surgery of the University of Udine, using pre-selected pre- and post-surgical indicators for the same type of intervention (appendectomy) performed by surgeons with various levels of experience.

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Table 1. Appendectomy broken down by surgeons' team [n (%)].

Year	G1	G2	G3	G4	Total
2009	21 (58.3%)	14 (38.9%)	1 (2.8%)	-	36 (100.0%)
2010	8 (19.5%)	31 (75.6%)	1 (2.4%)	1 (2.4%)	41(100.0%)
2011	9 (20.5%)	16 (36.4%)	10 (22.7%)	9 (20.5%)	44 (100.0%)
2012	10 (21.3%)	16 (34.0%)	7 (14.9%)	14 (29.8%)	47 (100.0%)
2013	4 (11.4%)	9 (25.7%)	7 (20.0%)	15 (42.9%)	35 (100.0%)
2014	4 (12.1%)	14 (42.4%)	9 (27.3%)	6 (18.2%)	33 (100.0%)
2015	31 (62.0%)	3 (6.0%)	8 (16.0%)	8 (16.0%)	50 (100.0%)
2016	39 (70.9%)	9 (16.4%)	5 (9.1%)	2 (3.6%)	55 (100.0%)
2017	26 (50.0%)	9 (17.3%)	13 (25.0%)	4 (7.7%)	52 (100.0%)
2018	24 (47.1%)	10 (19.6%)	6 (11.8%)	11 (21.6%)	51 (100.0%)
2019	38 (57.6%)	8 (12.1%)	12 (18.2%)	8 (12.1%)	66 (100.0%)
Total	214 (42.0%)	139 (27.3%)	79 (15.5%)	78 (15.3%)	510 (100.0%)

Table 2. Comparison among the different teams [n (%)/Median (p25, p75)].

Variables	G1	G2	G3	G4	Total	*p*-value
Years						
2009–2013	52 (25.6%)	86 (42.4%)	26 (12.8%)	39 (19.2%)	203 (100.0%)	<0.00001
2014–2019	162 (52.8%)	53 (17.3%)	53 (17.3%)	39 (12.7%)	307 (100.0%)	(χ^2 = 54.67)
Gender						
Male	121 (42.2%)	76 (26.5%)	44 (15.3%)	46 (16.0%)	287 (100.0%)	0.94
Female	93 (41.7%)	63 (28.3%)	35 (15.7%)	32 (14.3%)	223 (100.0%)	(χ^2 = 0.39)
Age						
≤15	168 (50.0%)	86 (25.6%)	32 (9.5%)	50 (14.9%)	336 (100.0%)	<0.00001
>16	46 (26.4%)	53 (30.5%)	47 (27.0%)	28 (16.1%)	174 (100.0%)	(χ^2 = 38.90)
Median (years)	12	13	18	12	12.5	0.0004
p25, p75	9, 15	10, 26	10, 38	8, 23.3	9, 23.2	(H = 6.65)
Surgical access						
Laparotomy	70 (23.7%)	111 (37.6%)	54 (18.3%)	60 (20.3%)	295 (100.0%)	0.00001
Laparoscopy	144 (67.0%)	28 (13.0%)	25 (11.6%)	18 (8.4%)	215 (100.0%)	(χ^2 = 98.28)
SAGS score						
0–1	117 (38.4%)	88 (28.9%)	51 (16.7%)	49 (16.1%)	305 (100.0%)	0.25
2–4	97 (47.3%)	51 (24.9%)	28 (13.7%)	29 (14.1%)	205 (100.0%)	(χ^2 = 4.01)
Postoperative indicators						
Total	109 (48.7%)	53 (23.7%)	34 (15.2%)	28 (12.5%)	224 (100.0%)	
Abdominal drainage	62 (29.0%)	30 (21.6%)	17 (21.5%)	15 (19.2%)	124 (24.3%)	0.20 (χ^2 = 4.52)
Complications	28 (13.1%)	16 (11.5%)	13 (16.5%)	10 (12.8%)	67 (13.1%)	0.78 (χ^2 = 1.10)
Reoperation	9 (4.2%)	3 (2.2%)	2 (2.5%)	1 (1.3%)	15 (2.9%)	0.51 (χ^2 = 2.30)
Readmission	10 (4.7%)	4 (2.9%)	2 (2.5%)	2 (2.6%)	18 (3.5%)	0.70 (χ^2 = 1.43)
Median (days)	3	3	3	3	3	0.19
p25, p75	2, 6	2, 4	2, 4	2.7, 5	2, 5	(H = 4.79)

SAGA, Sunshine Appendicitis Grading System.

