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Orthogeriatric Trauma Unit Improves Patient Outcomes in Geriatric Hip Fracture Patients

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Abstract

Introduction: An aging population in developed countries has increased the number of osteoporotic hip fractures and will continue to grow over the next decades. Previous studies have investigated the effect of integrated orthogeriatric trauma units and care model on outcomes of hip fracture patients. Although all of the models perform better than usual care, there is no conclusive evidence which care model is superior. More confirmative studies reporting the efficacy of orthogeriatric trauma units are needed. The objective of this study was to evaluate outcomes of hip fracture patients admitted to the hospital before and after implementation of an orthogeriatric trauma unit. **Materials and methods:** This retrospective cohort study was conducted at a level 2 trauma center between 2016 and 2018. Patients aged 70 years or older with a hip fracture undergoing surgery were included to evaluate the implementation of an orthogeriatric trauma unit. The main outcomes were postoperative complications, patient mortality, time spent at the emergency department, time to surgery, and hospital length of stay. **Results:** A total of 806 patients were included. After implementation of the orthogeriatric trauma unit, there was a significant decrease in postoperative complications (42% vs. 49% in the historical cohort, $p = 0.034$), and turnaround time at the emergency department was reduced by 38 minutes. Additionally, there was significantly less missing data after implementation of the orthogeriatric trauma unit. After correcting for covariates, patients in the orthogeriatric trauma unit cohort had a lower chance of complications (OR 0.654, 95% CI 0.471-0.908, $p = 0.011$) and a lower chance of 1-year mortality (OR 0.656, 95% CI 0.450-0.957, $p = 0.029$). **Conclusions:** This study showed that implementation of an orthogeriatric trauma unit leads to a decrease in postoperative complications, 1-year mortality, and time spent at the emergency department, while also improving the quality of data registration for clinical studies. **Level of Evidence:** Level III.

Keywords

orthogeriatric, trauma, fracture, hip, mortality, geriatric

Introduction

An aging population in developed countries has increased the number of osteoporotic hip fractures and will continue to grow over the next decades.[1,2] The surgical management of these patients is complex due to age-related comorbidities. Complications that result from immobilization occur frequently during hospitalization, along with delirium and death.[3,4] It is necessary to revise the present model of care, to manage the increasing numbers of hip fracture patients in the future.

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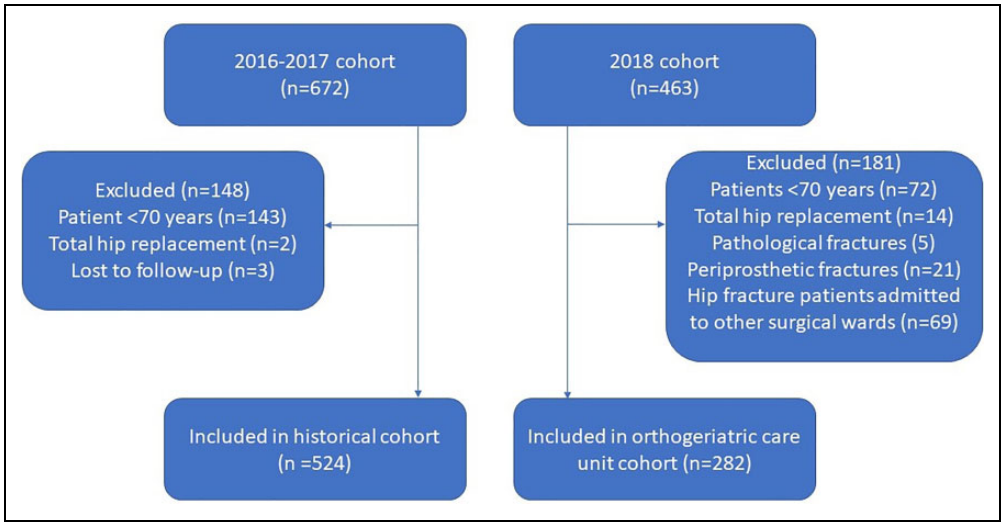

Figure 1. Patient flowchart.

