Journal of Pediatric Surgery 56 (2021) 269–273

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Quantifying the effect of resident education on outcomes in pediatric appendicitis☆,☆☆

Brittany L. Johnson [a,b], Geran W. Barton [a], Huirong Zhu [c], Charlene Barclay [c], Monica E. Lopez [a,b], Mark V. Mazziotti [a,b,*]

[a] Michael E. DeBakey Department of Surgery, Division of Pediatric Surgery, Texas Children's Hospital, Baylor College of Medicine, Houston, TX, USA
[b] Baylor College of Medicine, Houston, TX, USA
[c] Outcomes and Impact Services, Texas Children's Hospital, Houston, TX, USA

ARTICLE INFO

Article history:
Received 14 April 2020
Received in revised form 26 August 2020
Accepted 30 August 2020

Key words:
Appendicitis
Appendectomy
Resident education
Outcomes
Operation

ABSTRACT

Background/purpose: Surgical residents are involved in the care of patients in a climate where quality of care is an important outcome measure. The purpose of this study was to evaluate the effect of resident involvement on appendectomy outcomes.
Methods: We retrospectively reviewed appendectomies, ages 0–18, from January 2016 to December 2018. Operative time, operative charges, and postoperative outcomes were evaluated for cases with and without a resident. Data were analyzed using Wilcoxon rank and Fisher's exact tests.
Results: Of 1842 appendectomies (1267 resident present and 575 no resident present), there was no difference in postoperative stay, abscess formation, readmission, or emergency room visits for simple or complex appendicitis. Operative time was significantly longer for cases of simple appendicitis by 10 min ($p = <0.0001$) and charges significantly higher by $600 ($p = <0.0001$) when a resident was involved in the case. These differences held true for complex appendicitis (time longer by 9 min, $p = <0.0001$ and charges higher by $500, $p = 0.03$).
Conclusion: Resident involvement results in an increase in operative time and charges, with no difference in length of stay or complications. These results highlight the cost of resident involvement, without an increase in complications experienced by patients.
Level of evidence: Level III evidence.

Resident education is a vital component of the mission of academic institutions. Learners from all subspecialites are heavily involved in the care of patients throughout their hospitalization. In medical specialites, this includes decision making, prescription administration, and counseling. In surgical specialties, there is the addition of operative intervention. In recent years, increasing emphasis has been placed on outcomes during hospital stay and following operative intervention [1,2]. The hospital and physician's success is increasingly being determined by the outcomes they produce which affect reimbursement and reputation of both parties [3]. It is unclear, however, what effect, if any, the presence of learners has on patient outcomes.

Approximately 300,000 appendectomies are performed in the United States each year, with this procedure being one of the most frequently performed operations in pediatric surgery [1]. In addition, appendectomy is also one of the most common surgical procedures for residents [1] and an ideal setting to investigate the effect the presence of a resident has on patient outcomes. The adult literature has evaluated resident involvement in appendectomy showing prolonged hospital stay and operative time [1,2]. The pediatric literature has found faster time to the operating room (OR) and shorter postoperative length of stay (LOS) in cases where a resident is involved [4]. These studies all showed no difference in postoperative morbidity, but did not evaluate cost as a component of outcomes.

Our institution, a large tertiary referral center, performs approximately 1400 appendectomies each year. Our health care system consists of a main hospital (MH) with faculty pediatric surgeons and residents and a community hospital (CH) with no residents present. This dual setting provides a unique opportunity to evaluate the effect of resident involvement on appendicitis management and outcomes. Thus, the purpose of this study was to evaluate the postoperative outcomes of children undergoing appendectomy with and without resident

☆ Study conception and design: MM. Analysis and interpretation of data: MM, BJ, HZ, CB. Drafting of manuscript: BJ and GB. Critical revision of manuscript: MM, ML, BJ, GB, HZ, CB. Annotations of changes: MM, ML, BJ.
☆☆ Funding source: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

* Corresponding author at: 6701 Fannin Street, #1210, Houston, TX 77030. Tel.: +1 832 822 3135; fax: +1 832 825 3141.
E-mail address: mvmazzio@texaschildrens.org (M.V. Mazziotti).

https://doi.org/10.1016/j.jpedsurg.2020.08.036
0022-3468/

involvement. We hypothesized that there would be no difference in patient outcomes when residents were involved in the procedure, but operative cost may be higher.