Methods

As this is a non-interventional observational retrospective study involving nothing more than the stratification of patient groups, ethical approval was waived by Università degli Studi di Udine. We collected data for a 10-year period from 1 January 2009 to 31 December 2019, divided into two subgroups (2009–2013 and 2014–2019). Data were extracted from the Database of the Regional Health System using codes related to the laparoscopic or laparotomic appendectomy procedure as the first procedure performed (excluding those associated with another type of surgery).

Table 3. The logistic regression analysis to compare the distribution of pediatric patients and laparoscopic access in pediatric patients between G1 surgery team and other ones.

Teams	Patients undergoing surgery			
	Pediatric n (%)	Adults n (%)	OR (95% CI)	*β/SE/Wald* χ^2 *value/p*
G1 (n:214)	168 (78.5%)	46 (21.5%)	3.6 (2.6–5.1)	1.3/0.17/58.5/<0.001
G2 (n:139)	86 (61.9%)	53 (38.1%)	0.4 (0.3–0.7)	–0.8/0.24/11.4/0.001
G1 (n:214)	168 (78.5%)	46 (21.5%)	3.6 (2.6–5.1)	1.3/0.17/58.5/<0.001
G3 (n:79)	32 (40.5%)	47 (59.5%)	0.2 (0.1–0.3)	–1.7/0.28/36.0/<0.001
G1 (n:214)	168 (78.5%)	46 (21.5%)	3.6 (2.6–5.1)	1.3/0.17/58.5/<0.001
G4 (n:78)	50 (64.1%)	28 (35.9%)	0.5 (0.3–0.9)	–0.7/0.29/6.2/0.013
Teams	Laparoscopic access in pediatric patients			
	Yes n (%)	No n (%)	OR (95% CI)	*β/SE/Wald* χ^2 *value/p*
G1 (n:144)	105 (72.9%)	39 (27.1%)	2.7 (1.9–3.9)	1.0/0.19/27.1/<0.001
G2 (n: 28)	3 (10.7%)	25 (89.3%)	0.04 (0.01–0.16)	–3.1/0.64/23.6/<0.001
G1 (n:144)	105 (72.9%)	39 (27.1%)	2.7 (1.9–3.9)	1.0/0.19/27.1/<0.001
G3 (n: 25)	5 (20.0%)	20 (80.0%)	0.09 (0.03–0.26)	–2.4/0.53/20.2/<0.001
G1 (n:144)	105 (72.9%)	39 (27.1%)	2.7 (1.9–3.9)	1.0/0.19/27.1/<0.001
G4 (n: 18)	3 (16.7%)	15 (83.3%)	0.07 (0.02–0.27)	–2.6/0.66/15.5/<0.001

We collected 510 appendectomy operations performed with a preoperative diagnosis of acute appendicitis.

The following variables were evaluated: gender [287 (56.3%) male, 223 (43.7%) female] and age of patients [336 (65.9%) pediatric $\leq$15 years, 174 (34.1%) adult over 16 years]; duration of surgery; type of surgery [295 (57.8%) laparotomic, 215 (42.2%) laparoscopic]; conversion rate (laparoscopic to laparotomic); severity index through the Sunshine Appendicitis Grading System (SAGS) score: 0–1 white or uncomplicated appendicitis [305 (59.8%)]/2–4 complicated appendicitis [205 (40.2%)]; use of abdominal drainage [124 (24.3%)]; postoperative complications [67 (13.1%)] such as wound dehiscence, fever, pain, incisional hernia, wound infection, abscesses, collections, other; re-operation within 30 days [15 (2.9%)]; readmission in less than 30 days after discharge [18 (3.5%)]; length of stay (total, pre and postoperative hospital stay). Then, we stratified the surgical teams according to their level of experience into four groups:

