The Influence of Perioperative Care and Treatment on the 4-Month Outcome in Elderly Patients With Hip Fracture

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The purpose of this descriptive cohort study was to identify perioperative risk factors associated with postoperative outcome up to 4 months after surgery in elderly patients with hip fracture.

Data were collected prospectively through the Swedish National Hip Fracture, the local Acute and Emergency, and Anesthesia registers, and retrospectively from medical and nursing records. The 428 patients (aged ≥ 65 years) with hip fracture were consecutively included. Multiple logistic regression analyses were used to identify factors predicting each of 4 outcomes.

Perioperative risk factors predicting death within 4 months after surgery were fasting time of 12 or more hours and blood transfusion of 1 U or more. Risk factors predicting postoperative confusion were postoperative oxygen saturation less than 90% and fasting time 12 hours or longer. Risk factors predicting in-hospital complications were transfusion of 1 or more units of blood, preoperative oxygen saturation less than 90%, and fasting time 12 hours or more. Risk factor predicting length of stay longer than 10 days was blood transfusion of 1 U or more.

To minimize morbidity and mortality, providers should increase efforts to optimize the patients' oxygen saturation and hemoglobin level and reduce fasting time and waiting time for surgery.

Keywords: Anemia, fasting, hypoxemia, mortality, postoperative confusion.

Elderly patients with hip fracture are frequent in the anesthetic setting. Often coexisting diseases make the patients extra vulnerable to anesthesia and surgery.[1] Elderly patients commonly sustain extensive fractures that increase the perioperative risks even more.[2] Furthermore, there are various perioperative factors related to care and treatment that may affect the well-being and postoperative outcome of these already frail persons. Despite recent research, there is still a need for a closer and more structured identification of these factors in order to make it possible to intervene successfully early in the hospital visit. In a previous study we identified several preoperative baseline characteristics as significant risk factors for outcome up to 4 months after surgery, of which some were contradictory with other similar research.[3-8] We wondered: Could this difference be the result of how the patients were taken care of in the hospital?

The purpose of the present study was therefore to investigate if factors such as prolonged waiting time before surgery, anesthetic technique, perioperative hypoxemia, hypotension, and anemia are associated with outcome in terms of mortality, postoperative confusion, in-hospital complications, and length of hospital stay (LOS) in elderly patients with hip fracture.

Materials and Methods

• *Design and Sample.* The present study was part of a descriptive, cohort study of the care, treatment, and outcome of elderly patients with acute hip fracture. Data were prospectively registered in the Swedish National Quality Hip Fracture register (*Rikshöft*), part of the Standardized Audit of Hip Fractures in Europe,[2,9] the Acute and Emergency (A&E) department, and the Anesthesia Register of the Lund University Hospital, Lund, Sweden. In addition, data were retrospectively collected from medical records and nursing charts. Details on the study design and cohort characteristics have been described previously.[3]

The sample included 436 consecutive patients with a hip fracture, aged 65 years or older, admitted to the Department of Orthopedics at the Lund University Hospital during the same 3 months in 1999, 2000, and 2001. During these periods a project for quality improvement of care called *Q-reg 99*, initiated by the National Board of Health and Welfare and the Swedish Association of County Councils, took place.[10] Eight patients were excluded: 5 patients who sustained fractures abroad, 1 with bilateral hip fractures, 1 who was moribund, and 1 who died before surgery. The study was conducted according to current ethical regulations and was approved by the Ethics Committee of the Medical Faculty at Lund University (LU 247-02).

• *Procedures and Data.* Most of the registrations of the *Rikshöft* (Primary registration, *Q-reg 99* form, and Follow-up registration form) were made by the study coordinator (A.H.). The coordinator interviewed the patients and assessed their mental status within 24 hours after admission and before surgery using the Short Portable Mental Status Questionnaire (SPMSQ).[11] The SPMSQ, validated with regard to dementia and acute confusional state and Scandinavian conditions,[12] is a screening test that includes 10 variables for assessment of organic brain deficit in elderly patients. A cutoff score of fewer than 8 SPMSQ points of 10 correct answers was considered to indicate cognitive impairment.[12,13]

Follow-up registration was completed at 4 months' follow-up visit by the responsible orthopedic surgeon or if a hospital visit was not needed, by the coordinator over the telephone. If at this time a patient was unable to answer, the next of kin or a caregiver was interviewed. Information regarding deceased patients was obtained from the Swedish official death certificates. Data collected from the A&E Register were calculated for a subsample of 249 (58%) patients, admitted during the same months for the years 2000 and 2001. Data on the ASA physical status classification system,[14] anesthetic technique, and clock hours were obtained from the Anesthesia register.

A chart review based on manual screening of data from the patients' medical record and nursing chart was performed by one of the authors (K.B.B.). Information included baseline data such as prescribed medications, neuropsychiatric illness and/or confusion, laboratory results, and data concerning oxygen saturation measured by pulse oximetry (Spo_2), systolic blood pressure (BP), intravenous (IV) infusions, analgesics and sedatives, anesthetic technique, blood losses, and blood transfusions. The anesthetic techniques used were spinal anesthesia (bupivacaine with or without IV sedative or analgetics) or general anesthesia (IV induction with thiopental or propofol; maintenance with propofol and opioids or with desflurane or sevoflurane in oxygen/nitrous oxide). Seventeen (27.8%) of the 61 patients with an Spo_2 level less than 90% measured at arrival in the operating room had been treated preoperatively with oxygen.

