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Identifying Perioperative Risk factors for Ninety Days Mortality, Reoperation and Length of Stay in Orthopedic Surgery

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Abstract

Background: Several patient, surgeon and health system risk factors have been associated with outcomes like mortality, length of stay and reoperations in previous literature. Yet, some risk factors are still being investigated in regards to their ability to predict certain outcomes and others are still not investigated. This study's aims were to investigate and identify existing as well as new risk factors, which may be used as predictors for mortality, length of stay and reoperations.

Method: A cohort study was designed with screening of all orthopedic patients admitted to Aalborg University Hospital from 1st August 2014 – 31th of October 2014. Only patients who underwent orthopedic surgery and who we could follow-up 3 months after the inclusion period were included in the study. Demographic and clinical patient data were collected during the inclusion and follow-up period by use of the internal hospital journal software Clinical Suite. Patient variables collected were: Gender, age (years), BMI (kg/m^2), admission type (acute/elective), Charlson Index score, diagnose type (hip fracture/other orthopedic diagnose), time to surgery (days), operation time (minutes), reoperation, prescribed rehabilitation plan, early rehabilitation, length of stay (days), 90-days mortality and comorbidities (heart disease, arrhythmia, hypertension, diabetes, chronic obstructive pulmonary disease, hypercholesterolemia, kidney insufficiency, neurological disease, history of apoplexy, depression). The outcome variables, mortality, length of stay and reoperations, were analyzed by multiple- and logistic regression.

Results: Nine hundred and seventy patients were admitted in the inclusion period, of these 663 patients were included in the study. Rehabilitation plan ($p < .05$), Charlson Index score > 3 ($p < .001$), age ($p < .05$) and history of apoplexy ($p < .05$) were significant predictors of 90-days mortality. Hip fracture ($p < .05$), operation time ($p < .001$), age ($p < .05$) and diabetes ($p < .001$) were significant predictors of prolonged length of stay. Lastly, elective admission ($p < .05$), depresssion ($p < .05$) and kidney insufficiency ($p < .05$) were significant predictors of reoperation.

Conclusion: Charlson Index score > 3, increased age and a history of apoplexy are potential predictors for increased risk of 90-days mortality. Patients prescribed a rehabilitation plan have a decreased risk of 90-days mortality. Patients having either hip fracture, long operation time, increased age or diabetes may be at risk for prolonged length of stay. Having depression, kidney insufficiency or being electively admitted may predict the occurrence of reoperation.

Introduction

The orthopedic ward is expected to be one of the hospital departments with the highest number of admissions in the future[4,5]. Orthopedic procedures such as total joint arthroplasty (TJA) are amongst the most common[6–8]. In the United States TJA cases went from 400.000 to 700.000 annually in the period 2000 – 2009[6]. Amongst pediatric patients, lower extremity fractures have become regular due to falls, non-accidental trauma and vehicle accidents[9]. Furthermore the life expectancy both in Europe and the U.S., have never been higher[10,11]. Since 1990 - 2010 the European population have grown to 990 million people[10]. The prolonged lifespan and reduction in childbirths amongst the population results in an increasing number of elders[10]. In the United States elders above the age of 85 are representing the most rapidly growing demographic factor and are estimated to constitute 2.3% of the population by 2030[11].

Even though Europe has achieved major improvements in living condition as well as higher functionality of the health care systems, massive future challenges still persists in managing the medical and surgical demands of the growing population[10–14]. The need for future medical treatment challenges society, health care resources and the families implicated[15–17]. Possible solutions have been attempted in the orthopedic department. Fast-track surgery, also known as enhanced recovery programs, has been recognized and demonstrated as being able to improve patient outcomes across several surgical specialisms such as colon surgery, cholecystectomy, nephrectomy, hip, knee and elbow arthroplasty[18–26]. The goal of enhanced recovery is to perform evidence-based multimodal intervention with help from a collaboration between orthopedic surgeons, anesthetist, nurses, pharmacist, physiotherapists and occupational therapists, hence resulting in the most optimal treatment and recovery for the patient[23,26]. Fast-track surgery has demonstrated significant results when conducted on TJA procedures in terms of faster and more painless recovery[27,28]. However to implement enhanced recovery programs with the highest quality and effectiveness, outcome risk factors for the various orthopedic procedures need to be identified. Mortality after hip fracture surgery has been a well reported outcome with different studies showing mortality rates between 12 – 33 %[29–33]. Within the surgical field of hip fractures studies have reported outcomes like length of stay (LOS) of 5–9.4 days in cases of total knee arthroplasty[34–36]. The influence of LOS has also demonstrated high financial demands on the health-care system[34]. Lastly, the number of hip and knee reoperations in the United States in 2030 is estimated to 96.700 compared to the 40.800 performed in 2005[37]. Identification of associated risk factors to these outcomes is needed in order to increase patient care and reduce financial costs. Outcomes such as mortality, LOS and reoperations has shown a high association with orthopedic TJA[38–41]. Several risk factors have been associated with mortality, LOS and reoperation. These are age, BMI, gender, admission type, Charlson Index, Hip fracture, rehabilitation, operation time, time to surgery and several comorbidities[5,14,38,40–43]. Several resources have been utilized in order to detect more reliable risk factors in order to optimize and implement fast-track surgery in several different fields of surgery[22]. Still, a need for improvement persists if the potential of enhanced recovery programs are to be utilized to the fullest[23].

