■ TRAUMA

Does time from fracture to surgery affect mortality and intraoperative medical complications for hip fracture patients?

AN OBSERVATIONAL STUDY OF 73 557 PATIENTS REPORTED TO THE NORWEGIAN HIP FRACTURE REGISTER

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Aims

The aim of this study was to investigate mortality and risk of intraoperative medical complications depending on delay to hip fracture surgery by using data from the Norwegian Hip Fracture Register (NHFR) and the Norwegian Patient Registry (NPR).

Patients and Methods

A total of 83 727 hip fractures were reported to the NHFR between 2008 and 2017. Pathological fractures, unspecified type of fractures or treatment, patients less than 50 years of age, unknown delay to surgery, and delays to surgery of greater than four days were excluded. We studied total delay (fracture to surgery, n = 38 754) and hospital delay (admission to surgery, n = 73 557). Cox regression analyses were performed to calculate relative risks (RRs) adjusted for sex, age, American Society of Anesthesiologists (ASA) classification, type of surgery, and type of fracture. Odds ratio (OR) was calculated for intraoperative medical complications. We compared delays of 12 hours or less, 13 to 24 hours, 25 to 36 hours, 37 to 48 hours, and more than 48 hours.

Results

Mortality remained unchanged when total delay was less than 48 hours. Total delay exceeding 48 hours was associated with increased three-day mortality (RR 1.69, 95% confidence interval (CI) 1.23 to 2.34; p = 0.001) and one-year mortality (RR 1.06, 95% CI 1.04 to 1.22; p = 0.003). More intraoperative medical complications were reported when hospital delay exceeded 24 hours.

Conclusion

Hospitals should operate on patients within 48 hours after fracture to reduce mortality and intraoperative complications.

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Patients with hip fractures are a frail group with a high perioperative mortality. In Norway, the 30-day mortality following a hip fracture is 8%.[1] However, the influence of the actual time to treating the hip fracture on both the short- and long-term mortality is not clear. Two retrospective studies have reported that both the in-hospital mortality and the 30-day mortality rise with increasing delay in treatment.[2,3] It has also been found that there is an increased mortality when there is more than 12 or 24 hours' delay in treatment.[4-6] A meta-analysis by Shiga et al[7] showed that a hospital delay of longer than 48 hours increased both 30-day and one-year mortality. On the other hand, several studies have suggested that there was no effect on mortality in hip fracture patients when there was a delay in hospital treatment.[8-12] This has led to controversy regarding the acceptable waiting time to surgery for patients with hip fractures.[13] This uncertainty is also reflected in the differing national guidelines for a specific time for surgery in these patients.[14] For example, in Norway there has been a national recommendation since 2014 that hip fractures should be operated on preferably within 24 hours, and certainly no later than 48 hours following admission to hospital.[15,16] However, these guidelines do not agree on whether the time to surgery should start from the time of the fracture or from the time of admission to hospital. In this study,

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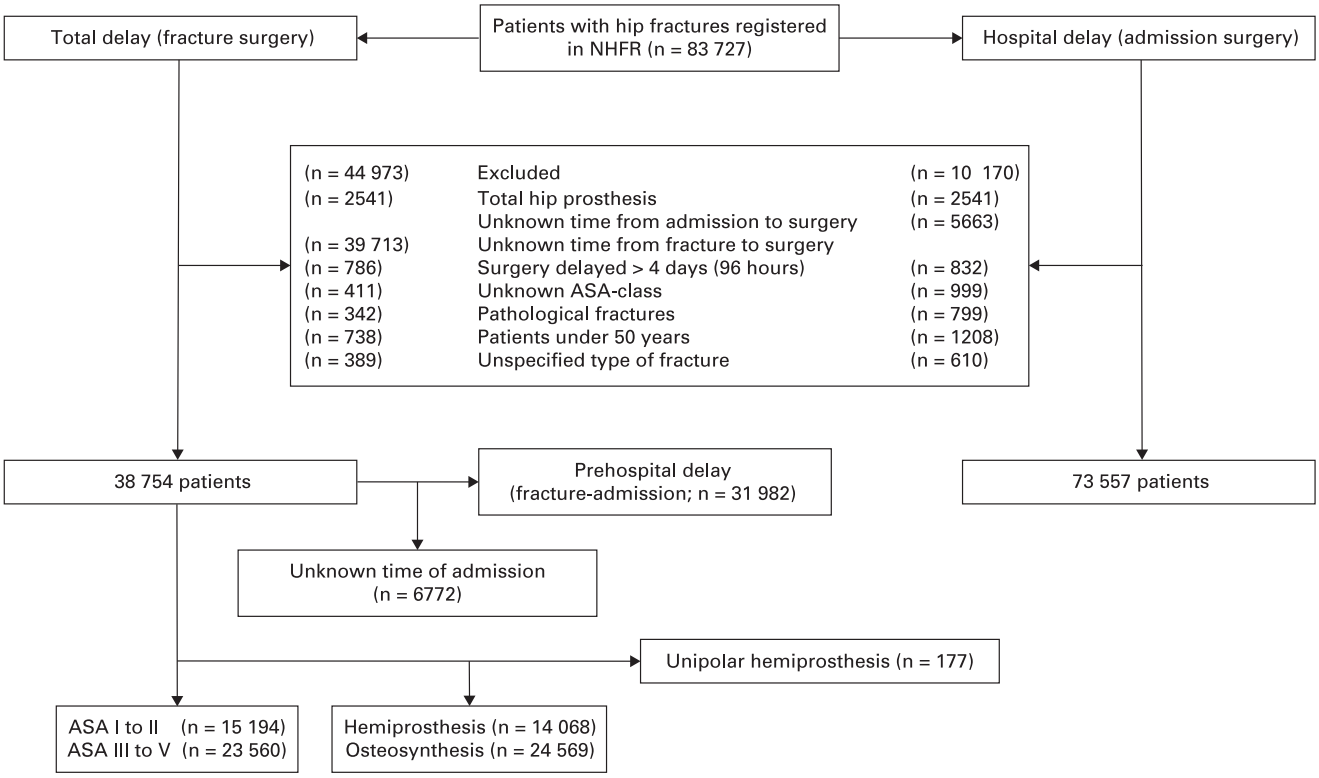

Fig. 1

Flowchart for patients included in the study.

we have used data from the Norwegian Hip Fracture Register (NHFR) and the Norwegian Patient Registry (NPR) to investigate whether the time from the moment of fracture to the start of surgery, rather than the time from the hospital admission to the start of surgery, influenced the mortality and risks of intraoperative complications.