In literature, 3 models of orthogeriatric trauma care are described:

1. Orthopedic/surgical ward with routine geriatric consultation.
2. Geriatric ward with the orthopedic surgeon acting as a consultant.
3. Orthogeriatric trauma unit with shared responsibilities by the surgeon and the geriatrician.[5,6]

Previous studies have investigated the effect of integrated orthogeriatric trauma units on hip fracture patients. These orthogeriatric trauma units have shown to reduce both short-term and long-term mortality in hip fracture patients, as well as hospital length of stay (HLOS) and time to postoperative mobilization.[5-10] Although all of the models mentioned above perform better than usual care, there is no conclusive evidence which care model is superior.[5,6] Therefore, more confirmative studies reporting the efficacy of orthogeriatric trauma units are needed to ascertain a greater understanding of the impact of different orthogeriatric care models on patient outcomes.

The objective of this study was to study the effect of implementation of an orthogeriatric trauma unit on postoperative complications, time spent at the emergency department (ED), time to surgery, hospital length of stay, and mortality of hip fracture patients admitted to the hospital. The hypothesis of this study is that patients receiving care after implementation of the orthogeriatric trauma unit have a lower chance of postoperative complications.

Materials and Methods

This retrospective cohort study was conducted in a level 2 trauma center at St. Antonius hospital between January 1st, 2016 and December 31st, 2018. The orthogeriatric trauma unit was implemented on the first of January 2018. In this study, the 2018 cohort was compared to a historical cohort before the implementation of the orthogeriatric trauma unit. Although no orthogeriatric trauma unit was present before 2018, there was a geriatric awareness program that increased awareness for common complications during admission for these patients. The orthogeriatric trauma unit at St. Antonius hospital is a unit with shared responsibilities by the surgeon and the geriatrician, where multidisciplinary care is provided for geriatric fracture patients.

The complete care pathway and the interventions of the orthogeriatric trauma unit are shown in Supplemental Figure 1. Hip fracture patients are admitted from the ED to the orthogeriatric trauma unit within 1 hour of arrival at the hospital. In the ED, standard ECG, blood testing, and additional radiology studies are performed and used by both the geriatrician and trauma surgeon for further treatment (e.g., cause of the fall, underlying pathology and deficiencies, malnutrition, and osteoporosis). After admission, immediate consultation of a physical therapist, geriatrician, dietician, is initiated. The physical therapist focusses on early weight-baring after surgery and prevention of common complications of hip fracture surgery (e.g., deep breathing exercises to prevent pneumonia in debilitated patients). The geriatrician visits the patients daily on the ward and gives recommendations for treatment to the treating physician/physician assistant. Furthermore, the geriatrician evaluates patient medication in the setting of fall prevention. The clinical staff coordinate their efforts to reduce postoperative complications, HLOS, time to surgery, ED admission time, and to facilitate an adequate and early discharge (e.g., to a rehabilitation facility). The clinical staff meets twice a week for a multidisciplinary consultation to discuss treatment goals and a discharge plan. The goal is to have patients ready for discharge in 5-7 days. Additionally, there is a focus on careful data registration for all patients in every step of their treatment (i.e., at the ED, during admission, and follow-up) by using healthcare pathways that are built into the electronic patient records.

All patients aged 70 years or older admitted to the ED with a hip fracture (Orthopaedic Trauma Association classification

31-A or 31-B) undergoing surgery were eligible for inclusion.[11] Exclusion criteria were pathological hip fractures, total hip replacement surgery, and periprosthetic hip fractures. Treatment codes were used for the identification of eligible subjects and data collection. It was possible for patients to be included in the study twice if the second admittance was due to a fracture of the contralateral hip.

The following baseline characteristics were collected from electronic medical records: age, sex, prefracture diagnosis of dementia (diagnosed by a geriatrician or general practitioner), Katz Index of Independence in Activities of Daily Living score (Katz-ADL),[12] prefracture living situation (i.e., independent at home, at home with assistance for activities of daily living, institutional care facility, or nursing home), type of fracture (i.e., medial femoral neck, trochanteric femur or subtrochanteric femur), and type of surgical procedure (i.e., hemiarthroplasty, cannulated hip screw, dynamic hip screw, intramedullary nail, or conservative treatment).