Data Analysis

For the evaluation of differences between various patient groups and variables of clinical interest, we used bivariate analyses.[15] For categorical variables the χ^2 and, when appropriate, the Fisher exact test were used. For continuous variables judged as normally distributed, the Student *t* test was applied. When the data were skewed, continuous variables were analyzed using the Mann-Whitney *U* test. For analyses of differences regarding Spo_2 variables between the operating room and the orthopedic ward postoperatively, the paired samples *t* test and the Wilcoxon signed rank test were used.

Most of the data were not normally distributed and were therefore expressed with median and quartiles (q_1-q_3) or range. Mean and SD were used for continuous variables if normally distributed. Due to the small number of patients in the ASA physical status 1 (n = 30) and the ASA physical status 4 (n = 14) classes and the fact that there were only minor clinically significant differences between the groups (ASA physical status 1 and 2, and ASA physical status 3 and 4, respectively) patients were divided into 2 categories: ASA physical status 1 and 2, and ASA physical status 3 and 4.

For categorization of variables as clinically meaningful we used the following. Age 85 years and over was considered a group with high perioperative risk,[16,17] use of 4 or more prescribed drugs was considered a risk factor for falling in elderly persons,[18] and SPMSQ fewer than 8 correct answers indicated cognitive impairment.[12,13] Hemoglobin level less than 100 g/L was defined as anemia[19,20]; potassium level less than 3.5 mmol/L (equivalent to mEq/L), hypokalemia[21]; blood creatinine more than 100 mol/L, renal insufficiency[22]; and Spo_2 value less than 90%, hypoxemia.[20,23] A waiting time for the operation of less than 24 hours was defined according to recommendations for early fixation.[1] Hypotension during anesthesia, with the systolic BP registered during a median (q_1-q_3) of 20 minutes (range, 15 to 30 minutes), was defined as a systolic BP decline to less than 0.66 of preoperative baseline or less than 90 mm Hg, requiring vasopressors or fluid resuscitation.[24,25] Categorization of fasting time less than 12 hours, anesthetic time less than 130 minutes, and blood loss less than 0.3 L were made according to clinical relevance and to the median/mean values of the sample.

Multiple logistic regression analyses (backward and likelihood ratio) were performed to identify factors predicting each of 4 outcome variables. One set of independent variables was tested in these analyses. Independent variables were entered according to the criteria that they had showed significant differences or a tendency ($P < .2$) in bivariate analyses (each and every dependent variable was tested against each and every independent variable) or that they had clinical significance. Baseline variables (dichotomized) among the study group, used in an earlier study on the same sample,[3] chosen to statistically control for differences in the logistic regression analysis, were first entered in the analyses. Due to multicolinearity with a dementia diagnosis, the variable SPMSQ score was not entered in 3 of these analyses. In 90 patients preoperative Spo_2 values monitored at admission to the operating room were missing. We therefore imputed Spo_2 values for 44 patients registered in the A&E Register, and the lowest Spo_2 values registered for 40 patients during anesthesia

(100% received oxygen). The relative importance of various predictors of outcome is presented as odds ratios (OR) with 95% confidence interval. The model was tested with the Hosmer and Lemeshow goodness-of-fit test.[26] The fit of the logistic regression model for every outcome was good, showing nonsignificant values. The SPSS software versions 11.5 and 14.0 (SPSS, Chicago, Illinois) were used for statistical analyses. A *P* value less than .05 was considered significant.

Results

Perioperative Patient Factors

• *Demographics and Functional Status.* Table 1 presents the demographics and functional status at admission to hospital in relation to 4 outcome groups: (1) died vs alive at 4 months, (2) postoperative confusion present vs absent, (3) in-hospital complications vs no in-hospital complications, and (4) LOS > 10 days vs LOS ≤ 10 days. The sample included 428 patients with a hip fracture, with a mean age of 82.5 years (range, 65 to 103 years). There were more women (72.9%) than men. Thirty-four percent (34.1%) of the patients suffered a displaced intracapsular fracture; 31.8%, a trochanteric fracture with 2 fragments; 18.0%, an undisplaced intracapsular fracture; and 16.1%, either a trochanteric multifragment, basocervical, or subtrochanteric fracture.

• *Biochemical and Physiologic Variables.* Table 2 presents biochemical and physiologic variables at admission to hospital and at arrival in the operating room in relation to the 4 outcome groups. Fifteen (48.4%) of the 31 patients with a hemoglobin level less than 100 g/L at arrival were treated with 1 or more units of blood transfusions preoperatively.

• *Waiting for Surgery.* Delay of surgery by more than 24 hours was registered in 191 (44.6%) patients. The causes of delay were late arrival to the hospital or delayed transport to the operating department (23.0%), time-consuming confirmation of diagnosis related to a late review or the need for repeated x-ray films (5.2%), and lack of available operating room space, surgeons and anesthesiologists, or hospital beds in the recovery unit or the orthopedic ward (57.4%). In 14.3% of the delays, the operation was postponed because the patient was considered in medical need of treatment owing to fluid imbalance, myocardial infarction, arrhythmia, gastrointestinal bleeding, or adjustment of anticoagulant therapy.