G1: Consultant Surgeon

G2: Senior Resident (5 or 6 years of graduate school) + Consultant

G3: Junior Resident (1, 2, 3, or 4 years of graduate school) + Consultant

G4: Junior Resident + Senior Resident

Data were analyzed using the statistical package IBM SPSS, V.20 (IBM SPSS Statistics, Chicago, IL, USA). Categorical variables are displayed as n (%). The chi-square test was used to compare the distribution in the four groups of operators: gender, age groups, study periods, surgical access, SAGS score (0–1, 2–4), presence of abdominal drainage, complications, re-intervention, readmission and conversion. The continuous variables (mean age, duration of surgery, length of postoperative hospital stay) were not normally distributed, expressed using median (p25, p75), as determined by the Shapiro-Wilk test. Therefore, the Kruskal-Wallis test was used to compare the group medians. To investigate possible predictive factors in patient allocation (sex, age, SAGS score, surgical access) and the occurrence of adverse postoperative events (drainage, complications, reinterventions, readmissions), the Odds Ratio was calculated with 95% confidence intervals, comparing the two groups at a time for the variables considered. Logistic regression was used to investigate the different approaches used by different teams to treat pediatric patients. The level of statistical significance was defined as $p < 0.05$.

Results

During the period under review (2009–2019), 510 appendectomy operations were performed. 214 (42.0%) were performed by the G1 surgical team, 139 (27.3%) by the G2 surgical team, 79 (15.5%) by the G3 surgical team, and 78 (15.3%) by the G4 surgical team. The trend in the number of interventions by year is shown in Table 1.

(a) Analysis by Team Type and Analysis of Two Different Periods

Considering the totality of surgical procedures, the comparison between the two time periods (2009–2013 vs 2014–2019) shows a reduction in the surgical activity of the resident as the first operator ($p < 0.00001$) (Table 2).

(b) Demographic Data and Pediatric Subpopulation

Regarding the demographic data, there were no gender differences among the patients operated on by the different teams. In contrast, pediatric patients (336) were operated on mainly by consultants in 50.0% of the cases or 25.6% by a resident in collaboration with them ($p < 0.00001$). The statistically significant difference in the percentage distribution of pediatric patients among the teams was confirmed

Table 4. Laparoscopic appendectomies [n (%)/Median (p25, p75)].

Variables	G1	G2	G3	G4	Total	*p*-value
Gender						
Male	81 (66.4%)	14 (11.5%)	13 (10.7%)	14 (11.5%)	122 (100.0%)	0.26
Female	63 (67.7%)	14 (15.1%)	12 (12.9%)	4 (4.3%)	93 (100.0%)	($\chi^2 = 4.00$)
Age						
≤15	105 (90.5%)	3 (2.6%)	5 (4.3%)	3 (2.6%)	116 (100.0%)	0.00001
>16	39 (39.4%)	25 (25.3%)	20 (20.2%)	15 (15.2%)	99 (100.0%)	($\chi^2 = 63.59$)
Operating room time						
Median (min.)	50	70	63	65	55	0.0016
p25, p75	40, 68.7	50, 93.7	55, 80	50, 81.2	45, 75	($H = 15.26$)
Period						
2009–2013	15 (62.5%)	6 (25.0%)	2 (8.3%)	1 (4.2%)	24 (100.0%)	0.27
2014–2019	129 (67.5%)	22 (11.5%)	23 (12.0%)	17 (8.9%)	191 (100.0%)	($\chi^2 = 3.88$)
SAGS score						
0–1	70 (59.8%)	15 (12.8%)	19 (16.2%)	13 (11.1%)	117 (100.0%)	0.03
2–4	74 (75.5%)	13 (13.3%)	6 (6.1%)	5 (5.1%)	98 (100.0%)	($\chi^2 = 8.96$)
Postoperative indicators						
Total	81 (61.8%)	19 (14.5%)	19 (14.5%)	12 (9.2%)	131 (100.0%)	
Abdominal drainage	46 (31.9%)	10 (35.7%)	9 (36.0%)	5 (27.8%)	70 (32.6%)	0.93 ($\chi^2 = 0.47$)
Conversion to laparotomy	9 (6.3%)	3 (10.7%)	1 (4.0%)	-	13 (6.0%)	0.58 ($\chi^2 = 1.07$)
Complications	15 (10.4%)	5 (17.9%)	6 (24.0%)	4 (22.2%)	30 (14.0%)	0.17 ($\chi^2 = 4.98$)
Reoperations	4 (2.8%)	-	1 (4.0%)	2 (11.1%)	7 (3.3%)	0.21 ($\chi^2 = 3.09$)
Readmission	7 (4.9%)	1 (3.6%)	2 (8.0%)	1 (5.6%)	11 (5.1%)	0.90 ($\chi^2 = 0.59$)
Median (days)	3	3	3	3	3	0.76
p25, p75	2, 6	2, 4	2, 5	2, 3.5	2, 5	($H = 1.17$)

by the results of logistic regression analysis (Table 3). Infact, each surgical team had a different propensity for intervention in pediatric patients, with G3 intervening significantly less than the others (OR = 0.2, 95% CI: 0.1–0.3, $p < 0.001$) and G1 (the reference group) having the highest propensity for intervention (OR = 3.6, 95% CI: 2.6–5.1, $p < 0.001$).

