ORIGINAL ARTICLE

CrossMark

The consistency of care for older patients with a hip fracture: are the results of the integrated orthogeriatric treatment model of the Centre of Geriatric Traumatology consistent 10 years after implementation?

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Abstract

Summary In the past 10 years after implementation, the orthogeriatric treatment model led in general to consistent outcomes for 1555 older adults in terms of most of the complications and mortality. Surgery was more often delayed to 24–48 h after arrival at the hospital, while the length of hospital stay shortened.

Introduction Since 1 April 2008, patients aged ≥ 70 years presenting themselves with a hip fracture at Ziekenhuisgroep Twente (ZGT) have been treated according to the orthogeriatric treatment model. The aim of this study was to investigate if outcomes of the orthogeriatric treatment model are consistent over the first 10 years after implementation.

Methods Between 1 April 2008 and 31 December 2016, patients aged ≥ 70 years who were surgically treated at ZGT for a hip fracture were included and divided into three periods equally distributed in time. Patient characteristics, in-hospital logistics, complications, and mortality data were compared between the three periods.

Results A total of 1555 patients were included. There was a shift in the surgical treatment for the fractured neck of femur from dynamic hip screw/cannulated screws to hemiarthroplasty ($p < 0.001$). Surgery within 24 h after arrival to the hospital decreased ($p < 0.001$), while surgery within 48 h stayed the same ($p = 0.085$). Length of hospital stay significantly decreased over time ($p < 0.001$). Complication rates were consistent except for the number of postoperative anemia, delirium, and urinary tract infections. Mortality rates did not change over the years.

Conclusions The orthogeriatric treatment model leads in general to consistent outcomes concerning mortality and most of the complications, except for postoperative anemia, delirium, and urinary tract infections. Inconsistent complication rates were influenced by altered diagnosis and treatment protocols. Length of hospital stay reduced, while time to surgery was more often delayed to 24–48 h. Monitoring clinical outcomes of the orthogeriatric treatment model over time is recommended in order to optimize and maintain the quality of care for this frail patient population.

Keywords Hip fracture · Orthogeriatric · Fragility fracture · Aged · Outcome

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Introduction

Hip fractures are common, affecting 1.5 million people per year worldwide. Due to the aging of population, hip fractures are expected to increase to approximately 6.3 million per year by 2050 [1]. Most hip fracture patients are characterized by older age, multiple comorbidities, and functional and cognitive impairment. The prognosis of a hip fracture is poor. One-year mortality can be up to 36%. Only 50% of the patients who were able to function independently in performing basic activities of daily living (ADL) before the fracture regain independence in performing ADL at 6 months after surgery [2–4].

In April 2008, the Centre for Geriatric Traumatology (CvGT) was founded at Ziekenhuisgroep Twente (ZGT) location Almelo in order to optimize the quality of care for this frail population. It was the first center in the Netherlands with an integrated orthogeriatric treatment model. Three years later, the treatment model was also implemented at the other location of the hospital. The treatment model is characterized by rapid surgical management, intensive co-management by the geriatrician, and the use of multidisciplinary clinical pathways, starting at the emergency department (ED) up to the outpatient clinic. Besides focusing on trauma surgery, these pathways focus on other age-related aspects such as limiting the risk of developing delirium, comorbidity, nutritional status, osteoporosis, and prevention of falls. One of the most important features of this treatment model is the proactive attitude on preventing patients from adverse events.

Earlier research of Folbert et al. has shown that the implementation of the orthogeriatric treatment model at ZGT was associated with a reduction in complications, length of stay, re-admissions, in-hospital mortality, and 1-year mortality [5, 6]. These studies describe the unfavorable patient profile of our population. Age, comorbidities, osteoporosis, and dementia make that the elderly hip fracture patient is more frail than the elderly patient without a hip fracture [7]. The concept of frailty is a geriatric syndrome characterized by the age-associated decline in physiological reserve and function across multi-organ systems, leading into increased vulnerability for adverse health outcomes [8].

Nowadays, we are 10 years after the implementation of the orthogeriatric treatment model. Although there are a number of papers published about outcomes of the orthogeriatric treatment for older adults with hip fractures in comparison to usual care, literature about the consistency of the outcome of the treatment model after the implementation phase is scarce [6, 9–13]. The aim of this study was to evaluate the consistency of the orthogeriatric treatment model over the past 10 years, in terms of in-hospital logistics, postoperative complications and mortality. This could be useful in order to evaluate the quality of care given to this patient population, change treatment protocols if needed, and share experiences for benchmarking with other hospitals.