Median time spent in the A&E department, including the transport to and from the radiology department, was 3.6 hours (range, 0.6 to 9.6 hours) (n = 249, 58.2%). The median intrahospital waiting time for surgery was 19.4 hours (range, 4.3 to 219.0 hours). Patients waiting 24 hours or more after arrival (n = 134, 31.3%) belonged significantly more often to ASA physical status group 3 and 4 (46.3% vs 35.0%; *P* = .031), and more often had a fasting time of 12 hours or more (73.1% vs 51.8%; *P* < .001). About 40% of the patients waiting 24 hours or more had received 1 L or less of IV fluid preoperatively.

• *Fasting Time.* The median fasting time was 12 hours (range, 2 to 56 hours). Patients fasting 12 hours or more (n = 249, 59.1%) belonged significantly more often to ASA physical status group 3 and 4 (43.4% vs 32.6%; *P* = .026), more often had a waiting time for surgery of 24 hours or more (40.5% vs 21.2%; *P* < .001), suffered more often from confusion either at arrival or preoperatively (22.1% vs 12.8%; n = 77; *P* < .015). About 55% of the patients fasting 12 hours or longer had received 1 L or less of IV fluid preoperatively.

• *Preoperative and Postoperative Analgesia and Sedation.* Analgesics were given preoperatively to nearly all patients (95.6%) and to all patients postoperatively. The most common choices were opioids (96.3%), acetaminophen (92.1%), and tramadol hydrochloride (67.5%). A minority of patients (n = 105, 24.5%) were given premedication, most often including a benzodiazepine. Not having premedication was significantly more often associated with postoperative confusion (58.6% vs 42.4%; *P* = .001), and with death within 4 months (19.9% vs 9.5%; *P* = .005).

• *Surgical Methods.* The most common surgical methods were screw and plate fixation (47.7%), hemiarthroplasty (27.6%), and 2 hook-pins (21.7%). A blood loss of 0.3 L or more was present in 121 (28.3%) of the patients. Most of these patients had a complicated fracture, either a displaced intracapsular or a trochanteric 2-fragment fracture. About 85% of the patients had a urinary catheter inserted before surgery. As routine, all patients except 24 patients receiving anticoagulant therapy received thrombosis prophylaxis with enoxaparin. All patients except 3 were mobilized on the first postoperative day.

• *Anesthesia.* Most patients (n = 275, 64.3%) had spinal anesthesia. In addition, about 67% of these patients also had benzodiazepines (n = 56), propofol (n = 120), or another sedative or ketamine (n = 8). Among patients who had general anesthesia (n = 153, 35.7%), this was preceded by an unsuccessful attempt at spinal anesthesia in 16 (5.8%) patients. General anesthesia was a more frequent choice in the ASA physical status 3 and 4 group than in the ASA 1 and 2 group (43.5% vs 30.6%; *P* = .007). However, spinal anesthesia was the more frequent choice among patients with dementia compared with other patients (74.0% vs 61.3%; *P* = .019). Perioperative hypotension occurring in 275 (64.3%) patients was more frequent in the general anesthesia group than in the spinal anesthesia group (81.8% vs 57.5%; *P* < .001). The incidence of hypotension, however, did not differ between the ASA physical status groups. Anesthesia length of 130 minutes or longer was shown to be more frequent in some patient groups (Table 3).

• *Changes in Levels of Oxygen Saturation and Hemoglobin.* A postoperative SpO_2 level of 90% or lower