1. Methods

1.1. Setting

This retrospective review was completed with the approval of our institutional review board (H-34501). The study took place at a large tertiary referral pediatric hospital with a main hospital (MH) and a community hospital (CH) within its network. While both hospitals are academic teaching institutions, the make-up of the surgical service differs across campuses. The MH has faculty surgeons, pediatric surgery fellows, physician assistants, and general surgery residents. The CH has the same profile of providers with the exception of pediatric surgery fellows and surgical residents. Additional learners present at both locations include nurse anesthetist students, OR technician students, and OR nursing trainees. Anesthesia residents, similar to pediatric surgery fellows and general surgery residents, are only present at the MH.

1.2. Patients

The medical records of all patients ages 0–18 who underwent a laparoscopic appendectomy from January 2016 to December 2018 were retrospectively reviewed. Diagnostic criteria for appendicitis included physical examination by the surgeon on duty, imaging including abdominal ultrasound (US) and/or computerized tomography (CT), and labarotory data available at presentation. Cases completed at the MH with a faculty pediatric surgeon and a resident, and cases performed at the CH with a faculty pediatric surgeon and no resident were included in the analysis. Cases performed at the main campus with a faculty pediatric surgeon present but no general surgery resident, were included in a separate analysis comparing cases completed at the MH with a general surgery resident present. Pediatric surgery fellows, present only at the MH, did participate in some of the cases involving residents at the main hospital. Pediatric surgery fellows also participated in cases with faculty and no resident present. When a pediatric surgery fellow was present, cases were counted as resident cases.

Exclusion criteria included incidental and interval appendectomies and suspected cases of appendicitis ultimately given another primary diagnosis (intussusception, ovarian pathology, etc.). Most of the faculty in our division operate at both campuses. However, a small number of surgeons operate exclusively at either campus (MH or CH) and these cases were excluded from the analysis to remove variability.

1.3. Data analysis and definitions

Data collected included age, appendicitis severity (simple or complex), operative time (incision start to incision close), postoperative length of stay (LOS), and complications (intraabdominal abscess, readmission rates, emergency room visits). Data on hospital charges were collected and analyzed based on the operative time for each case. This information was compared by each campus (MH vs. CH) and disease severity (simple vs. complex). Complex appendicitis was defined as any patient with intraoperative findings of a perforated and/or gangrenous appendix or presence of perforated appendicitis with an abscess at presentation. All others were classified as simple appendicitis. Abscess development was defined as any organized fluid collection following appendectomy that required the placement of a drain. Postoperative LOS was defined as time from end of the appendectomy to discharge from the hospital. Data were analyzed using Wilcoxon rank and Fisher's exact tests. All results were stratified by disease severity (simple or complex appendicitis) for patients seen at the MH or CH.

2. Results

2.1. Patient demographics

Of the 2397 appendectomies performed during the study period, 1842 appendectomies were included in the analysis. There were 1267 appendectomies completed at the MH and 575 completed at the CH.