(c) Laparoscopic Approach in the Pediatric Population

This difference is even more significant in procedures with laparoscopic access, where 90.5% of pediatric cases (105/116) were operated on by G1 ($p = 0.00001$) (Table 4). G1 had a relatively high baseline probability of choosing laparoscopy (OR = 2.7, 95% CI: 1.9–3.9, $p < 0.001$) (Table 3).

(d) Laparoscopy vs Laparotomy

The most frequently used surgical access was laparotomy (295 vs 215 cases), while a significant increase in the use of laparoscopic access in the second period considered, particularly by Consultants vs G2, G3, G4 groups [G1 = 67.3% (144/214) vs G2 = 20.1% (28/139), OR = 8.1, 95% CI: 4.9–13.5, $p < 0.0001$; G1 vs G3 = 31.6% (25/79), OR = 4.4, 95% CI: 2.5–7.7, $p < 0.0001$; G1 vs G4 = 23.1% (18/78), OR = 6.8, 95% CI: 3.8–12.5, $p < 0.0001$)] [Tables 3,4]. Regarding the conversion ratios performed by only the first three groups [G1 = 6.3% (9/46), G2 = 10.7% (3/10), G3 = 4.0% (1/9)], there were no statistically significant differences. The choice of placing an abdominal drain (24.3% of 510 cases) is not different in the four groups, although it is more commonly used in G1 (29.0%) [Table 2].

(e) Complications

Finally, in all cases, re-interventions (2.9%) and second hospitalizations (3.5%), while not differing significantly, are greater, again in percentage, in the Consultants group (G1: re-interventions = 4.2% and readmissions = 4.7%) [Tables 2,4,5,6,7], while complications (13.1%, 67/510), are more frequent in G3 (16.5%) [Tables 2,8,9,10]. Overall, there is a tendency, not statistically significant ($p = 0.25$), for structured physicians (G1 + G2 = 72.2%) to take charge of the most complex cases (SAGS score 2–4: n = 205), leaving only the least severe cases (SAGS score 0–1: n = 305) to the residency teams (G3 = 16.7%, G4 = 16.1%) [Ta-

Table 5. Laparotomic appendectomies [n (%)/Median (p25, p75)].

Variables	G1	G2	G3	G4	Total	*p*-value
Gender						
Male	40 (24.2%)	62 (37.6%)	31 (18.8%)	32 (19.4%)	165 (100.0%)	0.97
Female	30 (23.1%)	49 (37.7%)	23 (17.7%)	28 (21.5%)	130 (100.0%)	(χ^2 = 0.25)
Age						
≤15	63 (28.6%)	83 (37.7%)	27 (12.3%)	47 (21.4%)	220 (100.0%)	<0.00001
>16	7 (9.3%)	28 (37.3%)	27 (36.6%)	13 (17.3%)	75 (100.0%)	(χ^2 = 26.43)
Operating room time						
Median (min.)	50	50	52.5	60	55	0.07
p25, p75	35, 71.2	40, 60	45, 66.2	45, 70	40, 65	(H = 6.92)
Period						
2009–2013	37 (20.7%)	80 (44.7%)	24 (13.4%)	38 (21.2%)	179 (100.0%)	0.003
2014–2019	33 (28.4%)	31 (26.7%)	30 (25.9%)	22 (19.0%)	116 (100.0%)	(χ^2 = 13.97)
SAGS score						
0–1	47 (25.0%)	73 (38.8%)	32 (17.0%)	36 (19.1%)	188 (100.0%)	0.71
2–4	23 (21.9%)	38 (35.5%)	22 (20.6%)	24 (22.4%)	107 (100.0%)	(χ^2 = 1.38)
Postoperative indicators						
Total	37 (34.6%)	37 (34.6%)	16 (15.0%)	17 (15.9%)	107 (100.0%)	
Abdominal drainage	16 (22.9%)	20 (18.0%)	8 (14.8%)	10 (16.7%)	54 (18.3%)	0.68 (χ^2 = 1.52)
Complications	13 (18.6%)	11 (9.9%)	7 (13.0%)	6 (10.0%)	37 (12.5%)	0.34 (χ^2 = 3.38)
Reoperations	5 (7.1%)	3 (2.7%)	1 (1.9%)	-	9 (3.1%)	0.22 (χ^2 = 3.04)
Readmission	3 (4.3%)	3 (2.7%)	-	1 (1.7%)	7 (2.4%)	0.66 (χ^2 = 0.81)
Median (days)	3	3	3	3	3	0.06
p25, p75	2, 4	2.7, 6	2, 4	(3, 5)	(2, 4)	(H = 7.25)

Table 6. Causes of reoperations by surgical teams (n/%).

