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Factors Affecting Operative Time Intervals for Lower Limb Arthroplasties – Correlation with Total Operative Time

Faktory ovlivňující operační čas jednotlivých fází operace v korelaci s celkovou operační dobou

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ABSTRACT

PURPOSE OF THE STUDY

The aim of this study is to evaluate the operative time intervals for major orthopaedic surgeries and analyze the correlation of different operative factors on total operative time.

MATERIAL AND METHODS

Specific time intervals; anesthesia release time (ART), surgical preparation time (SPT), operative procedure time (OPT), and anesthesia end time (AET); were recorded by independent observers. Total operative procedure time (TOPT), was also calculated and statisctical correlation analysis was performed between TOPT and study parameters.

RESULTS

The difference for ART and SPT time intervals between age groups below 65 and 65 to 85 years were found statistically significant. As the patient's age increased, ART and SPT time intervals were also significantly increased. As the patients ASA status increased, the ART intervals were also increased. ART and AET time intervals were significantly longer for residents compared to specialists.

DISCUSSION

This is one of the first studies in the literature analyzing different time intervals and their correlation on total operative time for major orthopaedic surgeries. Current study also analyzed the effects of other factors including age and ASA score of the patients, type of anesthesia and experience of anesthegiogist on operative time intervals. This study was designed for the analysis of specific time intervals previously described in the literature for only some major orthopaedic surgeries. By this way, we aimed to achieve a homogenous study group and to obtain comparable results with the literature.

CONCLUSIONS

The strongest correlation was found between ART and TOPT. As the patient's age increased, ART and SPT time intervals were also significantly increased. Increased age and higher ASA scores with an unexperienced anesthegiologist significantly increased the ART intervals. Therefore, reducing ART is the most important factor in reducing TOPT.

Key words: arthroplasty, anaesthesia, operation time.

INTRODUCTION

In the last decade, there is an increasing demand for surgeons to improve their surgical efficiency and to increase their caseloads (2). To address this increasing demand and to reduce the costs and resources, surgeons start to increase surgical volume by reducing the procedure time for anesthesia induction, surgical preparation and surgery (14).

In the literature, there are various studies analyzing the factors affecting these procedure times for surgical treatments (6, 12, 18, 23). Nevertheless, their data are variable and results are inconclusive. In all these studies, the operating room (OR) is utilized as the major production unit with under or over-utilized times (22). It is well known in the literature that, frequent work beyond scheduled hours not only leads to overtime cost but also results to dissatisfaction and reduced motivation of the staff. Overtime work is also one of the primary reasons for staff to terminate their employment, (21). Therefore, efficient OR management should aim for maximal use of available OR time while preventing frequent overtime work (4).

To evaluate the efficiency of this OR management, some of studies in the literature have set target or benchmark times for anesthesia induction and surgical preparation and have investigated reasons for any delay in these procedures (15, 25). However, there isn't any study in the literature that specifically evaluates major orthopaedic surgeries in a prospective manner for these time durations. It is generally accepted in the literature that, there is an increasing demand for the orthopaedic surgeons to use the OR efficiently in order to increase turnover rates. Nevertheless, this is a multifactorial issue that must be analyzed not only with the orthopedic surgeons but also with the other staff of surgery including anesthegiolists and technicians and patient characteristics' (16). Hence, to our knowledge, this is one of the first studies in the literature that specifically analyze time durations for major orthopaedic surgeries. We therefore prospectively analyzed major orthopaedic surgeries for the time progression from entrance to the exit of the patient from the OR. We also evaluated if there is any significant difference between the time durations required for anesthetic procedures and surgical preparation in regard to the type of surgery and anesthesia, age, gender and American Society of Anesthegiologists (ASA) physical status (PS) score of the patient and experience of the anesthesiologist.

MATERIALS AND METHODS

Study group

This prospective observer-based cross-sectional study was performed in our university hospital's ORs (n=9). All patients who were admitted to both inpatient and outpatient clinics of orthopaedics and who scheduled for any orthopaedic surgery from January 2016 to August 2017 were considered for this study. A priori power analysis was performed in order to determine the minimum number of surgeries for statistical significance. After priori power analysis, it is found that 120 primary arthorplasties were accepted as the minimum number of cases for the study group. After protocol review, an informed consent was granted and all guidelines for confidentiality were followed throughout the data collection. As an inclusion criterion, only major lower extremity Orthopaedic surgeries (primary athroplasties of hip and knee including unicondylar and partial arthoplasties) were included in the study group. To prevent any bias, upper extremity athroplasties, cemented total hip athroplasties and surgeries which were done by the residents were excluded from the final analysis. Other exclusion criteria for the study were: Revision arthroplastic surgeries, emergency surgical procedures including any trauma that require arthroplastic surgeries of any type, patients with ASA physical status IV or more, patients who had single-stage multiple surgeries and patients who scheduled for bilateral arthroplasty surgeries.