Patients and Methods

In 2005, the NHFR started registration of primary operations and reoperations for all hip fractures.[17] After each operation, the surgeon fills in a one-page paper form, which includes information on age, sex, cognitive function, American Society of Anesthesiologists (ASA) classification, type of fracture, type of operation, and exact time of start of surgery. The time from fracture to surgery is reported in hours. Data on death and emigration were provided by the National Registry in Norway,[18] where the follow-up of deaths is nearly 100%.[19] The NHFR has approval from the Norwegian Data Inspectorate to process health data. The NPR constitutes the basis for management of all Norwegian hospitals by dealing with data that is primarily used for activity-based financing.[20] The NPR contains identifiable patient information from 2008 onwards and time of admission to hospital is recorded. Using the time of fracture and time of surgery registered in NHFR, and time of admission registered in NPR, prehospital delay (fracture to admission), hospital delay (admission to surgery), and total delay (fracture to surgery) were calculated in hours. Completeness of primary operations in the NHFR has been shown to be 95% for hemiprosthesis and 88% for osteosyntheses.[21]

Figure 1 shows the study population. From 2008 to 2017, 83 727 primary operations for hip fracture were reported to the NHFR. Total delay could not be calculated in 39 713 operations (47%) because no exact time of fracture was reported to the NHFR. Hospital delay could not be calculated in 5663 operations (6.8%) due to lack of reported time of admission in the NPR. We excluded pathological fractures, unspecified type of fractures, fractures with unspecified treatment, fractures in patients below 50 years of age, and fractures where the operation was delayed for more than four days, in order to secure a homogeneous patient group.

A total of 38 754 patients were included in the total delay analyses and 73 557 patients were included in the hospital delay analyses (Fig. 1). Patients were divided into groups depending on their time from fracture to surgery or time from admission to surgery: greater than or equal to 12 hours, 13 to 24 hours, 25 to 36 hours, 37 to 48 hours, and more than 48 hours.

We separately studied hip fractures operated with osteosynthesis (n = 24 569) and bipolar hemiprosthesis (n = 14 068). Further, subanalyses were performed for patients with ASA class I to II (n = 15 194) and ASA class III to V (n = 23 560).

Norwegian surgeons report both intraoperative surgical and medical complications to the NHFR. As the time to surgery may affect the risk of medical complications emerging during surgery, we reviewed the intraoperative medical complications, including cardiac, pulmonary, and circulatory adverse events, which had been reported by the surgeons.

Statistical analysis. Survival analyses were performed using the Kaplan–Meier and Cox regression methods. Patients who

Table I. Baseline data for patients with a known total delay in the Norwegian Hip Fracture Register (NHFR)

Variable	Total	Time from fracture to surgery					p-value
		≤ 12 hrs	13 to 24 hrs	25 to 36 hrs	37 to 48 hrs	> 48 hrs	
Total, n (%)	38 754 (*100*)	9613 (*25*)	14 277 (*37*)	8303 (*21*)	3583 (*9.2*)	2978 (*7.7*)	N/A
Female sex, n (%)	27 147 (*70*)	6889 (*72*)	10 186 (*72*)	5731 (*69*)	2395 (*67*)	1946 (*65*)	< 0.001*†
Mean age, yrs (SD)	81.5 (9.8)	81.0 (10)	81.6 (9.9)	81.7 (9.4)	81.8 (9.2)	81.2 (9.3)	< 0.001*‡
ASA class, n (%)							< 0.001*†
I	1730 (*4.5*)	703 (*7.3*)	570 (*4.0*)	276 (*3.3*)	106 (*3.0*)	75 (*2.5*)	
II	13 464 (*35*)	3780 (*39*)	5113 (*36*)	2713 (*33*)	1070 (*30*)	788 (*27*)	
III	21 070 (*55*)	4697 (*49*)	7788 (*55*)	4761 (*57*)	2075 (*58*)	1749 (*59*)	
IV	2449 (*6.3*)	428 (*4.5*)	789 (*5.5*)	548 (*6.6*)	324 (*9.0*)	360 (*12.1*)	
V	41 (*0.1*)	5 (*0.1*)	17 (*0.1*)	5 (*0.1*)	8 (*0.2*)	6 (*0.2*)	
Fracture type, n (%)							< 0.001*†
Undisplaced FNF	5253 (*14*)	1341 (*14*)	1818 (*13*)	1150 (*14*)	478 (*13*)	466 (*16*)	
Displaced FNF	15 811 (*41*)	3239 (*34*)	5838 (*41*)	3613 (*44*)	1693 (*47*)	1428 (*48*)	
Basocervical fracture	1298 (*3.3*)	362 (*3.8*)	496 (*3.5*)	245 (*3.0*)	115 (*3.2*)	80 (*2.7*)	
Trochanteric A1§	6663 (*17*)	1876 (*20*)	2444 (*17*)	1367 (*17*)	524 (*15*)	452 (*15*)	
Trochanteric A2§	6650 (*17*)	1819 (*19*)	2505 (*18*)	1357 (*16*)	575 (*16*)	394 (*13*)	
Trochanteric A3§	872 (*2.3*)	243 (*2.5*)	323 (*2.3*)	194 (*2.3*)	58 (*1.6*)	54 (*1.8*)	
Subtrochanteric	2207 (*5.7*)	733 (*7.6*)	853 (*6.0*)	377 (*4.5*)	140 (*3.9*	104 (*3.5*)	
Primary operation, n (%)							< 0.001*†
Screw osteosynthesis	6682 (*17*)	1818 (*19*)	2334 (*16*)	1418 (*17*)	580 (*16*)	532 (*18*)	
Hemiarthroplasty	14 185 (*37*)	2733 (*28*)	5255 (*37*)	3303 (*40*)	1556 (*43*)	1338 (*45*)	
Sliding hip screw	12 131 (*31*)	3337 (*35*)	4495 (*32*)	2498 (*30*)	1013 (*28*)	788 (*27*)	
Short IM nail	3747 (*9.7*)	1128 (*12*)	1402 (*9.8*)	706 (*8.5*)	288 (*8.0*)	223 (*7.5*)	
Long IM nail	2009 (*5.2*)	597 (*6.2*)	791 (*5.5*)	378 (*4.6*)	146 (*4.1*)	97 (*3.3*)	

*Statistically significant
†Chi-squared test
‡One-way analysis of variance (ANOVA)
§AO/OTA classification
N/A, not applicable; ASA, American Society of Anesthesiologists; FNF, femoral neck fracture; IM, intramedullary nail

died or emigrated during follow-up were identified from files provided by Statistics Norway, and the follow-up time for these patients was cut off at the date of death or emigration. Only the first postoperative year was included in the analyses, as this period was considered most relevant for studying consequences of time to surgery. Pearson's chi-squared test was used to compare categorical variables in the independent groups. Student's *t*-test was used to compare continuous variables.