	Surgical revision	Radicalization	Dehiscence	Operated collections	Total
Readmissions					
Total	1 (6.7%)	1 (6.7%)	3 (20.0%)	10 (66.7%)	15 (100.0%)
Surgical teams					
G1	1 (11.1%)	1 (11.1%)	2 (22.2%)	5 (55.6%)	9 (100.0%)
G2	-	-	1 (33.3%)	2 (66.7%)	3 (100.0%)
G3	-	-	-	2 (100.0%)	2 (100.0%)
G4	-	-	-	1 (100.0%)	1 (100.0%)

bles 2,5]. This phenomenon becomes statistically significant (p = 0.03) in laparoscopic surgeries [G1 + G2 = 88.8% (87/98)] [Table 4]. No difference is shown in the length of hospitalization or the duration of surgery [Tables 2,4,5].

Discussions

Empowerment and the achievement of surgical autonomy are fundamental steps in the training of medical residents. They both must be part of the training program. Studies on Peer Education have highlighted the benefits of collaboration among residents, making the teaching and learning of necessary skills more efficient in achieving training objectives [7].

According to the EPA concept, the trainee's intraoperative autonomy is measured by the independent execution of both the technical gesture and the decision-making process of the procedure [8]. In this scenario, acute appendicitis is an excellent teaching procedure for young surgeons, as it remains one of the most common surgical procedures worldwide [8,9]. Thus, this procedure was selected in this analysis. A recent study by Barrett *et al.* [7] published in the Journal of American College of Surgeons points out that it is precisely with appendectomy that the concept of Peer Education should be encouraged among surgical residents, having the procedure performed by younger residents mentored by other more senior residents, as this system is a source of safe and effective teaching-learning, issue also supported by other work [10,11].

Table 7. Causes of readmissions by surgical teams [n (%)].

	Dehiscence	Collections	Radicalization	Instrumental examinations	Wound infection	Pain	Total	Surgical	Not surgical
Readmissions									
Total	2 (11.1%)	5 (27.8%)	1 (5.6%)	8 (44.4%)	1 (5.6%)	1 (5.6%)	18 (100.0%)	8 (44.4%)	10 (55.6%)
Surgical teams									
G1	1 (10.0%)	3 (30.0%)	1 (10.0%)	5 (50.0%)	-	-	10 (100.0%)	5 (50.0%)	5 (50.0%)
G2	1 (25.0%)	1 (25.0%)	-	2 (50.0%)	-	-	4 (100.0%)	2 (50.0%)	2 (50.0%)
G3	-	1 (50.0%)	-	1 (50.0%)	-	-	2 (100.0%)	1 (50.0%)	1 (50.0%)
G4	-	-	-	-	1 (50.0%)	1 (50.0%)	2 (100.0%)	-	2 (100.0%)

Table 8. Type of complications by surgical teams [n (%)].

	Dehiscence	Fever/Pain	Laparocele	Wound infection/Abscess/Collection	Other	Total
Complications						
Total	27 (40.3%)	5 (7.5%)	1 (1.5%)	24 (35.8%)	10 (14.9%)	67 (100.0%)
Surgical teams						
G1	9 (32.1%)	2 (7.1%)	-	11 (39.3%)	6 (21.4%)	28 (100.0%)
G2	10 (62.5%)	1 (6.3%)	-	4 (25.0%)	1 (6.3%)	16 (100.0%)
G3	5 (38.5%)	1 (7.7%)	1 (7.7%)	5 (38.5%)	1 (7.7%)	13 (100.0%)
G4	3 (30.0%)	1 (10.0%)	-	4 (40.0%)	2 (20.0%)	10 (100.0%)

Table 9. Type of complications in laparoscopic appendectomies by surgical teams [n (%)].