Methods

Study design

Between 1 April 2008 and 31 December 2016, all patients with the diagnostic treatment code "218 Femur, proximal (+collum)" treated at both locations of ZGT were included. Patients younger than 70 years, patients without a hip fracture, and patients not surgical treated in ZGT were excluded. Other exclusion criteria were preoperative mortality, pathological or periprosthetic fracture, referral to the orthopedic service for total hip arthroplasty and patients not treated according to the orthogeriatric treatment model. Patients who were not treaded according the orthogeriatric treatment model were those who were admitted to a department where the treatment model was not yet implemented. Included patients were divided into three periods, equally distributed in time based on date of admission: P1 (April 2008–February 2011), P2 (March 2011–January 2014), and P3 (February 2014–December 2016). In the first period, the orthogeriatric treatment model was only implemented at location A. Location H started with the implementation at the second period, taking the experiences of the health care professionals of location A into account. In the first period (P1), patients treated at location A were included; at the second and third period (P2 and P3), patients from both locations were included.

Setting

The integrated orthogeriatric treatment model at ZGT was characterized by early geriatric co-management starting at the admission to the ED. At the ED, most hip fractures were diagnosed using radiographs, consisting of an anteroposterior and a lateral projection of the hip. Blood tests, a chest radiograph, and an electrocardiography were taken for preoperative assessment. The patient was admitted to the CvGT as fast as possible. The geriatrician was called by the physician at the ED and visited the patient at the ED or CvGT. Comprehensive geriatric assessment was performed to identify geriatric conditions and to develop a personalized treatment plan. Hip fracture surgery was performed as fast as safely possible. In the CvGT, the patient was daily visited by a resident surgery (RS), a nurse practitioner (NP), or a physician assistant (PA) specialized in trauma surgery. The treatment was evaluated in a daily meeting between the RS/NP/PA and the geriatrician. During admission, a medication review, osteoporosis status, possible causes of falls, and nutritional status took place. A multidisciplinary meeting was held twice a week, in which a trauma surgeon, a geriatrician, a dietician, a physiotherapist and an elderly care physician were present. The aim was to have the patients ready for discharge within 5 days after surgery.

Data collection

In this study, the patient characteristics registered at baseline were age, gender, American Society of Anesthesiologist physical status classification (ASA score) [14], Charlson Comorbidity Index (CCI score) [15], pre-fracture living, fracture type, surgical treatment, hemoglobin level at admission, anemia at admission (defined as hemoglobin levels < 7.45 mmol/l in female and < 8.07 mmol/l in male [16]), dementia, history of osteoporosis, the Barthel Index (at

admission and at discharge), and the Parker Mobility Score (PMS) [17]. The ASA score is an assessment of a patient's overall health before the surgery, scored by anesthesiologists [14]. The CCI score contains 19 weighted comorbidities predictive for the 1-year mortality, including diabetes with diabetic complications, congestive heart failure, peripheral vascular disease, chronic pulmonary disease, mild and severe liver disease, hemiplegia, renal disease, leukemia, lymphoma, metastatic tumor, and acquired immunodeficiency syndrome [15]. The Barthel Index measures independence in activity of daily living (ADL) at admission and at discharge, with a total score ranging from 0 (fully dependent in ADL) to 20 (fully independent in ADL) [17]. The PMS measures the mobility level before fracture at admission, with a total score ranging from 0 (no walking ability) to 9 (fully independent walking ability) [18, 19].

The following complications were registered prospectively using the clinical care pathway: postoperative anemia, arrhythmia, cerebrovascular accident, delirium, heart failure, myocardial infarction, pneumonia, pulmonary embolism, renal failure, urinary tract infection, re-operation, and mortality (see Appendix 1 for definitions of complications). Mortality data have been obtained from the municipal death registry and was documented in time intervals: in-hospital mortality, and mortality within 30 days, 1 year, and 3 years after hip fracture surgery. Data of the 3-year survival of the third period (P3) was not yet available. To scrutinize the in-hospital logistics, length of stay at the ED, time to surgery after arrival to the hospital, and length of hospital stay were registered.

Statistical analysis

Categorical variables are described as number with corresponding percentages. Continuous variables are described as mean with standard deviation (SD), or in case of non-parametric data as median with interquartile range (IQR). Differences in baseline characteristics, logistic outcomes, complications, and mortality were tested between the three different periods using a chi-square test (Fisher's exact tests if appropriate) for categorical data and a one-way ANOVA with a Tukey's post hoc test, or a Kruskal-Wallis test for continuous data. Survival analysis was performed using Kaplan-Meier analysis. Three-year survival rates were described in percentages with 95% confidence intervals (CI). Comparison of the survival distribution was performed using the log rank test. A $p < 0.05$ was regarded as being statistically significant. All statistical analyses were carried out using the Statistical Package for the Social Sciences version 23 (SPSS Inc., Chicago, USA).