	Status at 4 mo			Postoperative confusion[a]			In-hospital complications			Length of stay		
	Dead	Alive	P^b	Present	Absent	P^b	Yes	No	P^b	> 10 d	≤ 10 d	P^b
Gender			< .001			.221			.001			.323
Women	37 (11.9)	275 (88.1)		158 (50.8)	153 (49.2)		174 (55.8)	138 (44.2)		150 (48.1)	162 (51.9)	
Men	31 (26.7)	85 (73.3)		65 (57.5)	48 (42.5)		43 (37.1)	73 (62.9)		62 (53.4)	54 (46.6)	
Age			.022			.015						.602
Age < 85 y	31 (12.4)	218 (87.6)		117 (47.6)	129 (52.4)		115 (46.2)	134 (53.8)	.028	126 (50.6)	123 (49.4)	
Age ≥ 85 y	37 (20.7)	142 (79.3)		106 (59.6)	72 (40.4)		102 (57.0)	77 (43.0)		86 (48.0)	93 (52.0)	
Residence/admitted from			< .001			<.001			<.001			<.001
Own home	14 (5.7)	233 (94.3)		90 (36.6)	156 (63.4)		105 (42.5)	142 (57.5)		148 (59.9)	99 (40.1)	
Sheltered housing, institutional care, or nursing home	44 (28.0)	113 (72.0)		116 (75.3)	38 (24.7)		93 (59.2)	64 (40.8)		53 (33.8)	104 (66.2)	
Rehabilitation unit or hospital	10 (41.7)	14 (58.3)		17 (70.8)	7 (29.2)		19 (79.2)	5 (20.8)		11 (45.8)	13 (54.2)	
Neuropsychiatric condition[c]			< .001			<.001			.542			<.001
No mental illness	35 (13.2)	230 (86.8)		103 (38.9)	162 (61.1)		129 (48.7)	136 (51.3)		153 (57.7)	112 (42.3)	
Dementia	32 (30.8)	72 (69.2)		93 (89.4)	11 (10.6)		57 (54.8)	47 (45.2)		32 (30.8)	72 (69.2)	
Schizophrenia, poststroke, alcoholism	1 (1.8)	54 (98.2)		27 (49.1)	28 (50.9)		29 (52.7)	26 (47.3)		27 (49.1)	28 (50.9)	
SPMSQ[d]			< .001			<.001			.017			<.001
≥ 8 correct answers	15 (7.0)	200 (93.0)		66 (31.0)	147 (69.0)		96 (44.7)	119 (55.3)		131 (60.9)	84 (39.1)	
< 8 correct answers	41 (27.3)	109 (72.7)		117 (78.5)	32 (21.5)		86 (57.3)	64 (42.7)		52 (34.7)	98 (65.3)	
ASA status			< .001			.104			.179			.723
ASA 1 and 2	27 (10.5)	231 (89.5)		127 (49.4)	130 (50.6)		124 (48.1)	134 (51.9)		126 (48.8)	132 (51.2)	
ASA 3 and 4	41 (24.1)	129 (75.9)		96 (57.5)	71 (42.5)		93 (54.7)	77 (45.3)		86 (50.6)	84 (49.4)	
Prescribed drugs[c]			< .001			.004			.018			.259
< 4	9 (6.3)	134 (93.7)		61 (43.0)	81 (57.0)		61 (42.7)	82 (57.3)		66 (46.2)	77 (53.8)	
≥ 4	59 (21.0)	222 (79.0)		162 (57.7)	119 (42.3)		154 (54.8)	127 (45.2)		146 (52.0)	135 (48.0)	

Table 1. Demographics and Functional Status at Admission to Hospital in Relation to 4 Outcome Variables

Comparisons are between patients with and without the following outcome groups: dead vs alive at 4 mo, postoperative confusion present vs absent, in-hospital complications vs no in-hospital complications, and length of stay > 10 d vs length of stay ≤ 10 d. Data are presented as number (percentage) of patients (n = 428 except where otherwise indicated). SPMSQ indicates Short Portable Mental Status Questionnaire.

[a] Data on postoperative confusion not available for 4 patients in following variables: gender, age, residence/admitted from, neuropsychiatric condition, ASA physical status, and prescribed drugs. Data on postoperative confusion not available for 66 patients in variable SPMSQ.

[b] Pearson χ^2 test.

[c] n = 424.

[d] n = 365.

	Status at 4 mo			Postoperative confusion			In-hospital complications			Length of stay		
	Dead	Alive	P[a]	Present	Absent	P[a]	Yes	No	P[a]	> 10 d	≤ 10 d	P[a]
Hemoglobin, g/L[b]			.012			.403			.917			.576
≥ 100	58 (14.9)	331 (85.1)		206 (53.0)	183 (47.0)		197 (50.6)	192 (49.4)		196 (50.4)	193 (49.6)	
< 100	10 (32.3)	21 (67.7)		14 (45.2)	17 (54.8)		16 (51.6)	15 (48.4)		14 (45.2)	17 (54.8)	
Potassium (serum), mmol/L[c,f]			.613			.397			.347			.051
3.5-5.0	58 (16.1)	303 (83.9)		190 (52.6)	171 (47.4)		183 (50.7)	178 (49.3)		186 (51.5)	175 (48.5)	
< 3.5	5 (16.7)	25 (83.3)		15 (50.0)	15 (50.0)		16 (53.3)	14 (46.7)		9 (30.0)	21 (70.0)	
≥ 5.0	3 (27.3)	8 (72.7)		8 (72.7)	3 (27.3)		8 (72.7)	3 (27.3)		7 (63.6)	4 (36.4)	
Creatinine (serum), µmol/L[d]			.030			.699			.285			.153
≤ 100	47 (14.6)	276 (85.4)		170 (52.6)	153 (47.4)		160 (49.5)	163 (50.5)		157 (48.6)	166 (51.4)	
> 100	17 (25.4)	50 (74.6)		30 (44.8)	37 (55.2)		38 (56.7)	29 (43.3)		28 (41.8)	39 (58.2)	
Oxygen saturation (Spo_2), % at arrival in the operating room[e]			.233			.101			.026			.514
≥ 90	55 (15.2)	306 (84.8)		184 (51.0)	177 (49.0)		175 (48.5)	186 (51.5)		179 (49.6)	182 (50.4)	
< 90	13 (21.3)	48 (78.7)		38 (62.3)	23 (37.7)		39 (63.9)	22 (36.1)		33 (54.1)	28 (45.9)	

Table 2. Biochemical and Physiologic Variables at Admission to Hospital and at Arrival in the Operating Room in Relation to 4 Outcome Variables

Comparisons are between patients with and without the following outcome groups: dead vs alive at 4 mo, postoperative confusion present vs absent, in-hospital complications vs no in-hospital complications, and length of stay > 10 d vs length of stay ≤ 10 d. Data are presented as number (percentage) of patients (n = 428 except where otherwise indicated).