The primary aim of this study was to investigate whether receiving a prescribed rehabilitation plan and early rehabilitation is a risk factor for postoperative 90-days mortality, reoperation and LOS. Secondarily, other possible risk factors influence on the three outcome variables were also explored. These risk factors were: Age, BMI, gender, admission type, Charlson Index, Hip fracture, operation time, time to surgery, heart disease, arrhythmia, hypertension, chronic obstructive pulmonary disease (COPD), hypercholesterolemia, kidney insufficiency, neurological diseases, history of apoplexy, diabetes and depression.

Hypothesis

Therefore, the null hypothesis of this study states that a prescribed rehabilitation plan and early rehabilitation would be associated with 90-days mortality, reoperation and LOS. Additionally, the secondary risk factors: Age, BMI, gender, admission type, Charlson Index, Hip fracture, operation time, time to surgery, heart disease, arrhythmia, hypertension, COPD, hypercholesterolemia, kidney insufficiency, neurological diseases, history of apoplexy, diabetes and depression can also be associated with 90-days mortality, reoperation and LOS.

Method

Study design

A cohort study of all performed orthopedic surgeries at Aalborg University Hospital was conducted. The inclusion period was from the 1st of August 2014 – 31th of October 2014. A three-month postoperative follow-up was performed in the period of 1st of November 2014 – 31th of January 2015. Patients from the orthopedic department at Aalborg University Hospital were identified and assessed on basis of the inclusion criteria. Subjects were included if they had undergone surgery at the orthopedic department at Aalborg University Hospital during the inclusion period. Patients whom were treated conservatively or underwent surgery at another hospital were excluded. Furthermore patients were excluded if they were foreign residents or tourist due to the lack of possibility for post-operative follow-up.

Lastly, the present study was written in agreement with the STROBE (strengthening the reporting of observational studies in epidemiology) guidelines and the self-help guide "Mastering Scientific and Medical Writing"[1,2].

Data Collection

All data was collected to form a larger data pool which we designated the Risk Evaluation in Orthopedic Surgery (REOS) datasheet. The pre-, intra- and postoperative data was extracted from the electronic patient journal system, Clinical Suite (CS), at Aalborg University Hospital. Through the inclusion period, the CS system was screened for new admissions to the orthopedic department on a daily basis. When new admissions were detected they were screened according to the inclusion and exclusion criteria of the study. If a new admission were determined as eligible for participation, the eligible subject would then be assigned an ID-number and registered in the REOS datasheet.

After registration in the datasheet, each patient journal and hospital stay were then thoroughly reviewed in order to gather demographic and clinical data (e.g. BMI, age, gender, comorbidities, LOS, time to surgery etc.).

Not all data was extracted from the CS system. Due to lack of digitalization, the anesthetic journals data had to be manually extracted from the anesthesia sheet located in the hardcopy patient journal.

Investigated Variables

One hundred and eight potential variables were collected per patient and recorded into the REOS datasheet. Of all these variables only some of them were included in the study. The following postoperative outcome variables were chosen for further investigation: LOS, reoperations and 90-days mortality. In addition age, gender, BMI, Charlson Index, type of admission, time to surgery, hip fracture diagnostic group, comorbidities, prescribed rehabilitation plan and early rehabilitation were chosen as risk factor variables.

LOS was defined as the time period in days from which the patients were admitted and until discharge. Reoperations would only be registered if they were related to the original diagnosis or operation. In example, if a hip fracture patient were readmitted to undergo surgery due to a fractured hand, then it would not be considered a reoperation. If the patient died within the follow-up period it would be considered 90-days mortality. The type of admission was registered as either elective or acute. Elective admissions were defined as patients being scheduled for surgery, whereas acute admissions included patients who visited the emergency or orthopedics department and were admitted immediately hereafter. Early rehabilitation was defined as assigned training with assistance from physiotherapists or occupational therapists and was to be started within the first postoperative day. A rehabilitation plan would be defined as a prescribed individual rehabilitation plan with startup shortly after discharge. The Charlson Index was not age adjusted and was used as an ordinal measure of the patients' comorbidity condition. The datasheet contained several diagnostic groups, however in this study, the hip fracture variable was the only one included. The comorbidities consisted of the following: Heart disease (ischemic or congestive), hypertension, arrhythmia, chronic obstructive pulmonary condition (COPD), depression, kidney insufficiency, diabetes, neurological diseases, hypercholesterolemia and previous apoplexy.

Statistical Analysis

The sample size was defined as the number of patients who underwent orthopedic surgery in the period 1st of August 2014 – 31th of October 2014 at Aalborg University Hospital.

The following demographic factors were chosen: Age (years), gender, Charlson Index (score of 0, 1-2, 3-4, 5+). Clinical factors were: Type of admission (acute or elective), BMI (kg/m^2), time to surgery (days), hospital mortality, hip fracture diagnostic group, comorbidities, rehabilitation plan, early rehabilitation and reoperation within 90 days after operation. Factors intended for analysis as outcome factors were: reoperation, LOS (days) and 90-days mortality postoperative.