The primary outcome of this study was postoperative complications. A complicated course was defined as one or more of the following complications according to the Dutch Hip Fracture Audit guidelines: congestive heart failure (confirmed by chest radiograph), pressure ulcer (diagnosed by attending physician), delirium (diagnosed by either geriatrician or physician assistant of the consultative orthogeriatric trauma team), pulmonary embolism (CTA-confirmed), deep venous thrombosis (duplex ultrasound confirmed), renal insufficiency (>24 ml/min decrease in glomerular filtration rate (GFR) compared to GFR at admission), pneumonia (confirmed by chest radiograph or positive sputum culture), urinary tract infections (UTI) (positive urine culture), in-hospital falls and surgical wound infection (diagnosed by attending physician), and need for blood transfusion (i.e., patient received red blood cell transfusion).[13]

Secondary outcomes were: time spent at the ED (in minutes, defined as the time between presentation to ED, and the time patient left the ED), time to surgery (in hours, defined as the time between presentation at ED, and time of surgery), hospital length of stay (in days, defined as the time between presentation at ED, and time of discharge from hospital), and patient mortality, with a follow-up period of 1 year. Mortality data were acquired by consulting the municipal citizen registry.

Statistical Methods

Previous studies have found a reduction in complications between 15% and 6%.[8,14-17] A sample size of 776 patients was needed to detect a 10% difference in complications with a statistical power of 80% and a significance level (α) of 0.05.

Differences between patients who were admitted before and after the implementation of the orthogeriatric trauma unit were analyzed using descriptive statistics. Continuous variables were tested for differences between groups with an unpaired t-test or Mann-Whitney U test, depending on normality. Normality was tested using the Shapiro-Wilk test. All categorical and dichotomous data were tested with a chi-square test. Kaplan-Meier curves were constructed, and a Mantel-Cox (log-rank) test was performed to compare survival between the 2 groups.

A multivariable analysis was performed to correct for covariates. The following variables were selected for multivariable analysis: age, sex, diagnosis of dementia, and Katz-ADL. Age, sex and dementia were included in the multivariable analysis as covariables because they are known risk factors for complications and mortality.[18-20] Katz-ADL score was included because of significant baseline differences between cohorts. Continuous predictor variables (i.e., age and Katz-ADL) were tested for linearity with a 2-tailed Pearson correlation test and had a linear correlation at the $p < 0.05$ level. Little's missing completely at random (MCAR) test was performed for patterns of missing data. Data was not missing completely at random ($p < 0.001$), which was caused by a significant difference in missing data between cohorts. There was significantly more missing data in the historical cohort. This type of selective missing data pattern is called missing at random (MAR) and should be dealt with using multiple imputation.[21-23] Missing data were imputed using the expectation-maximization technique (10 imputations). A binary logistic regression analysis was performed for complications and mortality to calculate odds ratios (OR) and 95% confidence intervals (CI). A multivariable regression analysis for continuous outcome variables (i.e., time at the ED, time to surgery, hospital length of stay) was not feasible, because these variables were non-normally distributed at the $p < 0.001$ level with the Shapiro-Wilk test. Additionally, there was too much data missing for these outcomes. All statistical analyses were done using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., 2017, Armonk, NY). A p-value of <0.05 was set as significant for all tests. This paper was written in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[24]

Results

For the historical cohort, 524 patients were included and a total of 282 patients were included in the orthogeriatric trauma unit cohort (Figure 1).

Baseline Characteristics

Median age was 85 years in the historical cohort (IQR 80-89) and 85 years in the orthogeriatric trauma unit cohort (IQR 80-90), $p = 0.527$ (Table 1). There were 380 female patients (73%) in the historical cohort and 199 (71%) in the orthogeriatric trauma unit cohort, $p = 0.557$. A total of 133 (26%) patients were diagnosed with dementia in the historical cohort, versus 77 (28%) in the orthogeriatric trauma unit cohort, $p = 0.679$. Patients in the historical cohort were less dependent at baseline in terms of KATZ-ADL: median 0 (IQR: 0-2) in comparison to the patients in the orthogeriatric trauma unit cohort: median 3 (IQR: 0-5), $p < 0.001$. There were no significant differences between the 2 cohorts at baseline in terms of living situation, fracture type or surgical procedure.

Table 1. Baseline Characteristics.