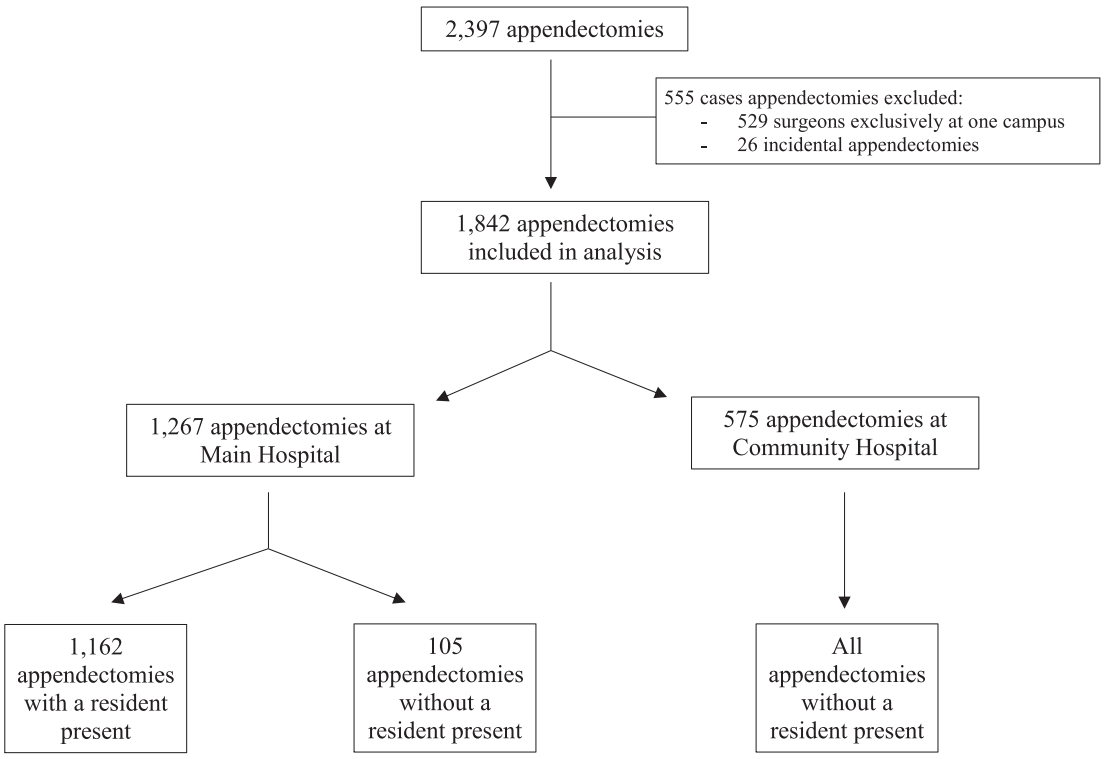

Fig. 1. Appendectomy cases included in study.

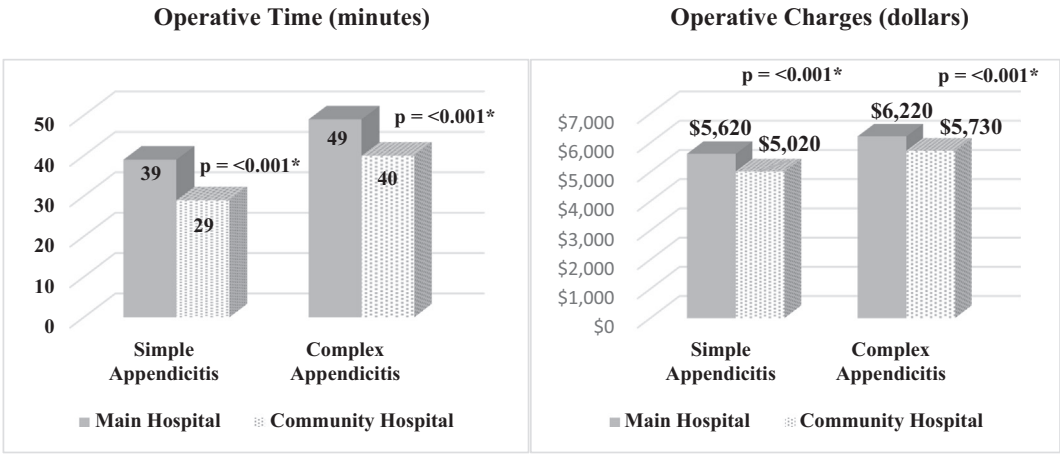

Fig. 2. Operative time and charges.

Of the 1267 MH cases, 1162 had a resident present and 105 had no resident present. All CH appendectomies only had faculty present. Five hundred fifty-five cases of appendicicits were excluded; 529 were completed by faculty that operate exclusively at one of the hospitals and not the other and 26 appendectomies for other indications (intussusceptions, malrotations, incidental appendectomy, interval appendectomy) (Fig. 1). There was no difference in the median age of patients seen at the MH or CH [simple appendicitis: MH 11 (IQR 8–14) years vs. CH 11 (IQR 9–14) years, p = 0.7; complex appendicitis: MH 10 (IQR 7–13) years vs. CH 10 (IQR 8–13) years, p = 0.7].

