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Factors Influencing Complication Rates in the Orthopaedic Theatre

Faktory ovlivňující četnost komplikací na ortopedickém operačním sále

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ABSTRACT

PURPOSE OF THE STUDY

The prevalence of complications in surgical units is available in the literature. The aim of this study was to compare the "rotational" (more than one surgeon) and "full-time single surgeon" use of the orthopedic theater.

MATERIAL AND METHODS

We retrospectively evaluated patients who underwent orthopedic surgery in 2016 in different theaters. A total of 604 of 1973 patients were excluded from the study, and 1369 patients were analyzed. The follow-up period was 1 year. While evaluating the cases, the duration and order of each case, the total operation time on the table, the number of surgeons, the total number of cases, the number of residents, and the experiences of the surgeons were investigated, and the effects of these parameters on the complication rates were analyzed. The Dindo-Clavien system was used to classify the complications.

RESULTS

When comparing the methods, the complication rate of the full-time single-surgeon method (12.9%) was less than that of the rotational method (21.7%) (p: 0.022). A higher rate of complications (8.5%) was observed in operations with a duration of 115 minutes or more compared to other operations ($p < 0.001$). A higher complication rate (23.7%) was observed in cases lasting more than 345 minutes ($p = 0.002$).

CONCLUSIONS

According to our study, full-time use of the orthopedic theater by a single surgeon was found to be safer than rotational use. In addition, the duration of surgeries lasting longer than 115 minutes or longer than 345 minutes during the day increased the rate of surgical complications.

Key words: patient safety, surgical planning, operation time, operation order, orthopedic complication.

INTRODUCTION

The prevalence of complications in surgical branches (13, 15), especially in orthopedic surgery units (5, 14, 24, 32), is available in different studies in the literature. The risk factors affecting the complication rate were identified in these studies. Although some of these factors (such as age and American Society of Anesthesiologists (ASA) score) can not be changed, some (such as case order, number of cases per day, improved operating theater conditions, and case time) can be altered, and complication rates can be minimized to ensure patient safety (25, 27).

The Modified Dindo-Clavien Classification was adopted in the literature to provide standardization in the evaluation of complications (32). This classification, which was initially used in the evaluation of general surgery cases, has also become usable in other surgical branches.

The aim of this study was to compare, for case scheduling in operating theaters, the development of complications in operating theaters that are used by a single surgeon throughout the day and those rotationally used by several surgeons. In other words, which are more successful, rested surgeons or warmed-up surgeons?

MATERIAL AND METHODS

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

The operations performed in the Orthopaedics and Traumatology Department of the Health Sciences University Umraniye Training and Research Hospital (46-bed, 12 specialists, 9 residents) between January 2016 and December 2016 were retrospectively evaluated. The data obtained from 2 operating tables were analyzed. The patients who underwent operations in 2 operating theaters of our clinic in 2016 had at least one-year follow-up records and gave consent to pharmacologic treatment, and surgical interventions were included in this study. To enable the analysis of long-term complications, the follow-up period was designated as 1 year.

The patients who had inadequate records or follow-up had diabetic foot-like problems and were thus subjected to debridement or amputation, had inadequate 1-year follow-up, developed anesthesia-related complications and underwent an urgently planned operation on an emergency operating table (open fractures, fracture-dislocations, vascular trauma accompaniment, compartment syndrome, etc.) were excluded from this study. Patients who were considered ASA 4 and 5, had operations under local anesthesia, had operations in other operating rooms, were classified as Modified Clavien-Dindo grade 1, 2, 4 and for whom damage control surgery was planned due to multiple trauma were also excluded. Only the first records of the patients who underwent repeated operations due to the development of infection were considered complications. Of the 1973 patients, 604 were excluded from the study, and 1369 were included in the analysis.

The patients were routinely called for control on the 15th and 30th days. Other controls differed depending on the type of surgery.

Two anesthesiologists (1 consultant and 1 resident) performed the patients' preoperative examinations, and the necessary medical examinations and consultations were requested. The clinic council for orthopedics evaluated the preoperative surgical indications. The postoperative X-rays of the patients who underwent operations were taken on the same day and reviewed by the council during their visit the same afternoon. Each case that developed complications was recorded in the hospital electronic information system as a 'complication'. While the evaluation as to whether any complication developed or not was performed during the retrospective screening, two orthopedists analyzed the data obtained.