Baseline variable	Data missing n (%)	Orthogeriatric care unit cohort (n = 282)	Historical cohort (n = 524)	*p*-value
Age; median (IQR)	0 (0)	85 (80-90)	85 (80-89)	0.527*
Female sex; n (%)	0 (0)	199 (71)	380 (73)	0.557
Prior diagnosis of dementia; n (%)	15 (2)	77 (28)	133 (26)	0.679
KATZ-ADL score, median (IQR)	160 (20)	3 (0-5)	0 (0-2)	**<0.001***
Living situation; n (%)	16 (2)			0.224
At home		141 (50)	238 (47)	
At home with ADL assistance		55 (20)	130 (26)	
Nursing home		33 (12)	65 (13)	
Institutional care facility		51 (18)	77 (15)	
Fracture type; n (%)	20 (3)			0.091
Medial femoral neck		153 (57)	287 (55)	
Trochanteric femur		109 (41)	228 (44)	
Subtrochanteric femur		6 (2)	3 (1)	
Surgical procedure; n (%)	2 (0)			0.592
Conservative treatment		0 (0)	2 (0)	
Hemiarthroplasty		127 (45)	237 (45)	
Cannulated hip screw		7 (3)	7 (1)	
Dynamic hip screw		28 (10)	46 (9)	
Intramedullary nail		120 (43)	230 (44)	

Statistically significant differences are shown in bold. *Mann Whitney U Test was performed for variables with a non-normal distribution at the $p < 0.001$ level (Shapiro-Wilk test).
Abbreviations: IQR; interquartile range, KATZ-ADL; Katz Index of Independence in Activities of Daily Living score, ADL; Activities of Daily Living.

Table 2. Patient Outcomes Before and After Implementation of the Orthogeriatric Trauma Unit, Univariable Analysis.

	Missing n (%)	Orthogeriatric care unit cohort (n = 282)	Historical cohort (n = 524)	*p*-value	Relative reduction**
Complication during admission; n (%)	3 (0)	117 (42)	257 (49)	**0.034**	**14%**
Time spent at the ED in minutes; median (IQR)	54 (7)	160 (110-228)	198 (142-257)	**<0.001***	**19%**
Time to surgery in hours; median (IQR)	53 (7)	20 (15-25)	21 (16-25)	0.343*	
Hospital length of stay in days; median (IQR)	42 (5)	6 (4-10)	6 (4-9)	0.284*	
30-day mortality; n (%)	2 (0)	26 (9)	47 (9)	0.919	
90-day mortality; n (%)	2 (0)	47 (17)	88 (17)	0.945	
1-year mortality; n (%)	2 (0)	75 (27)	153 (29)	0.415	

Statistically significant differences are shown in bold. *Mann Whitney U Test was performed for variables with a non-normal distribution at the $p < 0.001$ level (Shapiro-Wilk test) **Relative reduction was calculated for significant results only
Abbreviations: ED; emergency department, IQR; interquartile range

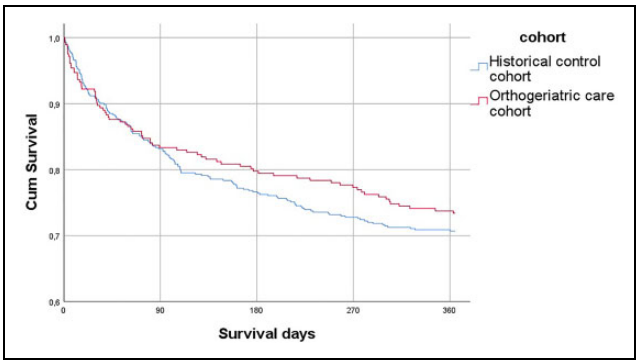

Figure 2. Kaplan Meier analysis.

Univariable Analysis of Patient Outcomes

After implementation of the orthogeriatric trauma unit, there was a significant decrease (42% vs. 49%, $p = 0.034$) in the number of patients with a complicated course (Table 2). Median turnaround time at the ED was 160 minutes (IQR 110-228) in the orthogeriatric trauma unit cohort and 198 (IQR 142-257) in the historical cohort, $p < 0.001$. There were no significant differences in time to surgery, HLOS, or mortality in the univariable analysis.

Survival Analysis

The survival analysis is shown for both cohorts (Figure 2). The orthogeriatric trauma unit cohort showed an overall 30-day

Table 3. Patient Outcomes, Multivariable Analysis.