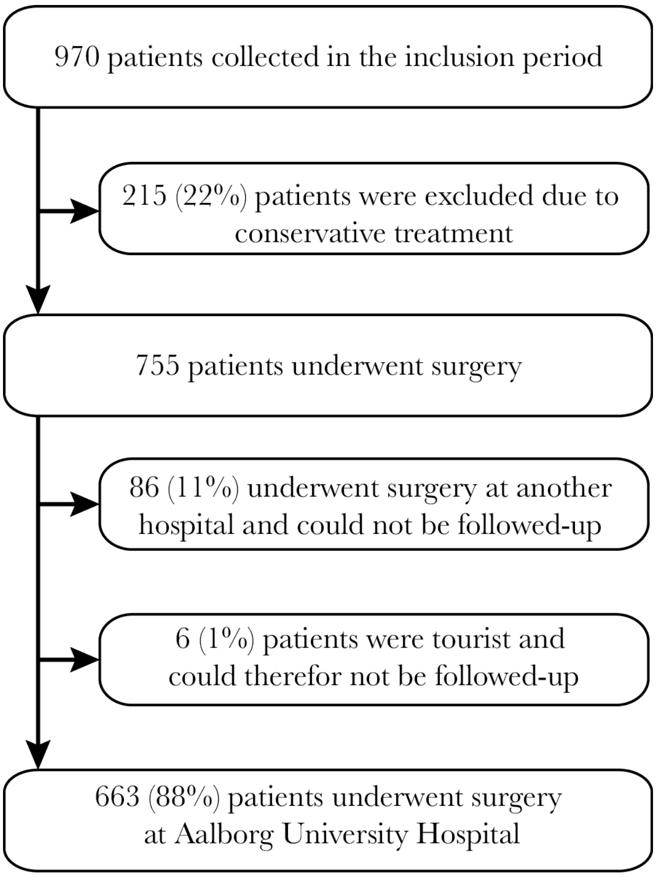
Missing data patterns were investigated for being missing completely at random (MCAR) by checking for correlations amongst the variables. Several variables were found not to be MCAR, therefore, multiple imputations on the data were performed. Hereby, 40 imputed datasets from our original data were generated to increase the power[3]. Multivariate analysis was used on the risk factors and outcome variables to detect any potential confounders that might influence the analysis.

Descriptive statistics were based on the original dataset and presented as mean (range) for numerical variables and frequency (percentage) for categorical variables. The multivariate analysis was performed based on the multiple imputated data. Each demographic and clinical factor was analyzed as a risk factor to the postoperative outcomes in a multiple logistic regression for categorical outcomes and a multiple regression for the numeric outcome. Afterwards a backwards-stepwise deletion method was used on the resulting models of the multiple logistic regressions and multiple regression. All statistical findings with α $p < .05$ was considered significant. The statistical software used in this study was RStudio for Mac OS X, Version 0.98.1087 by RStudio Inc.

Results

Information from 970 patients was extracted from the electronic patient system CS at Aalborg University Hospital. Postoperative data was extracted in a 3-month follow-up period for patients who had undergone orthopedic surgery. Of the 970 patients only 663 (68%) met the inclusion criteria and were followed-up 3 months postoperatively. Of these, 215 (22%) were removed from the sample due to not undergoing a surgical procedure (e.g. conservative treatment etc.). Eighty-six (9%) patients were excluded because they underwent surgery at other hospitals than Aalborg University, which made us unable to follow-up. Six (1%) patients were not permanently residing in Denmark and were post-treated in their home countries, hence they were removed from the sample because it was impossible to perform follow-up. Finally 663 patients were included into the final statistical analysis (Figure 1).

Figure 1. Flowchart of Patient Inclusion and Exclusion.



Missing Data

Missing data analysis showed that 60% of the patients had at least one missing variable. Table 1 shows an overview of the percentage of missing data present in the variables analyzed in this study. The correlation between the missing data in one variable and another was analyzed. It is clear that time to surgery tends to have missing data when there are missing in both operation time (r = 0.34) and LOS (r = 0.32). Furthermore missing data in operation time correlated highly with missing data in time to surgery (r = 0.79). Lastly, LOS tends to have missing data when time to surgery had missing (r = 0.32).

Table 1. Variables and the percentage of missing data

Variable	Frequency (%)
BMI	54 %
Time to Surgery	0.75 %
Operation Time	5.8 %
Length of stay	4.4 %

Patient Characteristics

Of the 663 patients in our study sample men constituted 321(48%) and women 342 (52%). The mean age was 52.4 years (range 1-99) and mean BMI was 25.5 kg/m^2 (range 11.9 – 59.5). All patients in the study were scored in accordance with the Charlson Index resulted in 388 (59%) patients having a score of 0, 189 (29%) scored 1-2, 58 (9%) scored 3-4 and finally 28 (4%) of 5+. The most frequent comorbidities in this study were hypertension (37%), hypercholesterolemia (19%) and depression (16%), remaining comorbidity frequencies are summarized in table 2. Regarding the type of admission 434 (65%) was acute and 229 (35%) were electively admitted to the hospital. Mean time to surgery was 2.2 days and the mean length of stay (LOS) was 6.65 days. The reported 90-days mortality in the present study was 40 (6%). These demographic factors are summarized in table 3.