	Dehiscence	Fever/Pain	Wound infection/Abscess/Collection	Other	Total
Complications					
Total	3 (10.0%)	5 (16.7%)	16 (53.3%)	6 (20.0%)	30 (100.0%)
Surgical teams					
G1	1 (6.7%)	2 (13.3%)	8 (53.3%)	4 (26.7%)	15 (100.0%)
G2	2 (40.0%)	1 (20.0%)	1 (20.0%)	1 (20.0%)	5 (100.0%)
G3	-	1 (16.7%)	4 (66.7%)	1 (16.7%)	6 (100.0%)
G4	-	1 (25.0%)	3 (75.0%)	-	4 (100.0%)

Table 10. Type of complications in laparotomic appendectomies by surgical teams [n (%)].

	Dehiscence	Laparocele	Wound infection/Abscess/Collection	Other	Total
Complications					
Total	24 (64.9%)	1 (2.7%)	8 (21.6%)	4 (10.8%)	37 (100.0%)
Surgical teams					
G1	8 (61.5%)	-	3 (23.1%)	2 (15.4%)	13 (100.0%)
G2	8 (72.7%)	-	3 (27.3%)	-	11 (100.0%)
G3	5 (71.4%)	1 (14.3%)	1 (14.3%)	-	7 (100.0%)
G4	3 (50.0%)	-	1 (16.7%)	2 (33.3%)	6 (100.0%)

A previous study conducted during our training program at the SMM Hospital in Udine concerning laparoscopic cholecystectomy had already anticipated the same results regarding the safety of the educational model based on peer education [1]. There are some considerations to be made in commenting on the analysis and results obtained in this work on appendectomy. During the observed period, 2009–2019, along with the increasing application of a modern educational model with a tendency toward early autonomy of residents, there has been a change in the surgical standard for appendectomy, with a shift from laparotomic to laparoscopic appendectomy. The introduction of this approach resulted in a slowdown in the surgical procedures performed by the residents since a period of learning the laparoscopic technique and its teaching by the consultants themselves was necessary, in addition to the inherent greater complexity of the approach itself. However, the learning curve was relatively short (20 surgeries) [12–15].

This fact also explains some of our analysis's results: the most complex cases were treated by more experienced teams, as were most pediatric cases and almost all laparoscopic pediatric cases; drainage placement is more frequent in the G1 group because the surgical complexity (also given by the severity of the clinical picture) attributed to that group is higher.

Laparotomic appendectomy has long been a standard surgical procedure for acute appendicitis, representing the basis at the beginning of training in surgical residency [16,17]. However, laparoscopic appendectomy has been successfully adopted for patients diagnosed with acute appendicitis, and the laparotomic procedure is now rarely performed unless there is a specific reason [18,19]. Although some researchers have noted that surgical residents should have experience with laparotomic appendectomies before performing a laparoscopic one, recent articles have indicated the possibility of adopting the laparoscopic procedure as the first approach to be taught in surgical training [20–22].

Numerous publications in the literature over the last decade demonstrate a non-negative influence on patient safety in cases of appendectomy performed by residents. Among these, the work of B. Siam *et al*. [10] offers a valid overview, representing—with its 1649 cases—one of the largest available cohorts of patients operated on laparoscopic appendectomy in which a structured surgeon is compared to a resident in general surgery. Appendectomies were evaluated with pre-, intra-, and postoperative indicators, finding no statistically significant difference in rates of early and late complications [10]. In line with what has just been described, the same conclusions were drawn, among others, by L.J. Graat *et al*. [16], P. Singh *et al*. [23], I. Mizrahi *et al*. [24] and R. Fahrner *et al.* [11]. In our study, there were no significant differences in terms of postoperative outcomes between the different surgical teams considered: complications, reoperations, and readmissions are higher, as a percentage—without significance statistics—in groups G1 and G2, which we believe is due to the greater severity of the cases allocated in these two groups rather than to the type of surgical team.

If, therefore, the literature agrees in defining safe appendectomies performed by young surgeons, the considerations relating to the duration of the intervention are less unambiguous. Studies report that operative time increases [25,26], decreases or remains unchanged [27,28] compared to the acquisition of experience of the physician in training, without distinction between laparotomic and laparoscopic access. From the analysis of J. Mack *et al*. [29], it appears that the duration of appendectomies is also influenced by the role played by the surgeon in training. The appendectomies in which a senior resident was present as a "teaching resident" to teach a young colleague in training are the procedures that took the most time ever. In addition, J. Mack *et al*. [29] found that the shortest operative time belongs to structured physicians, and the presence of a junior resident in whatever role they are in a statistically significant increase in the duration of surgery, supporting the fact that the acquisition of skills and experience improves surgical performance. In contrast, we observed no significant difference in operating times between the four groups, either in the laparotomic or laparoscopic approaches.