Outcome	Variable	OR	95% CI	*p*-value
Complication during admission	*Treatment in orthogeriatric trauma unit*	0.654	0.471-0.908	0.011
	Age (per year increase)	1.064	1.040-1.088	<0.001
	Male sex	0.964	0.700-1.327	0.822
	Diagnosis of dementia	0.954	0.649-1.403	0.811
	Prefracture KATZ-ADL (per point increase)	1.052	0.953-1.162	0.308
30-day mortality	*Treatment in orthogeriatric trauma unit*	0.795	0.465-1.389	0.421
	Age (per year increase)	1.068	1.026-1.112	0.001
	Male sex	2.248	1.344-3.761	0.002
	Diagnosis of dementia	1.777	0.989-3.191	0.054
	Prefracture KATZ-ADL (per point increase)	1.152	1.001-1.327	0.049
90-day mortality	*Treatment in orthogeriatric trauma unit*	0.807	0.522-1.246	0.334
	Age (per year increase)	1.074	1.041-1.108	<0.001
	Male sex	2.393	1.596-3.589	<0.001
	Diagnosis of dementia	1.598	1.004-2.542	0.048
	Prefracture KATZ-ADL (per point increase)	1.110	0.995-1.239	0.062
1-year mortality	*Treatment in orthogeriatric trauma unit*	0.656	0.450-0.957	0.029
	Age (per year increase)	1.077	1.049-1.106	<0.001
	Male sex	2.227	1.557-3.183	<0.001
	Diagnosis of dementia	1.709	1.144-2.555	<0.001
	Prefracture KATZ-ADL (per point increase)	1.158	1.052-1.275	<0.001

None of the multivariable models showed a significant lack of fit (Hosmer and Lemeshow test).
Abbreviations: OR; odds ratio, CI; confidence interval, KATZ-ADL; Katz Index of Independence in Activities of Daily Living score

survival of 91%, a 90-day survival of 83% and a 1-year survival of 73%. The historical cohort showed an overall 30-day survival of 91%, a 90-day survival of 83% and a 1-year survival of 71%. Survival functions between the cohorts were not statistically different (log-rank test $p = 0.428$) without correction for covariates.

Multivariable Analysis of Patient Outcomes

After correcting for covariates age, sex, dementia and Katz-ADL score, patients who received care after implementation of the orthogeriatric trauma unit cohort had a significantly lower chance of complications (OR 0.654, 95% CI 0.471-0.908, $p = 0.011$) (Table 3). Patients in the orthogeriatric trauma unit cohort did not have a lower chance of 30-day mortality (OR 0.795, 95% CI 0.465-1.389, $p = 0.421$) or 90-day mortality (OR 0.807, 95% CI 0.522-1.246, $p = 0.334$). However, patients in the orthogeriatric trauma unit had a significantly lower chance of 1-year mortality (OR 0.656, 95% CI 0.450-0.957, $p = 0.029$).

Discussion

Red Line and Take-Home Message

This study shows that an integrated orthogeriatric trauma unit with shared responsibilities by the surgeon and the geriatrician reduces postoperative complications, 1-year mortality, time spent at the ED, and results in better data registration for clinical studies.

Comparison With Previous Literature

This study corresponds with previous studies that found a reduction in postoperative complications after implementing orthogeriatric trauma units.[5,9,15] In this study, time spent at the ED was reduced by 38 minutes (19%) after implementation of the orthogeriatric trauma unit. A previous study reported no significant reduction in time spent at the ED, although it may have been underpowered.[14]

In this study, hospital length of stay was not reduced after the implementation of the orthogeriatric trauma unit. A systematic review and meta-analysis compared 18 studies and found an average reduction in hospital length of stay of 0.25 days after implementation of geriatric care models.[5] However, the clinical relevance of such a marginal reduction is debatable. A randomized controlled trail comparing orthogeriatric care and usual care for hip fracture patients found a reduction in HLOS of 1.7 days.[10] Median time to surgery after the implementation of the orthogeriatric trauma unit was within 24 hours of presentation. Time to surgery over 24 hours is associated with more postoperative complications.[25] Time to surgery is not routinely collected in studies investigating the efficacy of geriatric trauma units, but previous studies that did investigate this outcome did not find any significant differences.[5,7,26] Thus, a thorough geriatric workup does not appear to increase time to surgery.