Results

Patient characteristics

A total of 2938 patients with a hip fracture were registered, of which 2082 patients were 70 years or older and underwent a surgical procedure for hip fracture in ZGT. A total of 527 patients were excluded as a consequence of preoperative mortality, pathological or periprosthetic fracture, total hip arthroplasty placement, double cases, or patients not treated according the orthogeriatric treatment model of the CvGT (Fig. 1). Of the 1555 patients included, 385 patients were admitted during the first period (P1: April 2008–February 2011), and respectively, 589 and 581 were admitted during the second (P2: March 2011–January 2014) and third period (P3: February 2014–December 2016).
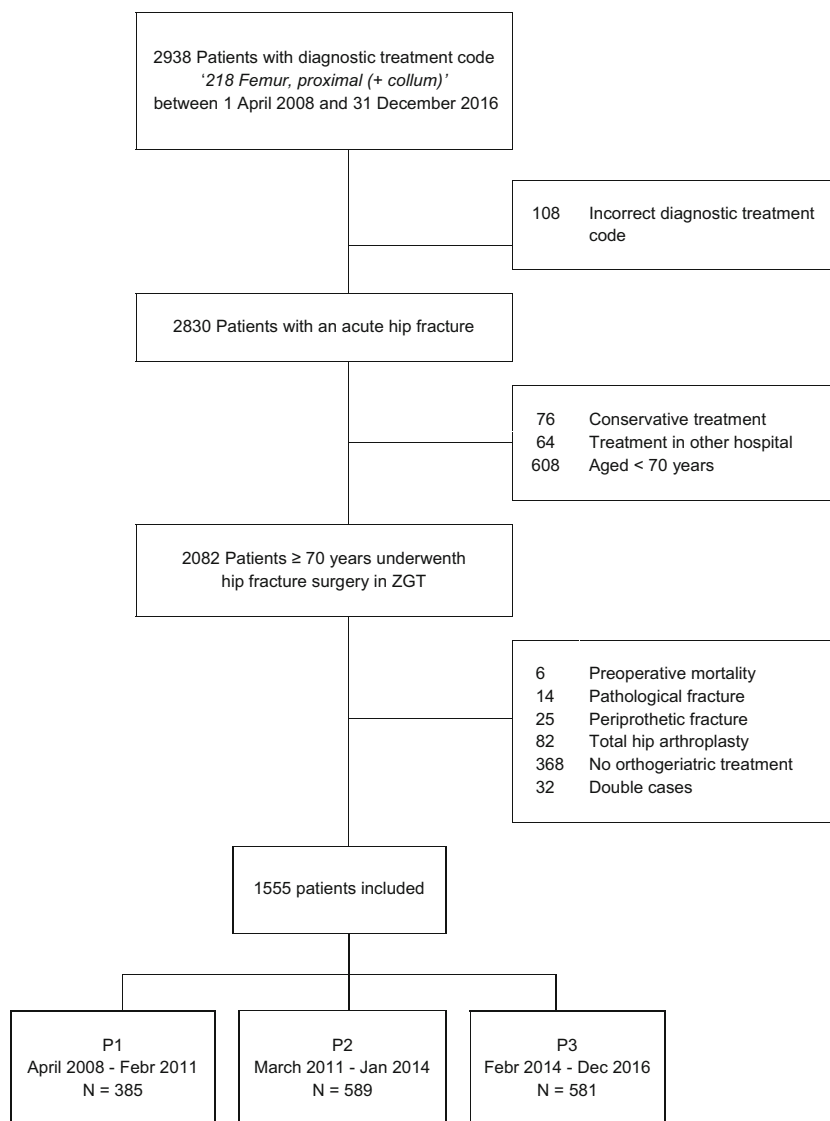
Seventy-two percent ($n = 1118$) of the included patients were female. The mean age was 83.1 years (SD 6.4 years). There was no difference in age ($p = 0.106$) or gender ($p = 0.094$) between the three periods. Sixty-eight percent of the included patients ($n = 1038$) had an ASA score of ≥ 3. Patients in the first and second period had a significantly higher ASA score in comparison to the patients in the third period (ASA ≥ 3: P1 = 81.2%, P2 = 71.5%, P3 = 53.3%, $p < 0.001$). There was a shift in the surgical treatment of the fractured neck of femur from dynamic hip screw (DHS)/cannulated screws to hemiarthroplasty ($p < 0.001$). Other baseline characteristics were not different between the three periods presented (Table 1).