Conclusions

This retrospective study allows some important conclusions to be drawn. Following an educational model based on Peer Education and gradual levels of responsibility and autonomy, the students can safely perform the intervention while maintaining adequate safety standards.

No statistically significant differences were noted between teams with different surgical experiences regarding intra- and postoperative complications, conversion rate, reoperations, and readmissions. The length of stay and the intervention time are also overlapping. Appendectomy (and probably procedures of similar complexity) can be considered EPAs and must be used for early autonomy and empowerment to achieve adequate and safe specialized training.

Availability of Data and Materials

The data that support the findings of this study are available on request from the corresponding author [VB]. The data are not publicly available due to privacy restrictions.

Author Contributions

VB and AR designed and supervised the paper. VM and DM contributed to the collection of data and statistical analysis. GT and RQ contributed to the implementation of the research. AR, VM, GT and VB wrote the paper. All authors revised the manuscript critically for important intellectual content. All authors have accepted responsibility for the entire content of this manuscript and consented to its submission to the journal, reviewed all the results and approved the final version of the manuscript.

Ethics Approval and Consent to Participate

As this is a non-interventional observational retrospective study involving nothing more than the stratification of patient groups, ethical approval was waived by Università degli Studi di Udine. Informed consent for the study was obtained from the patients or their guardians. This study adheres to the Declaration of Helsinki.

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Conflict of Interest

The authors declare no conflict of interest.

References

[1] Bresadola V, Pravisani R, Pighin M, Seriau L, Cherchi V, Giuseppe S, *et al*. Clinical strategies to aim an adequate safety profile for patients and effective training for surgical residents: The laparoscopic

cholecystectomy model. Annals of Medicine and Surgery (2012). 2016; 11: 58–61.

[2] Institute of Medicine (US) Committee on Quality of Health Care in America. Crossing the Quality Chasm: A New Health System for the 21st Century. 2001.

[3] McIlhenny C, Kurashima Y, Chan C, Hirano S, Domínguez-Rosado I, Stefanidis D. General surgery education across three continents. American Journal of Surgery. 2018; 215: 209–213.

[4] O'Dowd E, Lydon S, O'Connor P, Boland J, Offiah G, Byrne D. The development of a framework of entrustable professional activities for the intern year in Ireland. BMC Medical Education. 2020; 20: 273.

[5] Benè KL, Bergus G. When learners become teachers: a review of peer teaching in medical student education. Family Medicine. 2014; 46: 783–787.

[6] Ten Cate O, Durning S. Peer teaching in medical education: twelve reasons to move from theory to practice. Medical Teacher. 2007; 29: 591–599.

[7] Barrett JR, Drezdzon MK, Monawer AH, O'Rourke AP, Scarborough JE. Safety in Allowing Residents to Independently Perform Appendectomy: A Retrospective Review. Journal of the American College of Surgeons. 2019; 229: 621–625.

[8] Lindeman B, Petrusa E, Phitayakorn R. Entrustable Professional Activities (EPAs) and Applications to Surgical Training. 2017. Available at: https://www.facs.org/for-medical-professionals/news-publications/journals/rise/articles/entrustable (Accessed: 1 June 2017).

[9] Canal C, Scherer J, Birrer DL, Vehling MJ, Turina M, Neuhaus V. Appendectomy as Teaching Operation: No Compromise in Safety-An Audit of 17,106 Patients. Journal of Surgical Education. 2021; 78: 570–578.

[10] Siam B, Al-Kurd A, Simanovsky N, Awesat H, Cohn Y, Helou B, *et al*. Comparison of Appendectomy Outcomes Between Senior General Surgeons and General Surgery Residents. JAMA Surgery. 2017; 152: 679–685.

[11] Fahrner R, Schöb O. Laparoscopic appendectomy as a teaching procedure: experiences with 1,197 patients in a community hospital. Surgery Today. 2012; 42: 1165–1169.

[12] Pandey S, Slawik S, Cross K, Soulsby R, Pullyblank AM, Dixon AR. Laparoscopic appendicectomy: a training model for laparoscopic right hemicolectomy? Colorectal Disease: the Official Journal of the Association of Coloproctology of Great Britain and Ireland. 2007; 9: 536–539.