Ninety days Mortality

Table 4 represents the findings in the logistics regression analysis of postoperative 90-days mortality. The logistic regression model was found to be X^2 (11)=102.08 and with a $p < .001$. The models goodness of fit was reported as Naglekerke = 0.41.

Patients with an assigned rehabilitation plan displayed a significant decrease of 90-days

Table 2. Patient Comorbidities

Comorbidity	Frequency (%)
Hypotension	246 (37%)
Hypercholesterolemia	129 (19%)
Depression	105 (16%)
Diabetes	93 (14%)
Heart disease	91 (14%)
Arrhythmia	79 (12%)
Neurological disease	74 (11%)
History of Apoplexy	50 (8%)
COPD	47 (7%)

mortality ($p < .001$) with an odds ratio of 0.21 (CI, 0.08 – 0.54). Indexing of patients in accordance with the Charlson Index showed to be significant ($p < .001$) for patients with a score of 3-4 and 5+, consequently demonstrating increased odds for mortality by 17.39 (CI, 3.94 – 76.71) and 33.52 (CI, 7.24 – 155.40) respectively. However, patients with a Charlson Index score of 1-2 did not prove to have a significant ($p = .079$) association for 90-days mortality. Age also proved to be a significant ($p < .05$) predictor for increased 90-days mortality with an odds ratio of 1.05 (CI, 1.02- 1.09). Additionally the analysis significantly ($p < .05$) showed that patients with a history of apoplexy would have an increased odds ratio of 2.86 (CI, 1.09 – 7.52) for 90-days mortality. Lastly diabetes only showed a tendency ($p = .081$) as a decreasing predictor for 90-days mortality. Moreover neurological disease, operation time and time to surgery did not prove to be significant ($p > .05$) as predictors for 90-days mortality.

Reoperation

Logistic regression analysis was performed resulting in a model with X^2 (10)=27.265 with p=0.002. Goodness of fit in the model showed Naglekerke = 0.091. Being electively admitted to the hospital was found to be a significant ($p < .05$) predictor compared to patients being admitted acute. Elective admission had increased odds ratio 1.81 (CI, 1.02 – 3.23) and was associated with higher risk of reoperation. Depression and kidney insufficiency were also

Table 3. Demographics Table of the Collected Sample of Data.

Variables Total (n = 663)	n (%) or mean (SD)	
Gender (men)	321	(48%)
Gender (women)	342	(52%)
Age (years)	52.4	(±27.4)
BMI (kg/m^2)	25.5	(±6.6)
Charlson Index score		
Score 0	388	(59%)
Score 1-2	189	(29%)
Score 3-4	58	(9%)
Score 5+	28	(4%)
Time to surgery (days)	2.2	(± 2.9)
Admission time (days)	6.7	(± 8.8)
Admission type		
Elective	229	(35%)
Acute	434	(65%)
Rehabilitation plan		
Yes	306	(46%)
No	357	(54%)
Early rehabilitation		
Yes	240	(36%)
No	423	(64%)
90 days mortality		
Yes	40	(6 %)
No	623	(94 %)
Diagnose Group:		
Fractures (hip)	111	17 %
Fractures (upper body)	103	16 %
Wounds (leg)	86	13 %
Fractures (lower leg)	87	13 %
Alloplastic complications	68	10 %
Joints (leg)	50	8 %
Various spinal conditions (back)	47	7%
Wounds (upper body)	39	6 %
Unspecific	32	5%
Fractures (upper leg)	24	4 %
Scoliosis (back)	16	2%

Categorical data is stated as n (%); Numeric data is stated as mean (SD); BMI: Body Mass Index.

shown to be significant ($p < .05$), hence patients had increased likelihood of experiencing a reoperation due to an odds ratio of 1.97 (CI, 1.01 – 3.92) and 4.04 (CI, 1.01 – 16.17) respectively. Despite illustrating a tendency of significance ($p = .058$), the association of recei-

Table 4. Logistic Regression of Predictors for 90-days Mortality.

Predictor	B (SE)		95% CI for OR	CI	P-value	Fmi†
Rehabilitation plan	-1.55	(0.48)	0.21	0.08 - 0.54	0.001**	0.13
Charlson Index:						
Score 0			1.00			
Score 1-2	1.23	(0.70)	3.41	0.87 - 13.42	0.079	0.02
Score 3-4	2.86	(0.76)	17.39	3.94 - 76.71	0.000**	0.02
Score 5+	3.51	(0.78)	33.52	7.24 - 155.40	0.000**	0.02
Hip Fracture¥	0.80	(0.47)	2.23	0.88 - 5.66	0.090	0.04
Neurological disease	0.65	(0.47)	1.91	0.74 - 4.76	0.166	0.03
Operation time	-0.002	(0.002)	0.10	0.10 - 1.00	0.237	0.06
Time to surgery	-0.006	(0.016)	0.99	0.96 - 1.03	0.723	0.03
Age	0.05	(0.02)	1.05	1.02 - 1.09	0.002*	0.03
Previous Apoplexies	1.05	(0.49)	2.86	1.09 - 7.52	0.033*	0.01
Diabetes	-0.90	(0.51)	0.41	0.15 - 1.12	0.081	0.03

Snell = 0.15, Nagelkerke = 0.41; model statistics: $x^2(11)=102.08$, $p < 0.000$; † Fmi: States the fraction of missing data that is attributable for the uncertainty in the variable and which has been replaced by multiple imputations; ¥ Hip fracture is referenced to other orthopedic surgeries; $p < .05$ *, $p < .01$**

ving early rehabilitation demonstrated an odds ratio of 0.55 (CI, 0.29 – 1.02), thereby lowering the odds of getting a reoperation. Patients with a Charlson Index score of 5+ ($p = .091$) and hypercholesterolemia ($p = .079$) showed a relative trend of having an association with reoperation. Finally, no significance could be proved between having a history of apoplexy, hypertension, Charlson Index score of 0-4 and an association with the occurrence of reoperation. Reoperation logistic regression findings are summarized in table 5.