The Cox multiple regression model was used to compare the relative risks (RRs) of postoperative death among patients divided into groups based on preoperative wait time. We adjusted for possible influences of sex, age of the patient at surgery, ASA classification, type of surgery, and type of fracture. Mortality was studied within three days, 30 days, and one year postoperatively. In addition, 95% confidence intervals (CIs) were calculated for RRs. When analyzing intraoperative medical complications, we used odds ratio (OR) to express the risks. Patients operated on within 13 to 24 hours of admission or within 13 to 24 hours after fracture defined the reference groups as this was the largest group and within the national guidelines for hip fracture surgery.[16] p-values < 0.05 were considered statistically significant.

Assessments of proportionality in the Cox models were performed using log-minus-log plots of the adjusted survival curves and the proportionality assumptions were fulfilled. The statistical software packages R (version 3.4.0; http://www.R-project.org) and IBM SPSS Statistics (version 24.0; IBM Corp., Armonk, New York) for Windows were used for the statistical analyses.

Results

Total delay. Table I presents the study population with known total delay (n = 38 754). A significantly higher percentage of men and patients with ASA class IV was operated on more than 48 hours after fracture. A lower proportion of hemiprosthesis were inserted within 24 hours of admission. For patients with a known time of fracture (n = 38 754), the mean total delay was 24 hours. For patients with a known time for both fracture and admission (n = 31 982), the mean prehospital delay was 6.2 hours. Figure 2a demonstrates the distribution of total delay while Figure 2b demonstrates the distribution of prehospital delay.

Mortality. When analyzing all hip fractures with exact time of fracture, a total delay of less than 48 hours did not change either short or long-term mortality. Patients, though waiting more than 48 hours from fracture to surgery, had an increased three-day and one-year mortality, while 30-day mortality did not increase (Table II).

This effect was most pronounced in the first three days (RR 1.69, 95% CI 1.23 to 2.34; p = 0.001), but persisted even one year after surgery (RR 1.06, 95% CI 1.04 to 1.22; p = 0.003; Table II). When patients were stratified depending on comorbidity (ASA I to II or ASA III to V), a total delay greater than 48 hours was associated with an increased three-day mortality for

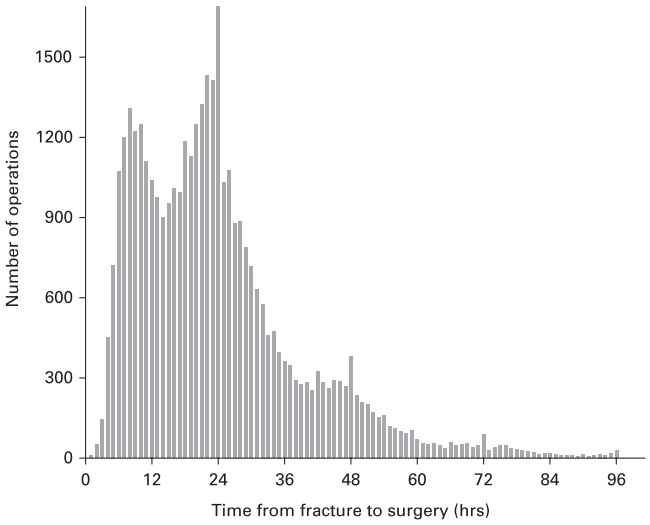

Fig. 2a

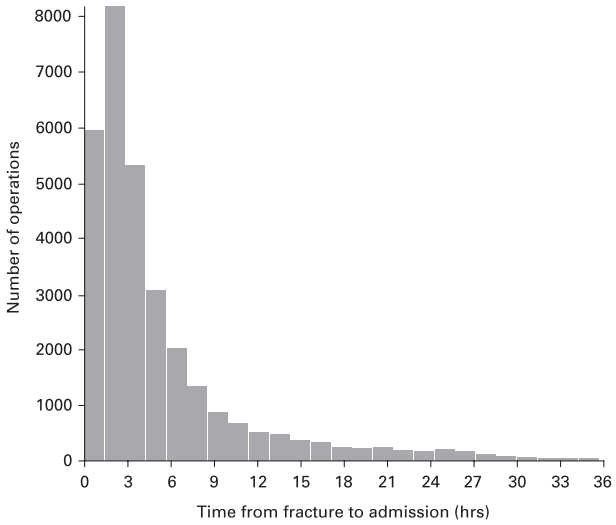

Fig. 2b

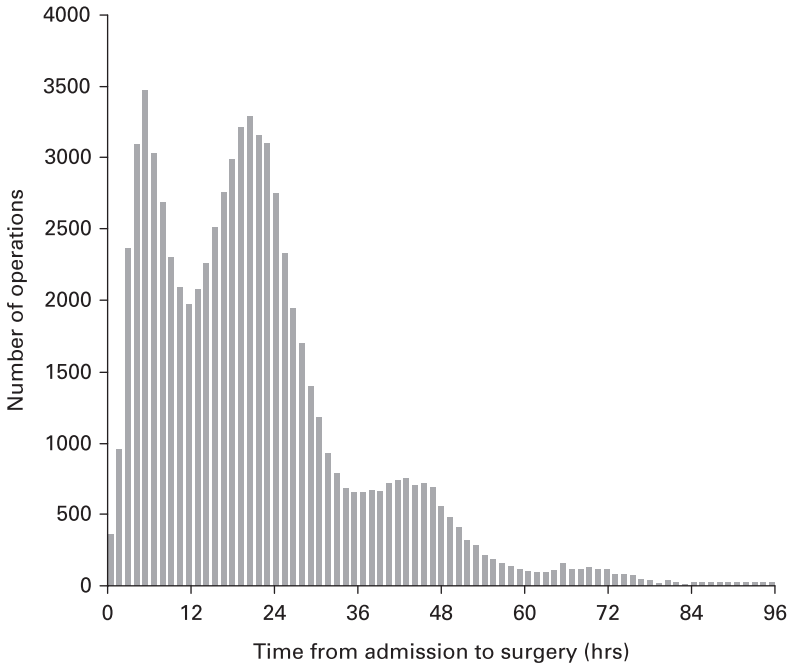

Fig. 2c

a) Time from fracture to surgery (total delay) in the study population (n = 38 754; median 22.0 hours (interquartile range (IQR) 13.0 to 30.0); mean 24.1 hours (SD 15.4)). b) Time from fracture to admission (prehospital delay) in the study population (n = 31 982; median 3.4 hours (IQR 1.76 to 6.62); mean 6.2 hours (SD 8.9)). c) Time from admission to surgery (hospital delay) in the study population (n = 73 557; median 19.4 hours (IQR 10.0 to 27.7); mean 21.7 hours (SD 15.2)).

patients with serious comorbidity but did not significantly affect mortality for the healthier patients (Table III). An increased one-year mortality was observed for both ASA I to II patients and III to V patients when total delay exceeded 48 hours. Furthermore, a reduction in 30-day mortality was observed for ASA I to II patients with a short total delay (less than 12 hours), while no such effect could be found for ASA III to V patients.