When evaluating the cases, the duration of each case and the total operation time on the table were analyzed. In every room, there was a surgical nurse and a circulating nurse responsible for maintaining order. The circulating nurse noted the time from anesthesia induction until skin closure.

The Modified Clavien-Dindo Classification for surgical complications was used in the comparison (Table 1).

The aim of this study was to evaluate isolated orthopedic complications; therefore, Grades 1, 2 and 4 patients were excluded from this study (3, 6).

Some days, only one surgeon performed all the operations on the operating table, whereas on other days, more than one surgeon operated rotationally. The complication rates relating to operating tables used by a single surgeon and rotationally used by several surgeons were analyzed. The effect on the results of the year of seniority of the surgeon (0–10 years and over 10 years), the number of residents and the involvement of a single or several surgeons were evaluated. Whether the complication rate decreased with the increasing year of seniority of the surgeon and whether the experience affected the case time were also evaluated. Furthermore, the effect of the case time, the involvement/noninvolvement and number of residents on the complication rates were evaluated. The effects of the total number and duration of operations (performed on the operating table) on complications (infection, implant failure, inadequate reduction, malposition, nonunion, recurrence, death etc.) were evaluated. Whether the type of surgery (trauma, arthroplasty, vertebrae, sports surgery, hand surgery, pediatric orthopedic surgery and general) had any effect on complication rates was analyzed. The effects of these factors on the postoperative hospitalization period were evaluated. The operation order of the patients who had complications was evaluated. They were categorized as 1st, 2nd, 3rd and ≥4th and analyzed to determine after which operation the complication rates increased, i.e., the complication rates increased whether or not any cut-off value was available. Whether re-hospitalization was required to treat the patients who developed complications was analyzed. The age group of the patients was categorized as 0–18, 19-65, ≥65 and the complication rates of these groups were compared. The effect of the patient's age on the complication rate was also analyzed.

The association of the development of postoperative surgical site infection with the operation order, numbers of surgeons and residents and with the type of operation was evaluated.

The distribution according to the type of operation was as follows: 58% trauma, 15% arthroplasty, 13% sports surgery, 11% general, 2% pediatric and 1% vertebra. The distribution according to the type of anesthesia was as follows: 68% general, 31% spinal and 1% block anesthesia.

No residents involved 12%, 1 resident involved 35%, and 2 or more residents involved 35% of the operations. The ages of the patients varied between 0 and 99 and the distribution according to age groups was as follows: 0–18 age group (14%), 19–65 age group (63%) and 65–99 age group (23%).

Table 1. Modified Clavien-Dindo Classification

Grade	Complication
1	Any deviation from the normal postoperative course without the need for pharmacologic treatment or surgical or radiologic intervention.
2	Complications requiring pharmacologic treatment with drugs other than those allowed for grade 1.
3A	Complications requiring surgical, endoscopic, or radiologic intervention without the need for general anesthesia.
3B	Complications requiring surgical, endoscopic, or radiologic intervention under general anesthesia.
4A	Life-threatening complications involving single organ dysfunction.
4B	Life-threatening complications involving multiple organ dysfunction.
5	Death.

Table 2. Distribution of general characteristics

Operation order	1st	2nd	3rd	≥4th	
	441 (32%)	412 (30%)	312 (23%)	201 (15%)	
Type of operation	arthroplasty	general	pediatric	sports	trauma
	209 (15%)	151 (11%)	23 (2%)	184 (13%)	787 (58%)
Type of anesthesia	block	general	spinal		
	14 (1%)	919 (68%)	429 (31%)		
Number of residents	0	1	≥2		
	162 (12%)	717 (53%)	475 (35%)		
Infection	developed	not developed			
	50 (4%)	1312 (96%)			
Complication	developed	not developed			
	77 (6%)	1289 (94%)			
Age group	0-18	19-65	65-99		
	189 (14%)	856 (63%)	321 (23%)		
Duration of surgery	≤115	>115			
	643 (47%)	718 (53%)			
Use of operating table (single/rotational)	1	≥2			
	247 (56%)	194 (44%)			
Total operation time	≤345	>345			
	263 (60%)	177 (40%)			
	mean ± SD		median (min–max)		
Duration of surgery	127.14 ± 67.52		120 (10–600)		
Postoperative hospitalization period	3.07 ± 4.89		2 (0–90)		