Length of Stay

LOS was analyzed by multiple regression and resulted in a model fit of $R^2 = 0.19$. The

Table 5. Logistic Regression of Predictors for Reoperation.

Predictor	B (SE)		95% CI for OR	CI	P-value	Fmi†
Early rehabilitation	-0.606	(0.320)	0.546	0.291 - 1.022	0.058	0.004
Charlson Index:						
Score 0			1.00			
Score 1-2	0.126	(0.353)	1.134	0.567 - 2.268	0.720	0.004
Score 3-4	-0.797	(0.694)	0.451	0.115 - 1.760	0.251	0.004
Score 5+	1.049	(0.619)	2.855	0.847 - 9.622	0.091	0.004
Depression	0.686	(0.346)	1.986	1.007 - 3.920	0.048*	0.005
Hypertension	0.549	(0.318)	1.736	0.927 - 3.235	0.085	0.008
Elective admission¥	0.595	(0.294)	1.813	1.018 - 3.228	0.043*	0.004
Previous apoplexies	0.825	(0.506)	2.282	0.845 - 6.160	0.103	0.007
Hypercholesterolemia	-0.741	(0.421)	0.477	0.208 - 1.090	0.079	0.005
Kidney Insufficiency	1.397	(0.705)	4.043	1.012 - 16.168	0.048*	0.005

Snell = 0.041, Nagelkerke = 0.091; model statistics: x^2 (10) = 27.265, p = 0.00236; † Fmi: States the fraction of missing data that is attributable for the uncertainty in the variable and which has been replaced by multiple imputations; ¥ Elective admission is referenced to acute admission;
$p < .05$ *, $p < .01$**

Table 6. Multiple Regressions of Predictors for Length of Stay.

Predictor	B	(SE)	β	P-value	Fmi†
Early rehabilitation	-1923.08	(1024.78)	-0.074	0.061	0.05
Hip Fracture	3395.24	(1465.04)	0.100	0.021*	0.07
Operation time	14.17	(3.354)	0.168	0.000**	0.12
Time to surgery	-41.26	(38.04)	-0.041	0.279	0.04
BMI	143.68	(115.15)	0.074	0.215	0.53
Age	74.81	(21.76)	0.163	0.001**	0.11
Previous Apoplexy	-2681.13	(2057.64)	-0.055	0.193	0.15
Hypercholesterolemia	2079.12	(1358.12)	0.066	0.126	0.08
Kidney Insufficiency	4483.41	(3426.83)	0.057	0.192	0.24
Diabetes	7677.59	(1597.13)	0.210	0.000**	0.09

$R^2 = 0.187$; † Fmi: States the fraction of missing data that is attributable for the uncertainty in the variable and which has been replaced by multiple imputations; $p < .05$ *, $p < .01$**

predictors hip fracture, age and diabetes all showed a significant relationship ($p < .05$) of increased LOS. LOS was prolonged for patients with hip fractures compared to other orthopedic diagnoses. Correspondingly, diabetes, age and operative time was associated with increased LOS. Conversely, although only demonstrating a tendency of significance ($p = 0.061$), early rehabilitation had a negative correlation, hence lowering the LOS. The remaining predictors time to surgery, BMI, history of apoplexy, hypercholesterolemia and kidney insufficiency were not significant as predictors for prolonged LOS. All LOS multiple regression findings are displayed in table 6.

Discussion

The current study found that patients whom underwent surgery at the orthopedics department at Aalborg University Hospital and got a prescribed rehabilitation plan was a significant predictor for decreased 90-days mortality. Furthermore, early rehabilitation indicated a trend towards lower LOS and decreased risk of reoperations. Getting a prescribed rehabilitation plan was significantly associated with decreased 90-days mortality. Regarding early rehabilitation in prediction of reoperations and LOS we found a trend. Studies in patients undergoing hip fracture surgery and subsequently receiving physical rehabilitation showed a reduced 90-days mortality[44–47]. There may be numerous explanations for the positive effect of rehabilitation. It is known that immobilization after orthopedic procedures may lead to sarcopenia, which is associated with disability, frailty and increased healthcare costs[48]. Thus effective rehabilitation may counter decreased functional capacity and might be a possible solutions to reduce the risk of mortality in elderly patients[49]. Other suggestion such as minimally invasive techniques might also potentially benefit in less postoperative pain and less surgical stress, hence resulting in faster rehabilitation. Multiple factors such as the surgical approach, postoperative pain management and hip restrictions may all be able to promote the initiation of the rehabilitation, hence helping to reduce the risk of mortality[50–52].