Also, for hip fracture patients operated on using a hemiprosthesis, an increased three-day and one-year mortality was observed when hospital delay exceeded 48 hours, while 30-day mortality remained unchanged (Table IV). Hemiprostheses inserted within 12 hours after the fracture were also associated with an increased three-day mortality. Hospital delay did not affect mortality at any time for patients treated with osteosynthesis (Table IV).

Hospital delay. The distribution of hospital delay (hours from admission to surgery) is shown in Figure 2c. The mean time from admission to surgery was 22 hours. As when studying total delay, an increased mortality was observed when hospital delay exceeded 48 hours (6% of the patients). This effect was most

Table II. Mortality at three days, 30 days, and one year postoperatively after hip fracture surgery for patients with known time from fracture to surgery (total delay; n = 38 754). Cox relative revision risk (RR; with total delay of 13 to 24 hours as reference) is given with adjustments for possible influences of sex, American Society of Anesthesiologists (ASA) class, age of the patient at surgery, type of surgery, and type of fracture

Mortality	Total, n	Deaths, n (%)	RR (95% CI)	p-value*
3-day				
≤ 12 hrs	9613	89 (*0.9*)	1.29 (0.98 to 1.69)	0.07
13 to 24 hrs	14 277	120 (*0.8*)	1 (reference)	N/A
25 to 36 hrs	8303	92 (*1.1*)	1.24 (0.95 to 1.63)	0.12
37 to 48 hrs	3583	39 (*1.1*)	1.08 (0.75 to 1.55)	0.68
> 48 hrs	2978	54 (*1.8*)	1.69 (1.23 to 2.34)	0.001†
All	38 754	394 (*1.0*)	N/A	N/A
30-day				
≤ 12 hrs	9613	610 (*6.3*)	1.01 (0.92 to 1.12)	0.81
13 to 24 hrs	14 277	998 (*7.0*)	1 (reference)	N/A
25 to 36 hrs	8303	635 (*7.6*)	1.03 (0.94 to 1.14)	0.53
37 to 48 hrs	3583	270 (*7.5*)	0.93 (0.82 to 1.07)	0.31
> 48 hrs	2978	274 (*9.2*)	1.10 (0.96 to 1.26)	0.15
All	38 754	2787 (*7.2*)	N/A	N/A
1-yr				
≤ 12 hrs	9613	1960 (*20.4*)	1.01 (0.96 to 1.07)	0.64
13 to 24 hrs	14 277	3114 (*21.8*)	1 (reference)	N/A
25 to 36 hrs	8303	1941 (*23.4*)	1.03 (0.97 to 1.09)	0.33
37 to 48 hrs	3583	870 (*24.3*)	1.13 (0.95 to 1.10)	0.56
> 48 hrs	2978	796 (*26.7*)	1.06 (1.04 to 1.22)	0.003†
All	38 754	8681 (*22.4*)	N/A	N/A

*Cox regression model
†Statistically significant
CI, confidence interval; N/A, not applicable

pronounced in the first three days (RR 1.31, 95% CI 1.02 to 1.68; p = 0.03), but persisted even at 30 days (RR 1.15, 95% CI 1.04 to 1.28; p = 0.006) and one year after surgery (RR 1.12, 95% CI 1.05 to 1.18; p < 0.001).

Intraoperative medical complications. A total of 304 medical intraoperative complications were reported to the NHFR (11.2% of all reported complications and 0.4% of all operations; Table V). Hospital delay longer than 24 hours was associated with more medical complications than hospital delay within 13 to 24 hours (Table VI). Patients operated on later than 48 hours after admission had an increased risk of medical complications both during surgery with osteosynthesis and hemiprosthesis.

Discussion

In this nationwide observational study of treatment of hip fractures, the mean prehospital delay was six hours and the mean hospital delay was 22 hours. There was no effect from total delay to surgery when the operation occurred within 48 hours, but mortality increased when total delay and hospital delay exceeded 48 hours. The association between mortality and total delay was most pronounced after three days and persisted throughout the first postoperative year. Patients with severe comorbidity (ASA III to V) and patients operated on with hemiprosthesis seem to be at higher risk if surgery is delayed. More intraoperative complications were reported for patients waiting longer than 24 hours from admission to surgery, thereby supporting the proposal for even earlier surgical intervention (Fig. 3).

Table III. Mortality at three days, 30 days, and one year postoperatively after hip fracture surgery (n = 38 754), hip fracture patients with American Society of Anesthesiologists (ASA) classes I to II (n = 15 194) and ASA classes III to V (n = 23 560) for patients with known hospital delay. Cox relative revision risk (RR; with total delay of 13 to 24 hours as reference) is given with adjustments for possible influences of sex, ASA class, age of the patient at surgery, type of surgery, and type of fracture