[a] Pearson χ^2 test.
[b] n = 420.
[c] n = 404.
[d] n = 390.
[e] n = 422.
[f] Data were not available for some patients for some variables, such as potassium in relation to outcome variables and postoperative confusion (equals 402 instead of 404).

was found in 17.8% of the patients having an anesthesia length of 130 minutes or more (n = 236; see Table 3). A significant decrease was found in median (q_1-q_3) SpO_2 levels between the measurements performed preoperatively in the operating room and postoperatively in the orthopedic ward (n = 208): 94.0% vs 93%, respectively (range, 92% to 96% vs 91% to 94%; $P = .003$). A significant decrease in mean hemoglobin levels (± SD) was also found postoperatively (n = 401): 121.3 ± 15.62 g/L preoperatively and 90.0 ± 16.07 g/L postoperatively; $P < .001$. About 65% of the patients with a postoperative hemoglobin level less than 100 g/L (n = 213) received one or several blood transfusions postoperatively. Of all patients with a postoperative hemoglobin level of less than 100 g/L, 64.3% had a basocervical, trochanteric, or subtrochanteric fracture ($P < .001$), and 63.4% were operated on with a screw and plate fixation ($P < .001$).

Postoperative Outcome

• *Mortality.* Twelve (2.8%) patients with cancer metastases or cardiac, respiratory, or renal insufficiency died during the hospital stay. Sixty-eight patients (15.9%) were dead 4 months after discharge. Of the patients who died, 60.3% belonged to the ASA physical status 3 and 4 group compared with 35.8% of the survivors ($P < .001$). Bivariate analyses showed 4 perioperative factors to be significantly associated with death within 4 months after hip fracture: a fasting time of 12 hours or more, perioperative transfusion of 1 U or more, postoperative SpO_2 level of less than 90%, and postoperative transfusion of 1 U or more (Table 4). Multivariate analysis (multiple logistic regression) revealed that fasting time of 12 hours or more (OR, 2.2), and blood transfusion of more than 1 U (OR, 2.0) together with dependency in living situation (OR, 8.1), male sex (OR, 3.4), and displaced intracapsular fracture (OR, 3.7) were independent risk factors significantly predicting death within 4 months after surgery (Table 5).

• *Postoperative Confusion.* Nearly 53% of the study population experienced postoperative confusion, as registered in medical records and nursing charts. Bivariate analyses showed that a postoperative SpO_2 level less than 90%, postoperative transfusion of 1 U or more, and postoperative hemoglobin level less than 100 g/L were significantly associated with postoperative confusion in patients not showing signs of confusion preoperatively (n = 147, 42.6%; see Table 4). Multivariate analysis revealed that a postoperative SpO_2 level less than 90% (OR, 2.0) together with a dementia diagnosis (OR, 7.5), and de-

	Anesthesia < 130 min	Anesthesia ≥ 130 min	P[a]
Fracture type			< .001
Undisplaced intracapsular	58 (75.3)	19 (24.7)	
Other fracture	134 (38.2)	217 (61.8)	
Surgery			< .001
Hemiarthroplasty/arthroplasty	21 (16.0)	110 (84.0)	
Screw/plate fixation/two hook-pins	171 (57.6)	126 (42.4)	
Anesthesia method			.010
Spinal anesthesia	136 (49.5)	139 (50.5)	
General anesthesia	56 (36.6)	97 (63.4)	
Perioperative blood loss (L)[b]			< .001
< 0.3	166 (54.8)	137 (45.2)	
≥ 0.3	25 (20.7)	96 (79.3)	
Peroperative blood transfusion (U)[b]			< .001
< 1	181 (50.7)	176 (49.3)	
≥ 1	10 (14.9)	57 (85.1)	
Postoperative blood transfusion (U)[b]			.003
< 1	133 (50.6)	130 (49.4)	
≥ 1	58 (36.0)	103 (64.0)	
Postoperative oxygen saturation (SpO_2), %			.001
≥ 90	179 (48.0)	194 (52.0)	
< 90	13 (23.6)	42 (76.4)	

Table 3. Variables Associated With Anesthesia Duration

Comparisons are between anesthesia length < 130 min vs anesthesia length ≥ 130 min. Data are presented as number of patients (percentage).

[a] Pearson χ^2 test.

[b] n = 424.