Risk factors for Length of stay

In the current study the variables hip fracture, operation time, age and diabetes was found to be risk factors that potentially could increase the LOS.

The reported results demonstrated a high likelihood of increased LOS if patients experienced prolonged operation time, thereby making operation time an important factor in predicting the LOS[53]. One might reason that surgeries with long operation time are due to use of highly complicated surgical techniques or the patient circumstances are very severe, which can be the case in some elective and acute admissions. Considering that the present study did adjust for the elective and acute admissions in the analysis underlines that operation time association with LOS could be due to the surgery complexity. Therefore, in future studies it is important to investigate the operation time as risk factor for LOS and if possible involve surgery complexity. Other studies like Eleswarapu et al.[54] also found longer operation time to be a predictor for LOS, whereas Siemionow et al.[55] did not. Though the study samples from Eleswarapu et al. and Siemionow et al. only consisted of patients undergoing spinal surgery. It is likely that operation time can be a possible predictor for LOS in other surgery fields, when considering the many types of surgery in this study's sample composition. However, Siemionow et al.[55] focused on minimally invasive procedures, hence the difference in scale of operation could be the reason that Siemionow et al. did not find any significance in regards to operation time as a risk factor for prolonged LOS. This raises the question whether operation time is affected by the scale of the operations and implies that future studies needs to take this into consideration in the analysis.

Increased age proved to be a highly associated predictor for LOS. This finding was in agreement with studies of Jørgensen et al.[27] and Clement et al.[56], however, in both studies the age was only found significant in elderly hip fracture patients. The two studies both had a narrow age range in comparison to this study[27,56]. Hip fractures represented a majority of the diagnoses in this study and was correlated with a higher LOS compared to other orthopedic diagnoses. This is in accordance with several other papers[57–60]. A reason for this might be due to lack of incorporation and use of enhanced recovery programs. Studies have shown that enhanced recovery programs may reduce LOS by lowering the need of extended care facilities especially for the elderly[41,61,62]. The influence of comorbidities may also be a possible cause of increased LOS, which has been documented in previous literature[63,64]

Amongst the investigated comorbidities in this study, diabetes was displayed as being a predictor for LOS, which is in accordance with other studies[59,65]. These findings were not only significant in relation to one type of surgery, but in several types of total joint replacements[59,65]. The reason diabetes could prolong the LOS might be due to the increased risk of deep infections[66–68]. Prophylactic initiatives may therefore be encouraged if LOS is to be reduced.

Risk Factors for Reoperations

The study findings showed patients being electively admitted or having comorbidities like depression and kidney insufficiency had increased likelihood of undergoing reoperation. The literature regarding admission type as a predictor of postoperative outcome such as reoperation is sparse[5]. Therefore, to the knowledge of the authors, this might be the first paper investigating elective admission as a predictor for orthopedic reoperations.

Patients admitted electively had 1.8 in odds of undergoing reoperation compared to acutely admitted patients. These findings may be multifactorial. Elective patients undergoing reoperations may be high-risk patients with confounding comorbidities. Often reoperations are due to surgical site infections which sometimes demands several reoperations[69]. Studies like Smucny et al.[70] reported that surgical site infections in shoulder arthroplasty patients were related to other diagnoses than the primary e.g. comorbidities, in-hospital events, kidney insufficiency etc. Moreover, the elective surgeries might be more complicated procedures than the acute surgeries. Both Zhan et al.[71] and Barrack et al.[72] demonstrated elective surgeries to be more complicated, which supports the importance of elective admission as a predictor. Studies concerning elective surgeries such as degenerative lumbar spondylolithesis, hip, knee, shoulder and total ankle arthroplasty have all reported different re-

operation rates of 6.1%, 2.1%, 1.8%, 25% and 28% respectively[73–77]. Based on the inconsistency of reoperations rates in orthopedic surgeries, it would be interesting to perform further observational studies to investigate possible predictors of reoperation.
Finally, kidney insufficiency and depression showed to increase the risk for reoperation. Numerous papers demonstrated this observation in both total knee arthroplasty (TKA) and total hip arthroplasty (THA)[39,40,78]. This information may be useful in the decision-making of the treatment when advising elderly patients with comorbidities whom are considering elective surgery, hereby reducing the risk of reoperation.

Risk Factor for Ninety days Mortality

The current study found Charlson Index score > 3, age and a history of apoplexy to increase the risk of 90-days mortality. On the contrary, a prescribed rehabilitation plan decreased the risk of 90-days mortality.
The Charlson Index correlated highly with 90-days mortality. Patients scoring 3-4 and 5+ had an odds ratio of 17.4 and 33.5 compared to patients with a Charlson Index of 0 respectively. These findings are in agreement with multiple studies[79–84]. Therefore, scoring with Charlson Index may function as a valuable tool in assessing the likelihood of postoperative 90-days mortality[85]. This study demonstrated a relationship between age and postoperative 90-days mortality. This is in agreement with several papers who found similar results[86–89]. Age is frequently reported as a predictor in studies regarding THA and TKA, which consist mostly of elderly patients with a high age. Papers such as Smith et al.[90] reports mortality rates higher amongst adults compared to pediatric patients in spine surgery. It might not be surprising that elderly patients are more exposed to mortality because they usually have several comorbidities and reduced performance status[85]. Lastly, having a history of apoplexy was strongly associated with 90-days mortality with an OR of 2.7. Literature regarding apoplexy as a predictor of 90-days mortality is inconsistent. Smith et al.[90] highlighted apoplexy as a common cause of postoperative death. Conversely, Nho et al.[91] and Mortazavi et al.[92] reported that history of apoplexy had no association with postoperative mortality. This emphasizes a need for investigation concerning this risk factor in regards to orthopedic surgeries[92].