Mortality	Total, n	Deaths, n (%)	RR (95% CI)	p-value*
3-day				
ASA I to II				
≤ 12 hrs	4483	10 (*0.2*)	0.77 (0.35 to 1.67)	0.50
13 to 24 hrs	5683	18 (*0.3*)	1 (reference)	N/A
25 to 36 hrs	2989	8 (*0.3*)	0.87 (0.38 to 2.01)	0.75
37 to 48 hrs	1176	1 (*0.1*)	0.27 (0.04 to 2.01)	0.20
> 48 hrs	863	6 (*0.7*)	2.37 (0.93 to 6.02)	0.07
All	15 194	43 (*0.3*)	N/A	N/A
ASA III to V				
≤ 12 hrs	5130	79 (*1.5*)	1.39 (1.03 to 1.87)	0.03†
13 to 24 hrs	8594	102 (*1.2*)	1 (reference)	N/A
25 to 36 hrs	5314	84 (*1.6*)	1.30 (0.98 to 1.74)	0.07
37 to 48 hrs	2407	38 (*1.6*)	1.18 (0.81 to 1.72)	0.38
> 48 hrs	2115	48 (*2.3*)	1.66 (1.18 to 2.35)	0.004†
All	23 560	351 (*1.5*)	N/A	N/A
30-day				
ASA I to II				
≤ 12 hrs	4483	83 (*1.9*)	0.74 (0.57 to 0.97)	0.03†
13 to 24 hrs	5683	149 (*2.6*)	1 (reference)	N/A
25 to 36 hrs	2989	69 (*2.3*)	0.91 (0.68 to 1.21)	0.50
37 to 48 hrs	1176	27 (*2.3*)	0.89 (0.59 to 1.34)	0.57
> 48 hrs	863	27 (*3.1*)	1.28 (0.85 to 1.93)	0.25
All	15 194	355 (*2.3*)	N/A	N/A
ASA III to V				
≤ 12 hrs	5130	527 (*10.3*)	1.07 (0.96 to 1.19)	0.23
13 to 24 hrs	8594	849 (*9.9*)	1 (reference)	N/A
25 to 36 hrs	5314	566 (*10.7*)	1.06 (0.95 to 1.18)	0.31
37 to 48 hrs	2407	243 (*10.1*)	0.94 (0.82 to 1.08)	0.42
> 48 hrs	2115	247 (*11.7*)	1.09 (0.95 to 1.26)	0.23
All	23 560	2432 (*10.3*)	N/A	N/A
1-yr				
ASA I to II				
≤ 12 hrs	4483	427 (*9.5*)	0.93 (0.82 to 1.05)	0.23
13 to 24 hrs	5683	618 (*10.9*)	1 (reference)	N/A
25 to 36 hrs	2989	304 (*10.2*)	0.94 (0.82 to 1.08)	0.40
37 to 48 hrs	1176	136 (*11.6*)	1.09 (0.90 to 1.31)	0.38
> 48 hrs	863	108 (*12.5*)	1.25 (1.02 to 1.53)	0.04†
All	15 194	1593 (*10.5*)	N/A	N/A
ASA III to V				
≤ 12 hrs	5130	1533 (*29.9*)	1.04 (0.98 to 1.11)	0.21
13 to 24 hrs	8594	2496 (*29.0*)	1 (reference)	N/A
25 to 36 hrs	5314	1.637 (*30.8*)	1.05 (0.99 to 1.12)	0.13
37 to 48 hrs	2407	734 (*30.5*)	1.01 (0.93 to 1.10)	0.76
> 48 hrs	2115	688 (*32.5*)	1.11 (1.02 to 1.21)	0.02†
All	23 560	7088 (*30.1*)	N/A	N/A

*Cox regression model
†Statistically significant
CI, confidence interval; N/A, not applicable

Most current research on waiting time to hip fracture surgery investigates hospital delay (i.e. the time from admission to hospital to the time to surgery).[4-6,8,12] Nevertheless, to optimize

Table IV. Mortality at three days, 30 days, and one year postoperatively after hip fracture surgery operated with hemiprosthesis (n = 14 068) and osteosynthesis (n = 24 569). Cox relative revision risk (RR; with total delay of 13 to 24 hours as reference) is given with adjustments for possible influences of sex, American Society of Anesthesiologists (ASA) class, age of the patient at surgery, type of surgery, and type of fracture

Mortality	Total, n	Deaths, n (%)	RR (95% CI)	p-value*
3-day				
Osteosynthesis				
≤ 12 hrs	6880	49 (*0.7*)	1.08 (0.75 to 1.56)	0.69
13 to 24 hrs	9022	69 (*0.8*)	1 (reference)	N/A
25 to 36 hrs	5000	44 (*0.9*)	1.12 (0.77 to 1.64)	0.56
37 to 48 hrs	2027	20 (*1.0*)	1.05 (0.64 to 1.74)	0.84
> 48 hrs	1640	21 (*1.3*)	1.28 (0.78 to 2.11)	0.32
All	24 569	203 (*0.8*)	N/A	N/A
Hemiprosthesis				
≤ 12 hrs	2718	40 (*1.5*)	1.71 (1.12 to 2.61)	0.01†
13 to 24 hrs	5207	48 (*0.9*)	1 (reference)	N/A
25 to 36 hrs	3268	47 (*1.4*)	1.45 (0.97 to 2.17)	0.07
37 to 48 hrs	1546	19 (*1.2*)	1.18 (0.69 to 2.01)	0.54
> 48 hrs	1329	33 (*2.5*)	2.21 (1.41 to 4.37)	0.001†
All	14 068	187 (*1.3*)	N/A	N/A
30-day				
Osteosynthesis				
≤ 12 hrs	6880	399 (*5.8*)	0.95 (0.83 to 1.07)	0.38
13 to 24 hrs	9022	619 (*6.9*)	1 (reference)	N/A
25 to 36 hrs	5000	370 (*7.4*)	1.04 (0.91 to 1.18)	0.57
37 to 48 hrs	2027	154 (*7.6*)	0.94 (0.79 to 1.13)	0.52
> 48 hrs	1640	143 (*8.7*)	1.04 (0.87 to 1.25)	0.67
All	24 569	1685 (*6.9*)	N/A	N/A
Hemiprosthesis				
≤ 12 hrs	2718	210 (*7.7*)	1.15 (0.97 to 1.36)	0.11
13 to 24 hrs	5207	375 (*7.2*)	1 (reference)	N/A
25 to 36 hrs	3268	258 (*7.9*)	1.01 (0.86 to 1.19)	0.89
37 to 48 hrs	1546	115 (*7.4*)	0.92 (0.75 to 1.14)	0.46
> 48 hrs	1329	131 (*9.9*)	1.19 (0.97 to 1.45)	0.09
All	14 068	1089 (*7.7*)	N/A	N/A
1-yr				
Osteosynthesis				
≤ 12 hrs	6880	1356 (*19.7*)	0.98 (0.91 to 1.05)	0.55
13 to 24 hrs	9022	1987 (*22.0*)	1 (reference)	N/A
25 to 36 hrs	5000	1199 (*24.0*)	1.06 (0.98 to 1.14)	0.13
37 to 48 hrs	2027	530 (*26.1*)	1.08 (0.98 to 1.19)	0.11
> 48 hrs	1640	442 (*27.0*)	1.11 (1.00 to 1.23)	0.06
All	24 569	5514 (*22.4*)	N/A	N/A
Hemiprosthesis				
≤ 12 hrs	2718	600 (*22.1*)	1.10 (1.00 to 1.22)	0.06
13 to 24 hrs	5207	1117 (*21.5*)	1 (reference)	N/A
25 to 36 hrs	3268	732 (*22.4*)	0.98 (0.89 to 1.07)	0.65
37 to 48 hrs	1546	339 (*21.9*)	0.94 (0.83 to 1.06)	0.34
> 48 hrs	1329	351 (*26.4*)	1.15 (1.02 to 1.29)	0.03†
All	14 068	3139 (*22.3*)	N/A	N/A

*Cox regression model
†Statistically significant
CI, confidence interval; N/A, not applicable

Table V. Reported intraoperative medical complications to the Norwegian Hip Fracture Register (NHFR)