2.2. Surgery and hospital course

For both simple and complex appendicitis, surgery time was significantly longer when a resident was involved in the case (Fig. 2). We then determined charges using surgery durations and standardized cost accounting information at our institution. For cases with a resident present, mean operative charges for simple and complex appendicitis were significantly higher [simple appendicitis: MH $5620 ± 789 vs. CH $5020 ± 824, p = <0.0001); complex appendicitis: MH $6220 ± 1280 vs. CH $5730 ± 1050, p = <0.0001]. Despite the longer operative times, this did not translate into a longer postoperative LOS. For simple and complex appendicitis, there was no difference in the median postoperative LOS when a resident was involved in the care of the patient [simple appendicitis: MH 0.6 (IQR: 0.3–0.8) days vs. CH 0.6 (IQR: 0.2–0.8) days, p = 0.62; complex appendicitis: MH 4 (IQR: 3–6) days vs. CH 5 (IQR: 3–6) days, p = 0.6].

2.3. Appendicitis outcomes

We queried readmission rate, intraabdominal abscess development and emergency center (EC) visits for all groups. When a resident was involved in the operation, there was no difference in readmission rate, intraabdominal abscess development, or EC visits in either simple or complex appendicitis (Table 1). When a resident was present, the rate of intraabdominal abscess for complex appendicitis did approach statistical significance (MH abscess rate: 7% vs CH abscess rate 3%, p = 0.06).

Table 1
Appendicitis Outcomes.

Outcomes	Main hospital % (*n*)	Community hospital % (*n*)	p-value
Simple appendicitis			
Intraabdominal abscess	0.2% (1)	0.6% (2)	0.3
Emergency room visit	7% (43)	8% (30)	0.4
Hospital readmission	2% (13)	2% (7)	1.0
Complex appendicitis			
Intraabdominal abscess	7% (38)	3% (7)	0.06
Emergency room visit	12% (63)	10% (21)	0.5
Hospital readmission	7% (35)	5% (11)	0.5

2.4. Main hospital analysis of resident involvement in the operation

Although the MH often has a resident present in the case, there are instances where a resident may not be involved in the operation. We utilized these cases to complete a subanalysis to evaluate the presence of a resident in the operation at the same hospital. There was no difference in the ages of these patients for either simple or complex appendicitis [simple appendicitis: resident: 11 (IQR 8–13) years vs. no resident: 11 (IQR 9–14) years, p = 0.7; complex appendicitis: resident: 10 (IQR 7–13) years vs. no resident: 10 (IQR 7–13) years, p = 0.7]. In simple and complex appendicitis, the operative time and operative charges were significantly higher when a resident was present in the case (Fig. 3).

However, there was no difference in postoperative LOS, readmission, intraabdominal abcess formation or EC visits postdischarge (Table 2).

3. Discussion

Appendicitis and subsequent appendectomy are common in the pediatric population and residents are frequently involved in the care of these patients. Academic institutions are commited to training future physicians and for surgical residents, their involvement in operative experiences is imperative. Several studies in the literature have evaluated patient outcomes following appendectomy when resident physicians are involved in the procedure showing patients do not experience increased complication rates, but may have longer hospital stays following the procedure [5,6]. There have been studies that have gone a step further and evaluated patient outcomes based on the postgraduate year (PGY) of the resident involved in the case. Similar to the aforementioned studies, results showed that there was no increase in complication rate among the PGY years of the residents [7–9]. Our results in this study were similar showing no difference in postoperative LOS or outcomes irrespective of appendicitis severity. We did show however, that when residents are involved, the operative time and charges of the procedure increased. This was likely owing to the fact that charges are calculated based on operative time at our institution and also the expected increase in time owing to teaching that occurs during each case.

We also observed that for complex appendicitis, the rate of intraabdominal abscess of 7% when a resident was in the case approached statistical significance when compared to the cases without a resident present (3%). At the MH, there were more cases in general and more cases of complex appendicitis. This may have accounted for the higher rate of intraabdominal abscess. Nevertheless, we acknowledge that this may be a trend that requires evaluation at our institution including operative course and review of postoperative care to ascertain