Remaining Non-Significant Predictors

In this current study the following predictors were not found to have significant association with their respective outcome variable. However, these predictors may have had some indirect effect on the other predictors, as they were not excluded from the statistical models in the analysis.
In this study, no significant association was demonstrated between BMI and LOS. Conversely, Jonas et al.[41] found BMI > 30 to be a risk factor for LOS. A meta-analysis by Liu et al.[93] proved that obese patients have longer operation times, higher number of infections and dislocations, which may lead to increased LOS. Time to surgery was not associated with LOS, but other studies have been able to demonstrate that surgical delay increases LOS[14,94]. In some cases a delay to undergoing surgery might be a potential advantage due to correction or stabilization of major clinical comorbidities[31,95]. Belmont et al. showed[38] a non-significant association for surgery delay of 2 days and LOS, however this was in relation to postoperative mortality.
Although hip fractures were not found to be a risk factor for mortality, the pathology still poses a great health challenge to society in cases of high mortality rates[96,97]. In the present study, Charlson Index scores did not report any significant association with reoperations. Contrary to this, Bozic et al.[39,40] presented two studies regarding Charlson Index score as a risk

factor. This indicates inconsistency in the literature regarding the Charlson Index as a predictor for reoperations.

Conversely to the present study, orthopedic geriatric departments and others reported that time to surgery had an increasing effect on postoperative mortality[96,98,99]. The reason for this may be multifactorial. First of all, prolonged immobilization until surgery might increase the risk of mortality[99]. Secondly, delay to surgery may be related to the need for comorbidity stabilization e.g. poor control of diabetes. Thirdly, different procedure-related issues such as: waiting for consultation, unavailable staff, occupied operating rooms, delayed laboratory results etc. might delay the time to surgery[98]. Operative time could not be determined as a predictor for mortality, but studies have previously proved it to be a predictor for major complications[100–102]. Although this study lacks the ability to present findings indicating operative time as a predictor for mortality, surgeons are nevertheless encouraged to minimize procedure time to avoid any major complications[7].

The comorbidities diabetes and neurological diseases were not associated with increased 90-days mortality in the current study. However, orthopedic studies have demonstrated diabetes patients have reduced survival rates[79]. Tebby et al.[103] displayed a higher association of mortality amongst diabetic patients, however, the study sample consisted of polytrauma patients with high-level complications. Thus, the mortality rates might be influenced by several other complicating factors. In previous papers neurodegenerative diseases like Parkinson, Alzheimer's and dementia have been related to increased risk of mortality in hip fracture patients[104,105]. Possible explanations for this might be based on the characteristics of neurological disease symptoms like rigidity and postural instability, which can lead to falls[106]. Hence, patients with reduced functional and medical capacity are more exposed to incur hip fractures and increased risk of mortality compared to healthy people[105]. This study did not find apoplexy to be in association with LOS and reoperation. Similar results have been reported in other studies, which have investigated multiple comorbidities, including apoplexy, as risk factors for orthopedic surgeries [39,40]. Most frequent reasons for reoperations in THA and TKA was various mechanical complications with the device implant and joint infections[39,40]. However, in a study by Licthe et al.[107], apoplexy was associated with both higher mortality and LOS. It should be noted that the study sample of Lichte et al.[107] was based on polytrauma patients and due to a high number of overall injury complications and comorbidities they were unable to establish a causal relationship of the apoplexies alone. Hypercholesterolemia did not show any correlation with LOS or reoperation in this present study. Bozic et al.[39,40] supported this finding in regards to reoperation. To the author's knowledge, hypercholesterolemia as a risk factor for LOS has not been elucidated in other studies. Yet, the literature shows that patients with metabolic syndrome and hypertension have an increased risk of cardiovascular events after total joint arthroplasty[108,109]. Hypercholesterolemia is a well-known risk factor of cardiovascular diseases, hence it is suggested that further investigation of hypercholesterolemia as a predictor for LOS is necessary[110]. Similarly, hypertension did not indicate any association with reoperation in this study, contrary to this Jämsen et al.[109] found it as a risk factor for early reoperation. As previously mentioned diabetes can induce deep infections, hence could be the reason for early reoperation[66–68]. Lastly, no relation between kidney insufficiency and LOS was observed in this study. The opposite was found by O'Mally et al.[111]. Here they demonstrated preoperative kidney insufficiency to prolong the LOS 1.26 days[111]. How the individual comorbidities are associated with orthopedic postoperative outcomes like mortality, reoperation and LOS remains unanswered still. The authors propose that the risk factors might contribute multifaceted and other factors such as surgical skills, complexity of the case and quality of the preoperative as well as postoperative treatment may have some influence in terms of better postoperative outcomes.