Complication	Patients, n (%)
Hypotension	94 (*30.9*)
Arrhythmias	46 (*15.1*)
Cardiac arrest	46 (*15.1*)
Myocardial infarction	36 (*11.8*)
Respiratory failure	34 (*11.2*)
Angina	18 (*5.9*)
Heart failure	10 (*3.3*)
Haematemesis	7 (*2.3*)
Stroke	7 (*2.3*)
Suspected infection	4 (*1.3*)
Circulatory collapse	2 (*0.7*)
All	304 (*100*)

treatment it is important to assess the total timespan from the initial trauma to surgery. Norwegian surgeons report to the NHFR time from fracture to surgery, providing unique information on prehospital delay. The patients included in this study spent a mean of six hours of their total delay outside of hospital care. From a medical point of view, this prehospital delay is important, since these patients have less surveillance and prophylaxis against possible complications. However, we could not find any differences in mortality provided these patients were operated on within 48 hours of the fracture. Comorbidity, cognitive state, and quality of home care may cause a bias, especially when patients are able to state their exact time of fracture. We also investigated hospital delay where a larger number of fractures could be included without the same risk of recall and selection bias as the time of admission is administratively reported.

Over the last decades, large amounts of healthcare resources have been applied to promote earlier surgical intervention for hip fracture patients,[22] and numerous fast-track algorithms have been implemented.[22,23] In 2013 in Norway, the mean public health cost for treating patients in the first year following a hip fracture was calculated to be £61 287 (662 547 NOK).[24] Such an economic cost drives the promotion of early hip fracture surgery, as early interventions have been shown to have shorter length of hospital stays.[4,25,26] Some studies also report fewer complications related to immobilization when the time to surgery is reduced; for example, there are less bedsores and infections.[8,27-29] However, it has been shown that there are inconsistencies regarding the effects of hospital delay on mortality, and guidelines worldwide have not agreed on an acceptable time to surgery for these patients. For example, Canadian and American guidelines advise hip fracture surgery within 48 hours,[30,31] while the National Institute for Health and Care Excellence (NICE) guidelines in the United Kingdom advise surgery on the day of, or the day after, admission.[32] Our study, which investigated total delay and hospital delay, supports hip fracture surgery taking place within 48 hours of the fracture, in order to reduce both the mortality and the risk of intraoperative complications, as has been advised by the national quality of care indicator in Norway.[15,16]

Earlier studies have reported higher comorbidity among patients with a long hospital delay compared with patients with early surgical intervention,[33] which was also observed in our study. The question is, therefore, whether surgery was delayed because of patients' increased risk of unwanted outcomes or if unwanted outcomes occurred due to delayed surgical interventions. During the time from admission to surgery, it is crucial

Table VI. Risk of medical complications during hip fracture surgery for patients with a known hospital delay (n = 73 557) for patients with American Society of Anesthesiologists (ASA) I to II (n = 27 435), ASA III to V (n = 46 122), osteosynthesis (n = 45 281), and hemiprosthesis (n = 28 076). Odds ratios (ORs; with hospital delay of 13 to 24 hours as reference) are given with 95% confidence intervals (CIs)

Medical complications	Total, n	Complications, n (%)	OR (95% CI)
All patients			
≤ 12 hrs	21 672	72 (*0.3*)	1.06 (0.77 to 1.45)
13 to 24 hrs	26 819	84 (*0.3*)	1 (reference)
25 to 36 hrs	13 675	65 (*0.5*)	1.52 (1.10 to 2.10)
37 to 48 hrs	6737	38 (*0.6*)	1.81 (1.23 to 2.65)
> 48 hrs	4654	45 (*1.0*)	3.11 (2.16 to 4.47)
All	73 557	304 (*0.4*)	N/A
ASA I to II			
≤ 12 hrs	9322	7 (*0.1*)	0.55 (0.22 to 1.36)
13 to 24 hrs	10 256	14 (*0.1*)	1 (reference)
25 to 36 hrs	4553	7 (*0.2*)	1.13 (0.45 to 2.79)
37 to 48 hrs	2055	9 (*0.4*)	3.22 (1.39 to 7.45)
> 48 hrs	1249	3 (*0.2*)	1.76 (0.51 to 6.14)
All	27 435	40 (*0.1*)	N/A
ASA III to V			
≤ 12 hrs	12 350	65 (*0.5*)	1.25 (0.89 to 1.75)
13 to 24 hrs	16 563	70 (*0.4*)	1 (reference)
25 to 36 hrs	9122	58 (*0.6*)	1.51 (1.06 to 2.14)
37 to 48 hrs	4682	29 (*0.6*)	1.47 (0.95 to 2.27)
> 48 hrs	3405	42 (*1.2*)	2.94 (2.00 to 4.32)
All	46 122	264 (*0.6*)	N/A
Hemiprosthesis			
≤ 12 hrs	6508	32 (*0.5*)	1.13 (0.72 to 1.77)
13 to 24 hrs	10 533	46 (*0.4*)	1 (reference)
25 to 36 hrs	5645	39 (*0.7*)	1.59 (1.03 to 2.43)
37 to 48 hrs	3248	23 (*0.7*)	1.63 (0.98 to 2.69)
> 48 hrs	2142	26 (*1.2*)	2.80 (1.73 to 4.54)
All	28 076	166 (*0.6*)	N/A
Osteosynthesis			
≤ 12 hrs	15 114	40 (*0.3*)	1.13 (0.72 to 1.76)
13 to 24 hrs	16 201	38 (*0.2*)	1 (reference)
25 to 36 hrs	7986	26 (*0.3*)	1.39 (0.84 to 2.29)
37 to 48 hrs	3474	15 (*0.4*)	1.85 (1.01 to 3.36)
> 48 hrs	2506	19 (*0.8*)	3.25 (1.87 to 5.65)
All	45 281	138 (*0.3*)	N/A