[13] Jaffer U, Cameron AEP. Laparoscopic appendectomy: a junior trainee's learning curve. JSLS: Journal of the Society of Laparoendoscopic Surgeons. 2008; 12: 288–291.

[14] Neugebauer E, Troidl H, Kum CK, Eypasch E, Miserez M, Paul A. The E.A.E.S. Consensus Development Conferences on laparoscopic cholecystectomy, appendectomy, and hernia repair. Consensus statements–September 1994. The Educational Committee of the European Association for Endoscopic Surgery. Surgical Endoscopy. 1995; 9: 550–563.

[15] Kim CW, Jeon SY, Paik B, Bong JW, Kim SH, Lee SH. Resident Learning Curve for Laparoscopic Appendectomy According to Seniority. Annals of Coloproctology. 2020; 36: 163–171.

[16] Graat LJ, Bosma E, Roukema JA, Heisterkamp J. Appendectomy by residents is safe and not associated with a higher incidence of complications: a retrospective cohort study. Annals of Surgery. 2012; 255: 715–719.

[17] Sartelli M, Baiocchi GL, Di Saverio S, Ferrara F, Labricciosa FM, Ansaloni L, *et al*. Prospective Observational Study on acute Appendicitis Worldwide (POSAW). World Journal of Emergency Surgery: WJES. 2018; 13: 19.

[18] Markar SR, Penna M, Harris A. Laparoscopic approach to appendectomy reduces the incidence of short- and long-term post-operative bowel obstruction: systematic review and pooled analysis. Journal of Gastrointestinal Surgery: Official Journal of the Society for Surgery of the Alimentary Tract. 2014; 18: 1683–1692.

[19] Jaschinski T, Mosch CG, Eikermann M, Neugebauer EA, Sauerland S. Laparoscopic versus open surgery for suspected appendicitis. The Cochrane Database of Systematic Reviews. 2018; 11: CD001546.

[20] Carrasco-Prats M, Soria Aledo V, Luján-Mompeán JA, Ríos-Zambudio A, Pérez-Flores D, Parrilla-Paricio P. Role of appendectomy in training for laparoscopic surgery. Surgical Endoscopy. 2003; 17: 111–114.

[21] Chiu CC, Wei PL, Wang W, Chen RJ, Chen TC, Lee WJ, *et al*. Role of appendectomy in laparoscopic training. Journal of Laparoendoscopic & Advanced Surgical Techniques. Part a. 2006; 16: 113–118.

[22] Tata MD, Singh R, Bakar AA, Selvindoss P, P K, Gurunathan R. Laparoscopic appendicectomy: the ideal procedure for laparoscopic skill training for surgical registrars. Asian Journal of Surgery. 2008; 31: 55–58.

[23] Singh P, Turner EJH, Cornish J, Bhangu A, National Surgical Research Collaborative. Safety assessment of resident grade and supervision level during emergency appendectomy: analysis of a multicenter, prospective study. Surgery. 2014; 156: 28–38.

[24] Mizrahi I, Mazeh H, Levy Y, Karavani G, Ghanem M, Armon Y, *et al*. Comparison of pediatric appendectomy outcomes between pediatric surgeons and general surgery residents. The Journal of Surgical Research. 2013; 180: 185–190.

[25] Scarborough JE, Bennett KM, Pappas TN. Defining the impact of resident participation on outcomes after appendectomy. Annals of Surgery. 2012; 255: 577–582.

[26] Papandria D, Rhee D, Ortega G, Zhang Y, Gorgy A, Makary MA, *et al*. Assessing trainee impact on operative time for common general surgical procedures in ACS-NSQIP. Journal of Surgical Education. 2012; 69: 149–155.

[27] Lin YY, Shabbir A, So JBY. Laparoscopic appendectomy by residents: evaluating outcomes and learning curve. Surgical Endoscopy. 2010; 24: 125–130.

[28] Advani V, Ahad S, Gonczy C, Markwell S, Hassan I. Does resident involvement effect surgical times and complication rates during laparoscopic appendectomy for uncomplicated appendicitis? An analysis of 16,849 cases from the ACS-NSQIP. American Journal of Surgery. 2012; 203: 347–347–51; discussion 351–2.

[29] Mack J, Turner C, Carter D, Hallagan L, Whiting J, Falank C, *et al*. The Effect of Resident Participation on Appendectomy Operative Times. Journal of Surgical Education. 2020; 77: e196–e200.