Strength and Limitations

The major strength in this study is based on the study population composition and size. The study population is composed of all patients undergoing orthopedic surgery within the inclusion period. This gives the sample a huge diversity in several aspects such as age, types of surgery, comorbidities etc. As a result of this sample diversity, the results are considered to possess an external validity. In addition, the cohort design of this study does not allow any results to prove any causality between risk factors and postoperative outcomes, wherefore further studies, preferably of a randomized-controlled design, are imperative. Even though confounders were taken into account in the multivariate analysis, unexplained external factors such as surgeons skills, other non-stated comorbidities, etc. may have influenced the results.

Bias might have occurred during the manual data extraction from the anesthesia sheet. At several occasions information was simply unaccounted for, which therefore resulted in missing data. Another factor that lead to missing data was due to poor handwriting in the anesthesia sheet, consequently some data had to be regarded as missing even though it was written in the anesthesia sheet. Finally lack of early rehabilitation and prescribed rehabilitation details administered to the individual patient may be a limitation. Furthermore, it was not possible to obtain any data regarding what type of physical therapy the patients were given as well as duration and intensity of the therapy.

Conclusion

In conclusion, getting a prescribed rehabilitation plan was found to decrease the risk of 90-days mortality. Whereas, Charlson Index score > 3, age and history of apoplexy was associated with an increased risk of 90-days mortality. Depression, elective admission and kidney insufficiency were all associated with increased likelihood of reoperation. Lastly, patients with hip fractures, long operation time, increased age or diabetes were at risk of longer LOS. Several other factors and comorbidities such as: early rehabilitation, hypercholesterolemia and hypotension demonstrated a tendency in prediction of outcomes. These risk factors are valuable information, which can be useful in establishing and optimizing enhanced recovery programs as well as in the treatment planning of orthopedic surgeries. Identification of these risk factors might help patients, with various modifiable or non-modifiable risk factors, to avoid negative postoperative outcomes.

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Appendix: Description of Literature Search

1. **Study aims/hypothesis:**
   The null hypothesis of this study was that a prescribed rehabilitation plan and early rehabilitation would be associated with 90-days mortality, reoperation and LOS. Additionally, the secondary risk factors: Age, BMI, gender, admission type, Charlson Index, Hip fracture, operation time, time to surgery, heart disease, arrhythmia, hypertension, COPD, hypercholesterolemia, kidney insufficiency, neurological diseases, history of apoplexy, diabetes and depression can also be associated with 90-days mortality, reoperation and LOS.

2. **Search terms:**
   a. **Study population:**
      i. Orthopedics
      ii. Orthopedic surgery
      iii. Surgical procedures, Elective
      iv. Acute patient OR Emergent
      v. Acute admission OR elective Admission
      vi. Subacute admission OR subacute care OR emergency care
      vii. Hospital admission
   b. **Intervention/outcomes:**
      i. Risk factor OR predictor
      ii. Bone injury
      iii. Blood loss, surgical OR operative blood loss
      iv. Patient readmission OR hospital readmission OR readmission
      v. Mortality OR hospital mortality
      vi. Operative time OR operation duration
      vii. Postoperative complications
      viii. Rehabilitation OR functional training OR geriatric rehabilitation OR
      ix. Length of stay
      x. Postoperative infection OR surgical infection OR surgical wound infection

3. Used Databases and applied search engines limitations (e.g. language, published last 5 years, study type, publication type etc.)

Databases used:

Database:	**Limitations:**
PubMed	Language: English
Cinahl	Language: English
Cochrane	Language: English
Embase	Language: English

- **3.b Often used search combinations (OR/AND):**
  - (Patient readmission OR Hospital mortality OR Length of stay OR Operative time OR Blood loss, surgical OR Postoperative complications)
  - Surgical procedures, elective AND orthopedics AND (Patient readmission OR Hospital mortality OR Length of stay OR Operative time OR Blood loss, surgical OR Postoperative complications)
  - Patient readmission AND orthopedics AND (Patient readmission OR Hospital mortality OR Length of stay OR Operative time OR Blood loss, surgical OR Postoperative complications)

4. General search results:

Database / Search terms	PubMed	Embase	Cinahl	Cochrane
Orthopedics AND Rehabilitation OR Functional training OR Geriatric rehabilitation OR Muscle training OR AND (Patient/hospital readmission OR Hospital Mortality/ survival rate OR Length of Stay OR Operative Time/duration OR Blood Loss, Surgical OR Postoperative Complications OR surgical wound infection)	17	35	22	1
Orthopedics AND Patient care AND (Patient readmission OR Hospital Mortality OR Length of Stay OR Operative Time OR Blood Loss, Surgical OR Postoperative Complications)	315	-	-	-
Orthopedics AND Acute Patient OR Emergency care OR Bone injury OR Emergency patient OR Wound and Injuries OR AND (Patient readmission OR Hospital Mortality/survival rate OR Length of Stay OR Operative Time OR Blood Loss, Surgical OR Postoperative Complications)	62	378	1	61
Orthopedics AND Sub-acute AND (Patient readmission OR Hospital Mortality OR Length of Stay OR	1	-	-	-

Operative Time OR Blood Loss, Surgical OR Postoperative Complications)				
Orthopedics AND Surgical Procedures, Elective AND Outcomes: (Patient readmission OR Hospital Mortality OR Length of Stay OR Operative Time OR Blood Loss, Surgical OR Postoperative Complications)	17	17	88	1