The data were obtained from a program named Health Information System (HIS) and the images were obtained from a program named PACS (Picture Archiving and Communication System Ankara, Turkey). Microsoft Excel was used to compile and save the data obtained.

Statistics

Using centralization and variance measurements indicated the behavior of the quantitative variables. Mean ± SD was used. Pearson's chi-square test was used to determine the ratio between categorical variables or differences between relationships. The statistical significance was adopted as p = 0.05 for all the cases. IBM SPSS (Statistical Package for Social Sciences for Windows, Version 21.0, Armonk, NY, IBM Corp.) package was used for the statistical analysis.

RESULTS

It was observed that the average age of the patients was 47 years, the minimum operation time was 10 minutes, the maximum operation time was 600 minutes and the average operation time was 127 minutes.

When the complication incidence rates were analyzed for all patients (Table 3), the successive operations throughout a day by a single surgeon were compared with the rotational use of the operating table and it was observed that the complication rate in successive operations performed by a single surgeon (12.9%) was less than that with the rotationally used operating table (21.7%) (p = 0.022). In a Chi-Square test (significance level = 0.05, power = 80%) used to determine the number of surgeons using the operating table, a sample size of at least 125 was required to detect an effect size of 0.25.

A higher complication rate (8.4%) was observed in the operations in which 2 or more residents were involved compared to those in which one or no resident involved (p = 0.003).

A higher complication rate (10.0%) was observed in the patient group taken to the operating theater 4th or after compared to those taken before (p = 0.033).

The complication rates were analyzed by evaluating the case times. The cut-off value was determined to be 115 minutes. A higher complication rate (8.5%) was observed in operations with a duration of 115 minutes or more compared to others (p<0.001).

A higher complication rate (17.6%) was observed in the patient group with a case time exceeding 115 minutes and taken to the operating theater 4th or after compared to those taken before (p = 0.003) (Fig. 1).

When the complication rates were analyzed over the total operation time throughout the day, the cut-off value was determined to be 345 minutes. A much higher complication rate (23.7%) was observed in cases lasting more than 345 minutes (p = 0.002).

Table 3. Comparing complication development

		Complication		
		developed	**not developed**	**p***
Duration of the surgery	=<115	16 (2.5%)	627 (97.5%)	<0.001
	>115	61 (8.5%)	657 (91.5%)	
Operation order	1st	19 (4.3%)	422 (95.7%)	0.030
	2nd	21 (5.1%)	390 (94.9%)	
	3rd	17 (5.5%)	294 (94.5%)	
	≥4th	20 (10.0%)	179 (90.0%)	
Operation order 2	≤3rd	57 (4.9%)	1106 (95.1%)	0.006
	>3rd	20 (10.1%)	179 (89.9%)	
Type of operation	arthroplasty	12 (5.7%)	197 (94.3%)	0.054
	general	6 (4.0%)	144 (96.0%)	
	pediatric	2 (8.7%)	21 (91.3%)	
	sports	3 (1.6%)	181 (98.4%)	
	trauma	54 (6.9%)	730 (93.1%)	
	vertebra	0 (0.0%)	12 (100.0%)	
Type of anesthesia	block	0 (0.0%)	14 (100.0%)	0.464
	general	57 (6.2%)	862 (93.8%)	
	spinal	20 (4.7%)	409 (95.3%)	
Number of residents	0	4 (2.47%)	158 (97.53%)	0.003
	1	33 (4.6%)	684 (95.4%)	
	≥2	40 (8.42%)	345 (91.58%)	
Age group	0–18	8 (4.3%)	178 (95.7%)	0.024
	19–65	41 (4.8%)	814 (95.2%)	
	65–99	28 (8.7%)	293 (91.3%)	
Experience	0–10	35 (4.9%)	676 (95.1%)	0.270
	10–20	42 (6.5%)	609 (93.5%)	
Total operation time	≤345	32 (12.2%)	231 (87.8%)	0.002
	>345	42 (23.7%)	135 (76.3%)	
Number of surgeons	1	32 (12.9%)	215 (87.1%)	0.022
insolved	≥2	42 (21.7%)	152 (78.3%)	

p Pearson Chi-Squared Test*

A higher complication rate (8.7%) was observed in patients within age group 65-99 compared to those within other age groups (p = 0.022).