As a result, 133 cases were found to be eligible. As there was no follow-up period, there was no lost to follow-up.

Data collection

Data were recorded on a standardized form by independent observers who were not involved in patient care. These independent observers were instructed by two of the authors (SA, EB) using a formal syllabus and a short instructional period in the OR. The data recording was performed by the same methodology previously described in the literature by Saadat et al. (16). The observers were in place for each study before the patient entered the OR and left the OR after skin incision. Observers stationed themselves in the OR so as not to be obtrusive and yet close enough to be able to observe and hear all the events that took place in the OR. To prevent bias, all surgeries were performed by senior surgeons who are experienced in arthroplasty and observers were rotated through each of the nine ORs with an assignment sequence based on the use of random number generator software for Windows. The type of anesthesia was applied as the preference of anaesthesiologist. In 17 procedures, anaesthesia were started by anesthesiology resident but failed to be performed and as a result, had to be completed by the senior anaesthesiologist.

For each procedure, the following punctual times were recorded based on the Association of Anesthesia Clinical Directors' glossary of standardized times (8): patient in room (PIR), anesthesia ready (AR), procedure start (PS), procedure finish (PF), and patient out of room (POR) (Figure 1). The following time intervals were calculated from these recorded punctual times: anesthesia release time (ART), surgical preparation time (SPT), operative procedure time (OPT), and anesthesia end time (AET) (Figure). The punctual time for patient in room was accepted as "time zero". ART was defined as the patient in the room (time zero) until the release of the patient to the surgeons for preparation and positioning. OPT was defined as the time from skin incision until completion of the application of the dressing in the OR. All intervals were measured by use of a stopwatch and are reported in minutes with start equal to time zero. The total operative procedure time (TOPT), ie, the total time a patient spends in the OR, was also calculated as the difference between the punctual times recorded for patient out of room and patient in room.

Additionally, for each procedure, gender (whether male or female), age (patient age was stratified into below 65, 65 to 85 years or older) the type of anesthesia (whether general, combined or spinal), the anesthesiologist (whether resident or specialist) and ASA score were also evaluated for time dependence.

Statistical analysis

Compliance with the normal distribution of continuous variables was checked with Shapiro-Wilk test. Homogeneity of groups' variances was checked by Levene's test. Groups' means or medians were compared by Student's t-test, Mann-Whitney U test, Kruskal-Wallis test and then multiple comparisons between pairs of groups were carried out according to Dunn test. Correlations between variables were evaluated with Spearman rank correlation coefficient rho. The results of statistical analysis were expressed as number of observations (n), mean ± standard deviation (M ± SD), median and minimum–maximum values [M (min–max)]. SPSS Ver. 17.0 (SPSS Inc., Chicago IL, USA) and MedCalc 13.1.0.0 (MedCalc Software bvba, Ostend, Belgium) statistical package programs were used for the analysis of data set. $p < 0.05$ was considered statistically significant.

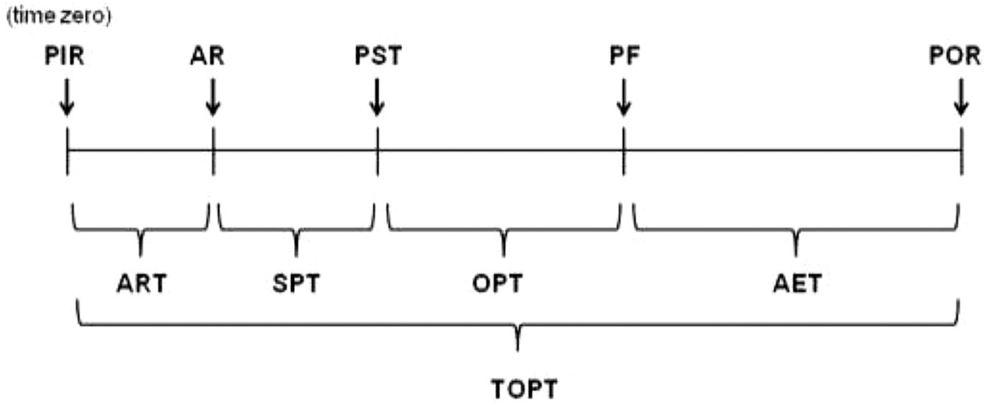

Fig. 1. The schematic drawing of punctual times based on the Association of Anesthesia Clinical Directors' glossary of standardized times [patient in room (PIR), anesthesia ready (AR), procedure start (PST), procedure finish (PF), and patient out of room (POR)] and time intervals between these punctual times (ART: anesthesia release time, SPT: surgical preparation time, OPT: operative procedure time, AET: anesthesia end time, TOPT: total operative procedure time).