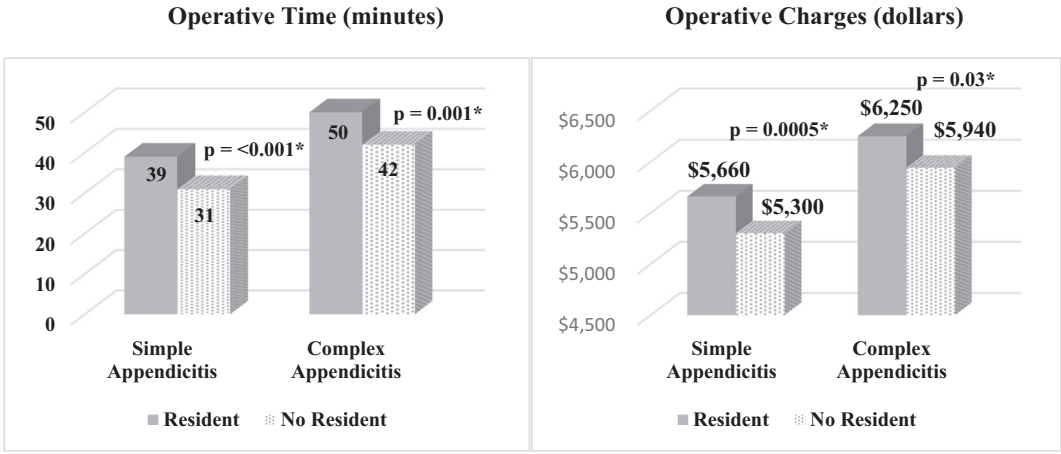

Fig. 3. Operative time and charges for main hospital appendectomies.

if improvements can be made. To further investigate this trend within our data, we would need to investigate the patients further in terms of operative technique, comorbidities, time to OR, etc. We do not have data of this nature within our dataset. Without a more comprehensive analysis, it is difficult to state whether the presence of the resident alone was a factor in the higher rate, or if patient factors played a role.

The literature is representative of studies that have evaluated outcomes of appendectomies when a resident is involved in the case. Kasotakis and colleagues completed a review of the National Surgical Quality Improvement Program (NSQIP) Database and showed that when a resident was present during appendectomies, exploratory laparotomies, and lysis of adhesion procedures patients experienced more postoperative complications (wound complications, pulmonary complications, intra- and postoperative events, etc) [10]. Similarly, Advani et al. showed increased complications following laparoscopic appendectomy when a resident was involved in the case [9]. A single institution review of general surgery procedures in the adult population showed no difference in outcomes and similar operative time when residents were involved in the case [11]. Our review represented a single center similar to the review of adult general surgery procedures and showed no difference in outcomes. The prior mentioned studies were reviews of large databases. While this gives a larger view of outcomes given larger numbers, single institutional reviews have merit in identifying outcomes at one center and making adjustments where needed, similar to our finding with complex appendicitis. Oftentimes large reviews are beneficial given their higher power; however, in cases where insitutions may want to make adjustments to practice, a review of their specific center's outcomes may be beneficial.

Given that our study took place at two different hospital campuses, there exist multiple biases that are difficult to control for across institutions such as workflows, logistical processes, and personnel present. We completed a subanalysis of patients seen only at the main hospital (MH) in an attempt to eliminate some of these biases. The comparison of cases completed with and without a resident at the MH showed identical results to the previous analyses. There were increased operative times and charges, but no difference in postoperative LOS or complications. This speaks to the validity of our results by eliminating biases between campuses.

Table 2
Appendicitis outcomes for main hospital appendectomies.

Outcomes	Resident present % (*n*)	No resident present % (*n*)	p-value
Simple appendicitis			
Intraabdominal abscess	0.2% (1)	0% (0)	1.0
Emergency room visit	7% (43)	2% (1)	0.1
Hospital readmission	2% (13)	0% (0)	0.6
Complex appendicitis			
Intraabdominal abscess	7% (38)	9% (4)	0.5
Emergency room visit	12% (63)	7% (21)	0.5
Hospital readmission	7% (35)	2% (1)	0.35

It was not unexpected that the operative time was longer when a resident was operating in the case and to a certain extent, this cannot be significantly altered as learners work on their learning curve. However, it does highlight an opportunity to improve resident preparedness for the operating room. Simulation training is increasingly being utilized in the education of general surgery residents [12–14]. In one study evaluating resident participation in robot assisted laparoscopic prostatectomy (RALP), surgical trainees were presented with a didactic and simulation curriculum and then taken through a series of operative cases with an assigned mentor. Role in the operation increased as the skill of the trainee with specific portions of the operation improved over time. Outcomes showed that using this technique resulted in no increase in blood loss or postive surgical margins in the trainee cases [15]. This training, or a similar technique, can be utilized for practice in specific procedures such as appendectomy.