N/A, not applicable

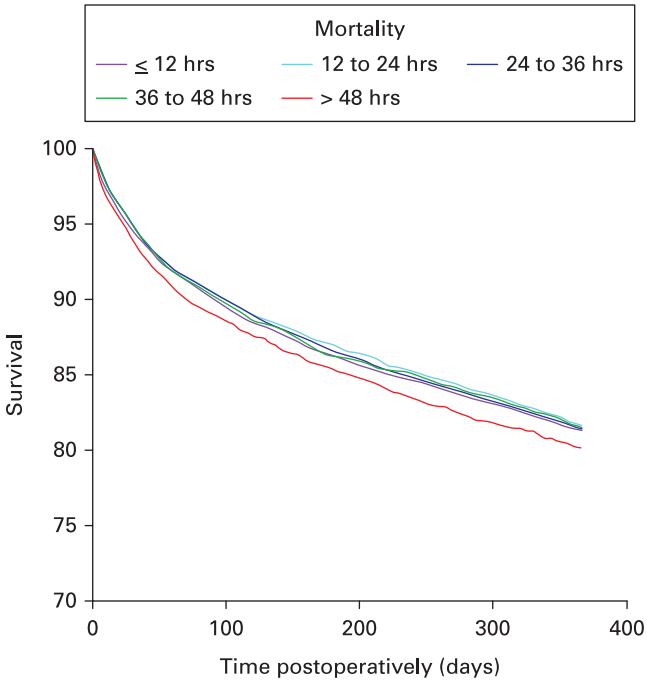

Fig. 3

Cox-adjusted survival curves for patients with a known total delay (n = 38 754) the first year after hip fracture surgery. Adjusted for sex, American Society of Anesthesiologists (ASA) class, age of the patient at surgery, type of surgery, and type of fracture.

to optimize the patient's medical conditions and potentially reduce perioperative complications.[26,34] Griffiths et al[34] stated that there are few acceptable reasons but many unacceptable reasons for delaying surgery. These reasons include electrolyte disturbances, awaiting echocardiography, and lack of facilities, theatre space, or surgical competence. In our study, delayed surgery increased three-day mortality for hip fracture patients with ASA III to V, but not for the healthier patients (ASA I to II). Noticeably, the three-day RR of death was actually higher for ASA I to II patients than for ASA III to V patients when delay exceeded 48 hours, but the difference did not reach statistical significance, probably due to the low number of patients in the healthy patient group. More intraoperative medical complications were reported both for ASA I to II and ASA III to V patients with a long total delay. Therefore, preoperative patient stabilization should not be used as an argument to delay surgical intervention.

In hip fracture patients, a hospital delay exceeding 24 hours has been shown to have an increased risk of postoperative respiratory complications and prolonged length of hospital stay.[35] In our study, intraoperative medical complications also seem to be associated with increasing hospital delay for more than 24 hours. Investigating outcomes for osteosyntheses and hemiprostheses separately, more patients treated with a hemiprosthesis waited longer than 24 hours for surgery than patients treated with osteosynthesis. The difference in hospital delay may partly explain why more intraoperative medical complications were reported after hemiprosthesis (0.6%) than osteosynthesis (0.3%). However, larger surgical trauma and the risk of bone cement implantation may also explain the higher number of medical complications following cemented hemiprosthesis.[36,37]

Our study has both strengths and limitations. It is not a randomized controlled trial (RCT) but may be categorized as a hypothesis-creating study. The study design allowed us to report associations between surgical delay and the effect on patient outcomes, yet causality cannot be proven. However, RCTs investigating early *versus* delayed surgery for hip fracture patients would not be ethically feasible, as it would be hard to defend trials where certain hip fracture patients are deliberately delayed for surgery.[4-6] Moreover, since patients who undergo hip fracture surgery are often old and frail, there would be a risk that only the healthiest patients would volunteer for a randomized study and their mortality rates would not be comparable to the typical population. Because this study reflects a broad

sample of practice across an entire country, with high completeness of registration of deaths,[19] we believe that it has high external validity and that the results should be generally applicable to other countries.

Our study is based on consistent voluntary reporting from orthopaedic surgeons in all hospitals treating hip fractures in Norway. However, the time of fracture could be reported inaccurately and thus weakening our results. Time of admission is reported to the NPR in the interest of activity-based financing and may therefore be a more dependable source of information when studying timelines in preoperative delay. However, we chose to study hospital delay in addition to total delay to strengthen our results, but intraoperative occurrences demand subjective interpretations by the surgeon. After each operation, the surgeon needs to decide whether complications had occurred, potentially causing under-reporting or over-reporting of events. Therefore, reported intraoperative complications should be interpreted with caution. This study reviewed a large number of patients by combining data from two national registries, so that we were able to observe data and outcomes that are hard to collect in other study designs.

In conclusion, both total delay and hospital delay exceeding 48 hours was associated with increased short and long-term mortality for patients with a hip fracture. Based on the findings of our study, we recommend that all hospitals should strive to operate on hip fractures within 48 hours, in line with several national recommendations. In particular, we recommend that patients with long prehospital delay must be given high priority for surgery in order to avoid a total delay exceeding 48 hours. Also, because our study has shown that there is a higher risk of medical intraoperative complications with more than 24 hours' hospital delay, we fully support the practice of early surgical intervention in the treatment of patients with hip fractures.

Take home message

- Both total delay and hospital delay exceeding 48 hours increased short- and long-term mortality for hip fracture patients. All hospitals should strive to operate on hip fractures within 48 hours, in line with several national guidelines.
- We support hip fracture surgery within 24 hours, as more medical intraoperative complications were reported when hospital delay exceeded 24 hours.