	Status at 4 mo			Postoperative confusion[a]			In-hospital complications			Length of stay		
	Dead (n = 68)	Alive (n = 360)	*P*[b]	Present (n = 147)	Absent (n = 198)	*P*[b]	Yes (n = 217)	No (n = 211)	*P*[b]	> 10 d (n = 216)	≤ 10 d (n = 212)	*P*[b]
ASA group 3 and 4	60.3	35.8	**< .001**	42.2	35.4	.218	42.9	36.5	.199	49.4	50.6	.767
Age ≥ 85 y	54.4	39.4	**.023**	42.2	34.8	.179	47.0	36.5	**.031**	52.0	48.0	.625
Male sex	45.6	23.6	**< .001**	30.6	24.2	.220	19.8	34.6	**.001**	46.6	53.4	.330
Waiting for surgery ≥ 24 h[c]	30.8	32.4	.885	33.2	28.1	.344	34.6	29.6	.295	41.8	58.2	**.013**
Fasting time ≥ 12 h[d]	75.8	56.1	**.003**	59.2	54.3	.381	63.6	54.6	.074	48.6	51.4	.553
Preoperative Spo_2 < 90%[e]	19.1	13.6	.258	17.0	11.2	.153	18.2	10.6	**.027**	45.9	54.1	.580
Perioperative transfusion ≥ 1 U[f]	25.0	14.0	**.029**	15.0	15.7	.881	16.7	14.8	.598	56.7	43.3	.287
Postoperative Spo_2 < 90%	23.5	10.8	**.009**	17.0	8.6	**.020**	15.2	10.4	.151	56.4	43.6	.388
Postoperative transfusion ≥ 1 U[f]	50.0	35.7	**.029**	49.0	30.8	**.001**	49.8	25.8	**< .0001**	41.0	59.0	**.005**
Total blood loss ≥ 0.3L[f]	48.5	38.8	.140	43.5	38.4	.375	43.7	36.8	.166	43.9	56.1	**.048**
Postoperative Hb < 100 g/L[g]	64.1	50.7	.056	61.3	47.3	**.014**	61.1	43.8	**.001**	43.2	56.8	**.022**
Surgery other than arthroplasty	60.3	71.1	.086	66.0	71.2	.347	68.7	70.1	.754	51.5	48.5	.531

Table 4. Postoperative Outcome in Relation to Different Groups and Various Baseline and Perioperative Factors

Data are presented as percentage of patients. Comparisons are made between the following groups: dead vs alive at 4 mo, postoperative confusion present vs absent, in-hospital complications vs no in-hospital complications, and length of stay > 10 d vs length of stay ≤ 10 d.

Spo_2 indicates oxygen saturation by pulse oximetry; Hb, hemoglobin.

[a] Excludes patients with preoperative confusion.
[b] Fisher exact test. Boldface indicates statistically significant.
[c] n = 417.
[d] n = 421.
[e] n = 422.
[f] n = 424.
[g] n = 403.

pendency in living (OR, 2.5) significantly predicted postoperative confusion (see Table 5).

• *Complications*. Bivariate analyses showed that the following perioperative factors were significantly related to in-hospital complications registered in the *Q-reg 99* form, such as urinary tract infection, pneumonia, and myocardial infarction: a preoperative Spo_2 level less than 90% in the operating room, postoperative transfusion of 1 U or more, and postoperative hemoglobin level less than 100 g/L (see Table 4). Multivariate analysis revealed that blood transfusion of more than 1 U (OR, 2.9), preoperative Spo_2 level less than 90% in the operating room (OR, 2.1), and fasting time of 12 hours or more (OR, 1.6) together with dependency in living (OR, 1.8) significantly predicted registered in-hospital complications (see Table 5).

• *Length of Stay*. The median (q_1-q_3) LOS was 10 days (range, 8 to14 days). Patients operated with 2 hook-pins (n = 93) had a significantly shorter median (q_1-q_3) LOS compared with patients operated with single screw and side plate or hemiarthroplasty: 8 vs 11 days, respectively (range, 6 to 12 days vs 8 to 18 days; $P < .05$). Bivariate analyses showed 4 perioperative factors to be significantly associated with a median LOS longer than 10 days: a waiting time for surgery of 24 hours or more, total blood loss of 0.3 L or more, postoperative hemoglobin level less than 100 g/L, and postoperative transfusion of 1 U or more (see Table 4). Multivariate analysis showed that blood transfusion greater than 1 U (OR, 1.6), trochanteric multifragment/subtrochanteric fractures (OR, 3.5), and basocervical/trochanteric 2-fragment fractures (OR, 2.0)

Outcome/risk factor	H&L	OR	95% CI for OR	P
Died within 4 mo[b]				
Dependency in living	0.374	8.11	3.92-16.77	< .001
Male sex		3.37	1.67-6.82	.001
Fracture type[a]		1.00		.011
Displaced intracapsular fracture		3.67	1.25-10.83	.018
Fasting ≥ 12 h		2.16	1.05-4.43	.036
Blood transfusion > 1 U		2.01	1.06-4.01	.048
Postoperative confusion[c]				
Dementia diagnose	0.964	7.47	3.63-15.37	< .001
Dependency in living		2.50	1.54-4.08	< .001
Postoperative oxygen saturation < 90%		2.02	1.03-3.97	.042
Fasting ≥ 12 h		1.48	0.95-2.30	.086
Registered in-hospital complications[d]				
Blood transfusion > 1 U	0.800	2.90	1.80-4.68	< .001
Preoperative oxygen saturation < 90%		2.10	1.05-4.23	.037
Dependency in living		1.79	1.13-2.85	.014
Fasting ≥ 12 h		1.61	1.01-2.57	.045
Trocanteric multifragment/subtrochanteric fracture		2.33	0.96-5.65	.061
Length of stay > 10 d[e]				
Fracture type[a]	0.467	1.00		.033
Basocervical and trochanteric 2-fragment fracture		1.98	1.032-3.81	.040
Trocanteric multifragment/subtrochanteric fracture		3.51	1.49-8.30	.004
Blood transfusion > 1 U		1.63	1.03-2.59	.039

Table 5. Multiple Logistic Regression Analysis of Factors Predicting Outcomes After Hip Fracture

H&L indicates Hosmer and Lemeshow goodness-of-fit test; OR, odds ratio; CI, confidence interval.