RESULTS

The mean values for ART, SPT, OPT, AET and TOPT were 34.3 ± 8.3 min. (min: 15, max: 55), 21.4 ± 4.9 min. (min: 15, max: 35), 159.1 ± 44.2 min. (min: 80, max: 292), 26.3 ± 7.4 min. (min: 15, max: 50) and 236.3 ± 48.1 min. (min: 238, max: 357), respectively.

There were 131 female (61.2%) and 83 male (38.8%) patients. The mean time intervals and statistical comparison results for each gender were summurized in Table 1. There was no statistically significant difference between female and male patients in regard to all time intervals (see the table for p values).

The mean age of the patients was 67.8 years (range: 59–81 years). The mean time intervals for differerent age groups and statistical comparison results were summurized in Table 2. The difference for ART and SPT time intervals between age groups below 65 and 65 to 85 years were found statistically significant ($p < 0.05$ for both). As the patient's age increased, ART and SPT time intervals were also significantly increased. On contrary, there was no significant difference for time intervals between age groups 65 to 85 years and over 85 years (see the table for p values).

There were 39 ASA I (29.3%), 81 ASA II (60.9%) and 13 ASA III (9.7%) patients in the study group. The ART time intervals were significantly different between ASA groups ($p < 0.05$). As the patients ASA status increased, the ART intervals were also increased. There was no significant difference between ASA groups in regard to OPT and TOPT intervals ($p = 0.152$ and 0.089, respectively).

Among the study population, the most commonly used type of anesthesia was combined anesthesia (n = 83, 62.4%). This was followed by spinal (n = 32, 24%) and general anesthesia (n = 18, 13.5%), respectively. The ART time interval was found significantly longer for combined anesthesia ($p < 0.05$). The mean time intervals for differerent anesthesiologist and statistical comparison results were summurized in Table 3. ART and AET time intervals were significantly longer for residents compared to specialists ($p < 0.05$).

Spearman rank correlation analysis for TOPT revealed that, there was a strong positive correlation between TOPT vs. ART (Spearman rho: 0.856) and modest correlation between TOPT vs. OPT (Spearman rho: 0.452). These two correlations were found staticsally significant ($p < 0.05$ for both).

Table 1. Mean time intervals in minutes for gender and the statistical comparison results

Gender	ART	SPT	OPT	AET	TOPT
Male	31.3	25.2	159.3	28.2	239.1
Female	33.5	26.1	158.9	27.1	241.2
p value	0.351	0.078	0.711	0.142	0.069

ART: anesthesia release time, SPT: surgical preparation time, OPT: operative procedure time, AET: anesthesia end time, TOPT: total operative procedure time

Table 2. Mean time intervals in minutes for age groups and the statistical comparison results

Age Groups	ART	SPT	OPT	AET	TOPT
<65	33.6	22.5	157.5	28.2	238.8
65–85	39.9	31.3	155.2	27.2	240.2
>85	34.9	29.9	159.8	26.4	238.9
p value	0.027	0.022	0.978	0.481	0.076

ART: anesthesia release time, SPT: surgical preparation time, OPT: operative procedure time, AET: anesthesia end time, TOPT: total operative procedure time

Table 3. Mean time intervals in minutes for anesthesiologists and the statistical comparison results

Anesthesiologist	ART	SPT	OPT	AET	TOPT
Resident	37.6	23.5	158.2	29.2	239.1
Specialist	32.8	22.8	157.5	25.1	237.2
p value	0.036	0.091	0.141	0.031	0.512

ART: anesthesia release time, SPT: surgical preparation time, OPT: operative procedure time, AET: anesthesia end time, TOPT: total operative procedure time

DISCUSSION

This is one of the first studies in the literature analyzing different time intervals and their correlation on total operative time for major orthopaedic surgeries, Current study also analyzed the effects of other factors including age and ASA score of the patients, type of anesthesia and experience of anesthegiogist on operative time intervals. In the last decade, with the overload of operative surgeries in different branches of medicine, the efective use of OR's has gain popularity (3, 5, 13, 19). As a result, there have been various reports in the literature in regard to this topic analyzing different time intervals for different surgical procedures. Nevertheless, there is still an ongoing debate about the efficient use of OR's. Most of the studies in the literature have heterogenous study populations including different surgical procedures from different branches and in addition, many has various benchmark time intervals that makes the results incomparable with the other studies (1, 7, 11, 24). In order to overcome these controversies, we have designed a study for the analysis of specific time intervals previously described in the literature for only some major orthopaedic surgeries. By this way, we aimed to achieve a homogenous study group and to obtain comparable results with the literature.