This study showed that patients in the orthogeriatric trauma unit had a lower chance of 1-year mortality. This corresponds with the results of a systematic review and meta-analysis that showed that integrated orthogeriatric care pathways reduce 1-year mortality.[5] In this study, differences in survival between groups became apparent after 90 days (Figure 2). The geriatric awareness program before the implementation may have reduced mortality in the historical cohort, thus resulting in bias that would underestimate the effect of implementation of orthogeriatric care in comparison to usual care.

Interpretation of Results

In this study, the implementation of an orthogeriatric trauma unit led to a decrease in complications. Although the effect was smaller than the 10% used in the power calculation, the sample size was large enough to detect this difference. The implementation of the orthogeriatric trauma unit may have led to better detection and registration of complications in comparison to the historical cohort. This possibility of detection bias may have led to an underestimation of the effect of orthogeriatric trauma unit on complications.

There were significantly more missing baseline data and outcome data in the historical cohort as described in the methods section ($p < 0.001$). This not surprising, as it is likely the result of better data registration for patients admitting to the orthogeriatric trauma unit. For example, there was a significant difference between the orthogeriatric trauma unit cohort and historical cohort in terms of Katz-ADL. Most of the missing data (n = 116) were in the historical cohort. This may be a possible source of bias, although this effect is not large because the overall amount of missing data is small and was imputed. This difference underscores that better data registration for patients admitted to the orthogeriatric trauma units will lead to higher quality data for clinical studies in the future.

A total of 69 patients were eligible for inclusion in the study, but were not admitted to the orthogeriatric trauma unit because the unit was at maximum capacity. These patients were younger at baseline (median 81 years, IQR 76-87) in comparison to patients admitted to the orthogeriatric trauma unit (median 85 years, IQR 80-90, $p = 0.011$), but there were no other baseline differences. This is a possible source of selection bias, because selective exclusion of younger patients may have led to an underestimation of the effect of the orthogeriatric trauma unit. The overall effect of this bias is likely to be small because the authors corrected for age and other covariates in the multivariable analysis.

Strengths and Limitations

This study adds another high-quality study with a large sample size to evaluate the effect of orthogeriatric trauma units. Our study used time-to-event data, which allowed the construction of Kaplan-Meijer curves and survival analysis. A previous study described overall survival in geriatric patients with any fracture in an orthogeriatric trauma unit but did not make a comparison with a control group.[27] This study is also the first to demonstrate a positive effect of process optimization after implementation of an orthogeriatric care model on time spent at the ED. Time spent at the ED is a relevant outcome measure because older patients with hip fractures are at risk for underassessment of pain and poorer pain management when time spent at the ED is longer.[28] A longer time spent at the ED is associated with longer time to surgery,[29] which is in turn associated with poorer patient outcomes.[30,31] The 19% reduction found in this study can help reduce the workload for both physicians and nurses at the ED. More importantly, it can improve the overall experience for the patient. Because for our patients, the waiting starts after they fall.[29]

This study has a few limitations. Apart from mortality, only short-term outcomes were measured in this study because it is difficult to obtain a good follow-up for geriatric trauma patients, particularly in retrospective studies. Geriatric patient populations in clinical studies are very prone to selective loss to follow-up. Additionally, this study only collected traditional outcome measures (i.e., mortality, complications, etc.) but no patient-reported outcome measures or functional outcomes. There is some evidence that orthogeriatric care models can improve these outcomes as well. A randomized controlled trail investigating the effect of orthogeriatric care on patient reported outcome measures found an improved quality of life at 4 months and 12 months follow-up, as well as improved physical function.[10] The authors advocate to use more patient-centered outcomes in future investigations and recommend that future studies in this field should include patient-reported outcome measures.

Conclusion

In conclusion, this study showed that implementation of an orthogeriatric trauma unit led to a decrease in postoperative complications, 1-year mortality, and time spent at the ED while also improving the quality of data registration for clinical studies. Although further studies are needed, physicians dealing with geriatric hip fracture patients regularly should consider integrating multidisciplinary orthogeriatric trauma care for their patients.

Authors' Note

This study was approved by the local institutional review board and medical ethical committee of St. Antonius Hospital (registration number Z17.048). The Dutch Medical Research Involving Human Subjects Act (WMO) did not apply to this study. This study was carried out in accordance with the ethical standards laid down in the 1964 the World Medical Association Declaration of Helsinki and its later amendments.

Declaration of Conflicting Interests

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Supplemental Material

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