References

1. **Leer-Salvesen S, Dybvik E, Engesæter LB, Dahl OE, Gjertsen JE.** Low-molecular-weight heparin for hip fracture patients treated with osteosynthesis: should thromboprophylaxis start before or after surgery? An observational study of 45,913 hip fractures reported to the Norwegian Hip Fracture Register. *Acta Orthop* 2018;89:615–621.
2. **Daugaard CL, Jørgensen HL, Riis T, et al.** Is mortality after hip fracture associated with surgical delay or admission during weekends and public holidays? A retrospective study of 38,020 patients. *Acta Orthop* 2012;83:609–613.
3. **Nyholm AM, Gromov K, Palm H, et al.** Time to surgery is associated with thirty-day and ninety-day mortality after proximal femoral fracture: a retrospective observational study on prospectively collected data from the danish fracture database collaborators. *J Bone Joint Surg [Am]* 2015;97-A:1333–1339.
4. **Bredahl C, Nyholm B, Hindsholm KB, Mortensen JS, Olesen AS.** Mortality after hip fracture: results of operation within 12 h of admission. *Injury* 1992;23:83–86.
5. **Bretherton CP, Parker MJ.** Early surgery for patients with a fracture of the hip decreases 30-day mortality. *Bone Joint J* 2015;97-B:104–108.
6. **Pincus D, Ravi B, Wasserstein D, et al.** Association between wait time and 30-day mortality in adults undergoing hip fracture surgery. *JAMA* 2017;318:1994–2003.
7. **Shiga T, Wajima Z, Ohe Y.** Is operative delay associated with increased mortality of hip fracture patients? Systematic review, meta-analysis, and meta-regression. *Can J Anesth* 2008;55:146–154.
8. **Grimes JP, Gregory PM, Noveck H, Butler MS, Carson JL.** The effects of time-to-surgery on mortality and morbidity in patients following hip fracture. *Am J Med* 2002;112:702–709.
9. **Parker MJ, Pryor GA.** The timing of surgery for proximal femoral fractures. *J Bone Joint Surg [Br]* 1992;74-B:203–205.
10. **Moran CG, Wenn RT, Sikand M, Taylor AM.** Early mortality after hip fracture: is delay before surgery important? *J Bone Joint Surg [Am]* 2005;87-A:483–489.
11. **Holt G, Smith R, Duncan K, McKeown DW.** Does delay to theatre for medical reasons affect the peri-operative mortality in patients with a fracture of the hip? *J Bone Joint Surg [Br]* 2010;92-B:835–841.
12. **Rae HC, Harris IA, McEvoy L, Todorova T.** Delay to surgery and mortality after hip fracture. *ANZ J Surg* 2007;77:889–891.
13. **Simunovic N, Devereaux PJ, Bhandari M.** Surgery for hip fractures: does surgical delay affect outcomes? *Indian J Orthop* 2011;45:27–32.
14. **Lewis PM, Waddell JP.** When is the ideal time to operate on a patient with a fracture of the hip? A review of the literature. *Bone Joint J* 2016;98-B:1573–1581.
15. **Lindahl AK, Talsnes O, Figved W, et al.** Measures for increased survival after hip fractures. Publication from The National Knowledge Center for the Health Service. 2014. https://www.fhi.no/globalassets/dokumenterfiler/notater/2014/tiltak-for-okt-overlevelse-etter-hoftebrudd2 (date last accessed 16 July 2019).
16. **No authors listed.** Norwegian Directorate of Health (Helsedirektoratet). Preoperative wait time for hip fracture patients, National Quality Indicator System: Quality indicator description. 2015. https://www.helsedirektoratet.no/statistikk/statistikk/kvalitetsindikatorer/behandling-av-sykdom-og-overlevelse/hoftebrudd-operert-innen-henholdsvis-24-timer-og-48-timer (date last accessed 16 July 2019)
17. **Gjertsen JE, Engesaeter LB, Furnes O, et al.** The Norwegian Hip Fracture Register: experiences after the first 2 years and 15,576 reported operations. Acta Orthop 2008;79:583–593.
18. **No authors listed.** The Norwegian Tax Administration. Registering a death. https://www.skatteetaten.no/en/person/national-registry/registering-a-death/ (date last accessed 6 June 2019).
19. **Pedersen AG, Ellingsen CL.** Data quality in the Causes of Death Registry. *Tidsskr Nor Laegeforen* 2015;135:768–770.
20. **No authors listed.** Norwegian Directorate of Health. Norwegian Patient Register (NPR). 2019. https://www.helsedirektoratet.no/tema/statistikk-registre-og-rapporter/helsedata-og-helseregistre/norsk-pasientregister-npr (date last accessed 16 July 2019).
21. **No authors listed.** Norwegian National Advisory Unit on Arthroplasty and Hip Fractures. Norwegian Arthroplasty Register, Norwegian Cruciate Ligament Register, Norwegian Hip and Fracture Register, Norwegian Paediatric Hip Register: report, June 2018. http://nrlweb.ihelse.net/eng/Rapporter/Report2018_english.pdf (page 234) (date last accessed 6 June 2019).
22. **Larsson G, Holgers KM.** Fast-track care for patients with suspected hip fracture. *Injury* 2011;42:1257–1261.
23. **Hip Fracture Accelerated Surgical Treatment and Care Track (HIP ATTACK) Investigators.** Accelerated care versus standard care among patients with hip fracture: the HIP ATTACK pilot trial. *CMAJ* 2014;186:E52-E60.
24. **Hektoen LF, Saltvedt I, Sletvold O, et al.** One-year health and care costs after hip fracture for home-dwelling elderly patients in Norway: Results from the Trondheim Hip Fracture Trial. *Scand J Public Health* 2016;44:791–798.
25. **Clague JE, Craddock E, Andrew G, Horan MA, Pendleton N.** Predictors of outcome following hip fracture. Admission time predicts length of stay and in-hospital mortality. *Injury* 2002;33:1–6.
26. **Orosz GM, Magaziner J, Hannan EL, et al.** Association of timing of surgery for hip fracture and patient outcomes. *JAMA* 2004;291:1738–1743.
27. **Verbeek DO, Ponsen KJ, Goslings JC, Heetveld MJ.** Effect of surgical delay on outcome in hip fracture patients: a retrospective multivariate analysis of 192 patients. *Int Orthop* 2008;32:13–18.
28. **Haleem S, Heinert G, Parker MJ.** Pressure sores and hip fractures. *Injury* 2008;39:219–223.
29. **Cordero J, Maldonado A, Iborra S.** Surgical delay as a risk factor for wound infection after a hip fracture. *Injury* 2016;47(Suppl 3):S56-S60.
30. **No authors listed.** CIHI (Canadian Institute for Health Information). Wait times for priority procedures in Canada, 2017. Ottawa: CIHI; 2017. ttps://secure.cihi.ca/free_products/wt2018-tech-notes-2018-en-web.pdf (date last accessed 16 July 2019).

31. **No authors listed.** Committee on Trauma, Trauma Quality Improvement Program (TQIP), American College of Surgeons (ACS), Orthopaedic Trauma Association. ACS TQIP best practices in the management of orthopaedic trauma, 2015. https://www.facs.org/~/media/files/quality%20programs/trauma/tqip/tqip%20bpgs%20in%20the%20management%20of%20orthopaedic%20traumafinal.ashx (date last accessed 6 June 2019).
32. **No authors listed.** National Institute for Health and Care Excellence (NICE). Hip fracture: management. Clinical guideline [CG124], June 2011. https://www.nice.org.uk/Guidance/CG124 (date last accessed 6 June 2019).
33. **Bottle A, Aylin P.** Mortality associated with delay in operation after hip fracture: observational study. *BMJ* 2006;332:947–951.
34. **Griffiths R, Alper J, Beckingsale A et al.** Management of proximal femoral fractures 2011: Association of Anaesthetists of Great Britain and Ireland. *Anaesthesia* 2012;67:85–98.
35. **Fu MC, Boddapati V, Gausden EB, et al.** Surgery for a fracture of the hip within 24 hours of admission is independently associated with reduced short-term post-operative complications. *Bone Joint J* 2017;99-B:1216–1222.
36. **Donaldson AJ, Thomson HE, Harper NJ, Kenny NW.** Bone cement implantation syndrome. *Br J Anaesth* 2009;102:12–22.
37. **Talsnes O, Vinje T, Gjertsen JE, et al.** Perioperative mortality in hip fracture patients treated with cemented and uncemented hemiprosthesis: a register study of 11,210 patients. *Int Orthop* 2013;37:1135–1140.

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