There are several limitations to our study. The design is retrospective in nature, thus limited by incomplete data. Our data source relies on appropriate disease severity classification by the surgeon's documentation. This however, should have been mitigated by our manual review of the data. We were also limited by our inability to capture data for patients who sought care outside of our institution following their surgery. These patients may have returned to primary care providers or outside hospitals for complications that developed, thus limiting our full knowledge of their outcomes. We are also a large, tertiary center with multiple learners present across disciplines. Learners in the fields of anesthesia, nursing, and OR technician training are present across campuses. This may contribute to the longer operative times, but exact effects are difficult to ascertain. Finally, pediatric surgery fellows were classified as residents in this study when determining cases with faculty and those without. The data were not analyzed to compare cases with pediatric surgery fellows and faculty, general surgery residents and faculty, and faculty alone. However, based on fellow case data at our institution, pediatric surgery fellows perform about 30 appendectomies a year. Given the increased expertise of pediatric surgery fellows compared to general surgery residents, this may have altered the outcomes for the resident case cohort. The affect was likely minimal, however, given the lower annual case numbers for fellows.

4. Conclusion

Resident education is a key component of the mission of academic institutions. We demonstrated that resident involvement is associated with a significant increase in operative time and charges in both

complex and simple appendicitis, with no difference in postoperative outcomes of patients. Thus, we conclude that resident involvement in appendectomies and postoperative care of patients is safe and necessary for the educational development of future surgeons. Regular participation in simulation curriculum may assist in lowering the time residents require to complete surgical procedures, thus decreasing operative charges.

References

[1] Baha S, Abbas A, Simanovsky N, et al. Comparison of appendectomy outcomes between senior general surgeons and general surgery residents. JAMA Surg. 2017; 152(7):679–85.
[2] Lee W, Parks SJ, Park MS, et al. Impact of resident-performed laparoscopic appendectomy on patient outcomes and safety. J Laparoendosc Adv Surg Tech A. 2018;28:41–6.
[3] Services CfMM. Hospital-acquired conditions; 2015.
[4] Mizrahi I, Mazeh H, Levy Y, et al. Comparison of pediatric appendectomy outcomes between pediatric surgeons and general surgery resident. J Surg Res. 2013;180(2):185–90.
[5] Graat LJ, Bosman E, Roukema JA, et al. Appendectomy by residents is safe and not associated with a higher incidence of complications: a retrospective cohort study. . 2012;255:715–9.
[6] Jolley J, Lomelin D, Simorov A, et al. Resident involvement in laparoscopic procedures does not worsen clinical outcomes, but may increase operative times and length of hospital stay. Surg Endosc. 2016;30:3783–91.
[7] Naiditch JA, Lautz TB, Raval MV, et al. Effect of resident postgraduate year on outcomes after laparoscopic appendectomy for appendicitis in children. J Laparoendosc Adv Surg Tech A. 2012;22:715–9.
[8] Singh P, Turner EJ, Cornish J, et al. Safety assessment of resident grade and supervision level during emergency appendectomy: analysis of a multicenter, prospective study. Surgery. 2014:28–38.
[9] Advani V, Ahad S, Gonczy C, et al. 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. Am J Surg. 2012;203: 347–51.
[10] Kasotakis G, Lakha A, Sarkar B, et al. Trainee participation is associated with adverse outcomes in emergency general surgery: an analysis of the National Surgical Quality Improvement Program Database. Ann Surg. 2014;260(3):483–90.
[11] Uecker J, Luftman K, Ali S, et al. Comparable operative times with and without surgery resident participation. J Surg Educ. 2013;70(6):696–9.
[12] Ryu WH, Dharampal N, Mostafa AE, et al. Systematic review of patient-specific surgical simulation: toward advancing medical education. J Surg Educ. 2017;74(6): 1028–38.
[13] Schwab B, Hungness E, Barness K, et al. The role of simulation in surgical education. J Laparoendosc Adv Surg Tech A. 2017;27(5):450–4.
[14] Miyasaka KW, Aggarwal R. Using simulation to address continuituy of care in general surgery resident education. Am J Surg. 2016;211(2):491–2.
[15] Schroeck FR, de Sousa P, Kalman RA, et al. Trainees do not negatively impact the institutional learning curve for robotic prostatectomy as characterized by operative time, estimated blood loss, and positive surgical margin rate. Endourology/MIS. 2008;71(4):597–601.