When the complication rates were analyzed considering the year of seniority of the surgeons under two separate groups as 0–10 and ≥10 years, no statistically significant difference was determined (p:0.27).

When the development of infection was compared (Table 4), a higher infection rate (8.0%) was observed in the patient group taken to the operating theater 4th or after compared to those taken before (p = 0.001).

A higher infection rate (5.6%) was observed in operations lasting ≥115 minutes compared to others (p<0.001).

A higher infection rate (5.9%) was observed in patients >65 years of age compared to others (p: 0.049).

When the development of infection was compared in terms of the number of surgeons involved in the case, a higher infection rate (4.8%) was observed in cases in which 2 or more residents involved compared to others; however, no statistically significant difference was determined (p: 0.138).

DISCUSSION

According to the primary results of our study, a lower complication rate was determined on the operating table used by a single surgeon throughout the day compared to that used rotationally. There has been a preconception that the physical and mental fatigue of a surgeon who successively enters operations would cause a higher complication rate. In our study, we observed that fewer complications developed in operations performed by a single surgeon. In a study by Gupta, it was stated that surgeons performing successive operations warm up,

Table 4. Comparing the development of infection

		Infection		
		developed	**not developed**	**p***
Duration of the surgery	=<115	10 (1.6%)	633 (98.4%)	0.000
	>115	40 (5.6%)	678 (94.4%)	
Operation order	1st	11 (2.5%)	430 (97.5%)	0.005
	2nd	13 (3.2%)	398 (96.8%)	
	3rd	10 (3.2%)	301 (96.8%)	
	≥4th	16 (8.0%)	183 (92.0%)	
Operation order 2	≤3rd	34 (2.9%)	1129 (97.0%)	0.001
	>3rd	16 (8.0%)	183 (92.0%)	
Type of operation	arthroplasty	8 (3.8%)	201 (96.2%)	0.059
	general	4 (2.7%)	146 (97.3%)	
	pediatric	2 (8.7%)	21 (91.3%)	
	sports	1 (0.5%)	183 (99.5%)	
	trauma	35 (4.5%)	749 (95.5%)	
	vertebra	0 (0.0%)	12 (100.0%)	
Type of anesthesia	block	0 (0.0%)	14 (100.0%)	0.789
	general	36 (3.9%)	883 (96.1%)	
	spinal	14 (3.3%)	415 (96.7%)	
Number of residents	0-1	27 (3.1%)	849 (96.9%)	0.138
	≥2	23 (4.8%)	452 (95.2%)	
Number of surgeons	1	21 (65.63%)	11 (34.38%)	1.000
	2	24 (64.86%)	13 (35.14%)	
	≥3	5 (62.5%)	3 (37.5%)	
Age group	0–18	6 (3.2%)	180 (96.8%)	0.049
	19–65	25 (2.9%)	830 (97.1%)	
	65–99	19 (5.9%)	302 (94.1%)	
Experience	0–10	25 (3.5%)	686 (96.5%)	0.862
	10–20	25 (3.8%)	626 (96.2%)	

p Pearson Chi-Squared Test*

and accordingly, case times shorten (15). Shanafelt was stated that the workload (working hours) of a surgeon is not statistically significant in complications or medical errors, but such errors are strongly associated with the quality of life and level of burnout of the surgeon (26). Moreover, Wetzel stated that extreme stress prompts surgeons to make mistakes (30).