[a] Fracture type reference category: undisplaced intracapsular fracture.

Variables not in the final model:

[b] Age (< 85 vs ≥ 85 y), ASA physical status (1 and 2 vs 3 and 4), prescribed drugs (< 4 vs ≥ 4 drugs), dementia diagnosis, hemoglobin level (≥ 100 vs < 100 g/L), creatinine level (≤ 100 vs > 100 μmol/L), walking ability (able to walk alone vs unable to walk alone), postoperative oxygen saturation level (≥ 90% vs < 90%), primary operation (hemiarthroplasty and total hip arthroplasty vs screws/pins with or without side plate).

[c] Age (< 85 vs ≥ 85 y), prescribed drugs (< 4 vs ≥ 4 drugs), walking ability (able to walk alone vs unable to walk alone), anesthetic method (spinal vs general anesthesia), total blood transfusion (0-1 vs > 1 U).

[d] Age (< 85 vs ≥ 85 y), sex (female vs male), prescribed drugs (< 4 vs ≥ 4 drugs), Short Portable Mental Status Questionnaire score (≥ 8 vs < 8 correct answers), walking ability (able to walk alone vs unable to walk alone).

[e] Living (independently vs dependently), walking ability (able to walk alone vs unable to walk alone), creatinine level (≤ 100 vs > 100 μmol/L), potassium level (≥ 3.5 vs < 3.5 mmol/L), peroperative hypotension (normotension vs hypotension), anesthetic time (< 130 vs ≥ 130 min).

were factors significantly predicting an LOS of more than 10 days (see Table 5).

Discussion

By means of multiple logistic regression analysis, a decreased Sp_{O_2} level, an increased fasting time, and an increased number of blood transfusions were identified as statistically significant perioperative risk factors for an impaired recovery and a poorer survival 4 months after surgery to treat a hip fracture. We also found that the fracture type influenced the outcome. Thus, the displaced intracapsular and the trochanteric multifragment and subtrochanteric fractures were identified as high risk factors. However, the anesthetic method used and the occurrence of episodes of hypotension during anesthesia were not identified as risk factors.

• *Hypoxemia.* Arterial hypoxemia in elderly bedridden patients after hip fracture is a common phenomenon[23,25,27] and is supposed to contribute to the development of the acute confusional state.[23-25,27,28] This is strongly supported by our findings that a logistic regression analysis identified decreased postoperative oxygen saturation (< 90%) to be a significant risk factor for postoperative confusion, and that in bivariate analyses hypoxemia was significantly associated with postoperative confusion as well as with death within 4 months. Moreover, a decreased preoperative Sp_{O_2} level before anesthesia induction was identified as a risk factor for in-hospital complications. These findings are illustrated by the fact that 55% of the patients monitored postoperatively had a significant decrease in Sp_{O_2} during the time lapsed between the arrival in the operating room and the postoperative stay at the orthopedic ward, and that almost 20% of the patients, who were monitored at arrival in the operating room, had an Sp_{O_2} level less than 90%. It is notable that only one-fourth of these patients had been treated with oxygen preoperatively. It is well known that traumatized elderly patients run a high risk for development of clinically significant hypoxemia soon after being bedridden because of an increased mismatching of ventilation to perfusion in the lungs, and that this situation in most cases can be prevented by oxygen treatment.[20,29] This clearly indicates the need of obligatory, early, and continuously administered supplemental oxygen in these patients.

• *Blood Loss and Anemia.* Anemia is frequent in older persons and has been associated with increased mortality rates in several studies.[30-32] In our study we used a hemoglobin level of less than 100 g/L as a limit. Even if this level has been judged as a quite stringent criterion for anemia,[20,33] it has nonetheless been accepted in patients with a hip fracture.[3,7] Evidently, however, many elderly patients are often dehydrated with falsely high hemoglobin levels at admission that decrease clearly after the initial fluid hydration.[8,34,35] This fact would further strengthen the need for an early blood transfusion.