Recent studies in the literature emphisized that gender was effective on different operative time intervals. In a study by Småbrekke at al. the duration of 31745 total hip replacements performed in Norway between 1987 and 2001 were analyzed in regard to gender difference (20). They found that young male patients were associated with long procedures along with perioperative complications and they have specific procedure characteristics such as a lateral surgical approach and trochanteric osteotomy. A technically demanding operation, an inexperienced surgeon and operating team or a combination of these factors can also increase operation time. In our study, we have found no relationship between patients' gender and operative time intervals. The reason for this may be that we have only analyzed time intervals for major orthopaedic surgeries with similiar surgical approaches.

There were also various studies in the literature analyzing the association between ASA scores and different time intervals. Ehrenwerth et al. performed a study to determine anesthesiologist's prediction of the duration of anesthesia and performed observer-based prospective study from 2001 to 2002 in 1558 cases (9). Anesthesia release time (ART) and surgical preparation time were recorded. They found that ASA/PS scores were corralated with ART. These findings were consistent with our study. In current study, we also found a significant association between ASA scores and ART time intervals. As the patient's ASA score increases, anesthesia risk increases and as a result, it takes longer time to make patient ready for surgery.

Ehrenwerth et al. study also evaluated the the effects of patients' age and the technique of anesthesia on operative time intervals (9). The analysis of anesthesia technique revealed that ART in monitored anesthesia care was shorter than general or regional anesthesia. As a result it was concluded that, the patient age and regional anesthetic technique increased ART significantly. In the current study, the difference for ART between age groups below 65 and 65 to 85 years were found statisticaly significant. On the other hand, in our analysis, we could not find any significant difference between age groups 65 to 85 years and over 85 years. As the patient age increases, there are also several comorbidities. As a result, different monitoring techniques are needed over 65 years old patients and extra time may be needed. There are also degenerative problems in vertebral columns in patients over 65. This may also contribute to longer time intervals for regional anestehesia.

The total time for patients' preparation before the start of surgery is another controversial topic in the literature (2). There are several studies in the literature with different benchmark time intervals (1, 2, 9, 12). In our study, after PIR punctual time, we have recorded ART and SPT time intervals before the start of the surgery. Sasano at al. investigated all elective surgeries in 1059 patients under general anesthesia (17). Regarding to surgery type, the most common four surgeries were general surgery, orthopaedic surgery, otorhinolaryngology and paediatric surgery. They divided time into two groups. The time duration from enterance to patient positioning indicates anesthetic stup time, and the time duration from position to insicion indicates surgical preparation time. In total, it took an average of 49.8 minutes from entrance to incision. In another study by Zafar et al., 300 patients were evaluated (25). Most of the patients had undergone orthopaedic surgery (27.8%). On average; it took approximately 34 minutes for anesthesia preparation, 21 minutes for surgical preparation. Totally we needed 55 minutes to start surgery in average. This time is a bit more than Sasano et al. (49 min.) and Zafar et al. (50 min.). This is probably because in most cases (86.4%) we used combined and spinal anesthesia in which it took four to seven minutes until efficient dose.

This study was performed in a university hospital with anesthesia residents perfoming aneshthetic applications for education. In our analysis, we found ART and AET time intervals significanty longer for anesthesia residents compared to specialists. In most cases, residents performed the anesthetic technique and generally it took long time with several attempts. This finding is consistent with the literature (10). In which ART and SPT were compared with ASA PS score, surgery type, anesthesia technique and anesthesiologist resident training level.

We showed a strong correlation between ART and TOPT (ART/TOPT: 14.5%). This was consistent with the study of Saadat et al. (16). They found that ART was about 15% of TOPT. Both studies confirmed one another and there was no difference between children and adults. Additionaly there was no significant difference between patient gender and ART.

There are several limitations in our study. First of all, we did not have detailed descriptions of procedures performed. Perioperative complications and comorbitities were not recorded. Same surgical team performed all surgeries in single center. Therefore the affect of surgeon and hospital volume can not be assessed. Lastly, the present study was performed in a teaching hospital. The training of residents may lead to long procedure times.

CONCLUSIONS

In conclusion, today, effective use of the operating room is becoming increasingly important. Procedure duration is the most important factor for peri-operative and post-operative morbidity. This is also very important for orthopaedic arthroplasty surgeons. There are a lot of studies investigating time intervals in OR but there is not a spesific study for orthopaedic surgery. In the current study, the strongest correlation was found between ART and TOPT. Therefore reducing ART is the most important factor in reducing TOPT. Increased age of the patient and higher ASA scores with an unexperienced anesthegiologist also significantly increased the ART intervals. More studies must focus on ART. Further studies can be carried out to determine the ideal time for the patient's safety and comfort.

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