Scheduling excessive numbers of operations within a single day prompts surgeons to speed up and consequently make mistakes. In a study by Frazee et al., it was stated that an excessive number of cases in an operating theater increases complication rates (10). In our study, the cut-off value was statistically determined to be ≥4 and we found that the complication rate prominently increases in the 4th and subsequent operations of the day.

Prolonged operative time increases the complications in orthopedic surgery. As the operative time increases, the team gets tired, particularly in trauma cases and the acceptability criteria increase. Therefore, the infection risk, anesthesia-related complication, etc. increase. In a study by Willhuber et al., it was stated that a prolonged operative time increases the major postoperative complications (32). Likewise, in a study by Collins et al., it was stated that a prolonged case time increases complications and extends the postoperative hospitalization period and cost (4). According to our results, when the complication rates were statistically analyzed by considering the case times, the cut-off value was determined to be 115 minutes. In cases lasting more than 115 minutes, the complication rates significantly increased.

In our study, when the case times on a single operating table were summed up on a daily basis and its effect on complications was analyzed, the cut-off value was found to be 345 minutes. In cases lasting more than 345 minutes, the complication rates significantly increased.

Patient age is an important factor for estimating adverse developments that may occur (7). Comorbidities

(diabetes mellitus, heart failure, immunosuppression, peripheral vascular disease, etc.) increase with age and adversely affect the results (11). According to the observations of Lau et al., the greatest risk factor that estimates complications is 'being over the age 65' (21). It has been stated in many studies in the literature that complications, the postoperative hospitalization period, cost and severity of complications increase with age (4, 14, 22, 23, 32). In our study, it was also observed that the complication rate in patients over the age of 65 was higher.

According to a study by Altieri et al., complication rates decrease with increasing surgical experience (1). Many publications in the literature support this finding (2, 12, 16, 20, 28, 31). In an article published by Walch et al. in 2012, it was stated that as the surgeon's experience improves, he/she better determines the indications; therefore, the results improve and complication rates decrease (29). In most of the publications, evaluations were made after indicating the sample size on a specific surgical branch. As expected, complication rates decrease and case times shorten with increasing experience (17, 28). However, Geubbels et al. stated that the experience of the surgeon has no effect on the complication rate in bariatric surgery, but the case time shortens with increasing experience (13). In our study, complication rates were analyzed by considering the year of seniority of the surgeons and no statistically significant difference was determined. However, it must be taken into consideration that in this study, the cases were not selected according to a specific surgery and that the analysis was carried out by evaluating all orthopedic surgical operations.

A prolonged case time, excessive number of cases on the operating table and being at the end of the case order increase the infection risk by causing an increase in particle count in the operating theater, colonization and contamination in the surgery site (8, 9, 18, 19). Naranje et al. analyzed the effect of the duration of surgery on the infection rates in total knee arthroplasty and stated that the infection incidence rate increases with a prolonged operation time (24). Likewise, Colman et al. determined that prolonged operative time increases the infection incidence rate in tibia plateau fractures (5). In our study, when we carried out a statistical analysis based on 115 minutes, the time at which the complication rates markedly increased, it was determined that the infection rates significantly increased. When we considered the daily operation schedule, we found that the infection rate significantly increased in the 4th and subsequent cases, whereas the first 3 cases exhibited similar infection rates. When analyzing the ages of the patients, it was determined that the infection rate in patients over the age of 65 was higher. We analyzed whether the number of surgeons involved in a case had any effect on the infection rate and determined that there was no significant difference.

This study has some limitations, most of which are inherent to its retrospective design and relatively small study group. The assessment of clinical outcomes was limited to chart documentation, which was incomplete in some cases, as can be expected in a study of this nature.

CONCLUSIONS

According to our study, full-time use of the orthopedic theater by a single surgeon was found to be safer than rotational use. In addition, the duration of surgery lasting longer than 115 minutes or longer than 345 minutes all day increases the rate of surgical complications.

Compliance with ethical standards

Conflict of interest: *All authors in this study declare that they have no conflict of interest. No benefits have been or will be received from a commercial party related directed or indirectly to the subject matter of this article.*

Ethical approval: *This article does not contain any studies with animals performed by any of the authors. This study had an ethical commitee approval from the local institution (no:54132726-000-26742 date: 20/12/2018).*

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