We found a postoperative hemoglobin level of less than 100 g/L (corresponding to a hematocrit of less than 30%) in about 50% of the study group, and a total mean postoperative decrease in hemoglobin level of nearly 18%, which may indicate a substantial blood loss. According to Marcantonio et al,[24] an intraoperative blood loss leading to a low hematocrit (< 30%) with a decline in tissue oxygen requiring repeated postoperative blood transfusions may well contribute to the development of acute confusional state. This mechanism is further supported by our findings that a postoperative hemoglobin level of less than 100 g/L, as well as a perioperative blood transfusion of more than 1 U, was significantly associated with postoperative confusion, in-hospital complications, and—near to statistical significance—death within 4 months. Most of the blood transfusions in our study were given only postoperatively. This fact taken together with the relatively high incidence of low levels of oxygen saturation may indicate that our patients had been exposed to a substantial decline in tissue oxygen for hours. It is also notable that of all patients with a postoperative hemoglobin level less than 100 g/L, a majority had the most complicated types of fractures and were operated on with a screw and plate fixation, yet only 65% of the patients had blood transfusions. Published results describing the impact of low hemoglobin levels and blood transfusions on outcome after hip surgery are contradictory. One study showed that even mild degrees of preoperative anemia increased the adjusted risk of 30-day postoperative mortality in elderly patients undergoing noncardiac surgery.[36] In 2 previous studies postoperative transfusion was not found to influence mortality in patients with a hip fracture after adjusting for hemoglobin levels of 80 to 100 g/L or less than 100 g/L, respectively.[4,7] Another study, however, has shown that a higher average postoperative hemoglobin level (≥ 110 g/L) may improve functional recovery after hip fracture.[37] Referring to these findings, one cannot rule out that the relatively poor postoperative recovery of our patients was at least in part due to low perioperative hemoglobin levels.

• *Delay of Surgery and Prolonged Fasting Time.* An increased waiting time for surgery in patients with a hip fracture is well known to be a significant risk factor for the development of various postoperative complications[1,38-41] as well as for an increased mortality rate.[1,42-44] Orosz et al[41] have shown that early hip fracture surgery is associated with fewer major complications, at least in patients who are medically stable at admission. In our study a delay of surgery (> 24 hours) was caused by medical instability with a need for treatment in quite a few patients (14%). More often, however, the delay was due to various administrative reasons such as limited availability of surgeons, anesthesiologists, and hospital beds. The delay of surgery was to a significant degree caused by a prolonged wait in the A&E department; the median time spent in the A&E department was more than 3.5 hours. Such a long wait, very inconvenient for an elderly person with hip fracture and frustrating for relatives, should be easy to shorten by changing clinical routines.

Although we did not find a waiting time for surgery of 24 hours or more to be associated with complications or early death, we found a prolonged fasting time (≥ 12 hours) to be not only a significant predictor for contracting in-hospital complications but also for death within 4 months. In our study most of the patients waiting 24 hours or more had a fasting time of 12 hours or more. It is notable that about 55% of the patients fasting 12 hours or more had received only 1 L or less of IV fluid preoperatively. Most of the patients of the ASA physical status 3 and 4 group had a fasting time of 12 hours or more. By definition, patients of the ASA physical status 3 and 4 have systemic diseases that severely limit their physiologic vital organ capacity.[14] Likely, a prolonged fasting time may be especially harmful to these already weak patients.[35,45] Accordingly, as we have shown earlier, patients with hip fracture classified as ASA physical status 3 and 4 have a significantly increased mortality within 4 months.[3]

• *Premedication and Anesthesia.* Quite surprisingly we found that patients who had no premedication ran a significantly higher risk than other patients to develop postoperative confusion and to die within 4 months. The reason for this is not obvious. One could speculate that premedication reduces the psychological stress, thereby reducing the risk of development of acute confusional state. Another possibility has to do with a deliberate choice of the anesthesiologist to abstain from yet another centrally depressant medication in very sick patients already at risk. The choice of anesthetic method and the occurrence of episodes of hypotension during anesthesia were not identified as risk factors. This is in accordance with the results of previous randomized and quasirandomized trials involving predominantly elderly women with a hip fracture from 1978 to 2003 that failed to establish a benefit of one form of anesthetic over another.[46,47] The authors of the latter review suggested, however, that acute postoperative confusion may be more seldom seen after regional anesthesia than after general anesthesia. Clearly, this is an important topic for further investigation.

• *Strengths and Limitations.* The strength of the study is the large number of consecutively enrolled patients, prospectively registered through the standardized Swedish National Hip Fracture register,[2,9] and the Anesthesia Register, enabling a control of patient categorization based on the ASA classification. The majority of the registrations were made by an experienced researcher and followed the *Rikshöft*-Standardized Audit of Hip Fractures in Europe registration of data.[2,9,10] A potential weakness of this study was that clinical data from medical records and nursing charts were obtained by manual retrospective collection. This could give rise to some uncertainties because the documentation screened could be incomplete. A final weakness of our study was the use of variables with a relatively high internal dropout, such as the SPMSQ and the SpO_2, especially when measured before the start of anesthesia. The importance of this limitation, however, may be reduced in the light of the relatively high number of patients enrolled, which should be considered satisfactory with regard to reliability and responsiveness.

Conclusion

The results of this study indicate the great importance of perioperative optimization of the patient's oxygen saturation and hemoglobin level, and a reduction of fasting and waiting time for surgery in order to minimize postoperative morbidity and mortality. Findings of the present and similar studies have great implications for nurses and physicians involved in the prehospital setting as well as in the acute orthopedic and anesthesiology settings. Further research should investigate whether an intervention based on the present clinical knowledge could improve the outcome of patients with a hip fracture.

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