In-hospital logistics

In-hospital logistics are presented in Table 2. The length of stay at the emergency department decreased significantly over the years ($p = 0.020$). Surgery within 24 h after arrival to the hospital decreased (P1 = 72.9%, P2 = 73.8%, P3 = 64.7%, $p < 0.001$), whereas surgery within 48 h after arrival to the hospital did not change over the periods ($p = 0.085$): 96.2% of all the patients underwent surgery within 48 h after arrival to the hospital. Length of hospital stay in days significantly decreased over time (median (IQR): P1 = 9.8 (6.0–15.8), 7.9 (5.9–11.0), 6.9 (5.9–8.9), $p < 0.001$).

Complications

Complications, mortality, and 3-year survival are presented in Table 3. The number of arrhythmia, cerebrovascular accident, heart failure, myocardial infarction, pneumonia, pulmonary embolism, and renal failure was not different between the periods. The number of postoperative anemia was comparable for the first (15.8%) and second period (19.4%), but significantly increased in the third period (25.2%) (chi-square post hoc test: P1 versus P3, $p = 0.001$; P2 versus P3, $p = 0.017$). Type of

Fig. 1 Study inclusion and exclusion criteria

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┌──────────────────────────────────────┐
│ 2938 Patients with diagnostic         │
│ treatment code                        │
│ '218 Femur, proximal (+ collum)'      │
│ between 1 April 2008 and 31 December  │
│ 2016                                  │
└──────────────────────────────────────┘
                │
                │      ┌─────────────────────────────────────┐
                │      │ 108    Incorrect diagnostic treatment│
                │      │        code                          │
                │      └─────────────────────────────────────┘
                │
┌──────────────────────────────────────┐
│ 2830 Patients with an acute hip       │
│ fracture                              │
└──────────────────────────────────────┘
                │
                │      ┌─────────────────────────────────────┐
                │      │  76    Conservative treatment        │
                │      │  64    Treatment in other hospital   │
                │      │ 608    Aged < 70 years               │
                │      └─────────────────────────────────────┘
                │
┌──────────────────────────────────────┐
│ 2082 Patients ≥ 70 years underwenth   │
│ hip fracture surgery in ZGT           │
└──────────────────────────────────────┘
                │
                │      ┌─────────────────────────────────────┐
                │      │   6    Preoperative mortality        │
                │      │  14    Pathological fracture         │
                │      │  25    Periprothetic fracture        │
                │      │  82    Total hip arthroplasty        │
                │      │ 368    No orthogeriatric treatment   │
                │      │  32    Double cases                  │
                │      └─────────────────────────────────────┘
                │
┌──────────────────────────────────────┐
│ 1555 patients included                │
└──────────────────────────────────────┘
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P1	P2	P3
April 2008 - Febr 2011	March 2011 - Jan 2014	Febr 2014 - Dec 2016
N = 385	N = 589	N = 581

surgery was significantly associated with postoperative anemia (anemia per type of surgery: dynamic hip screw (DHS)/cannulated screws 7.0%, hemiarthroplasty 19.4%, proximal femur nail antirotation (PFN) 29.9%, $p < 0.001$). There was no difference in postoperative anemia per period per type of surgery. The number of urinary tract infections significantly decreased over the time (P1 = 10.1%, P2 = 8.3%, P3 = 4.3%, ($p = 0.001$)). There was a difference in number of observed delirium over period (P1 = 28.1%, P2 = 22.9%, P3 = 31.5%, $p = 0.004$). The prevalence of delirium significantly increased in P3 in comparison to P2 (chi-square post hoc test: $p = 0.001$), but no differences were found between P1 and P2 or P1 and P3 (chi-square post hoc test respectively $p = 0.070$ and $p = 0.253$). There was a significant association between the complications postoperative anemia and observed delirium (26.3% ($n = 112$) anemia in patients with a delirium, 18.5% (209) anemia without a delirium, $p = 0.001$). The number of reoperations and the reason for reoperation within 60 days after surgery did not differ between the three periods. Deep wound infection as reason for reoperation did not change over period (chi-square post hoc test, $p = 0.293$).

Mortality

The overall in-hospital mortality was 5.0% ($n = 77$), and the 30-day mortality was 8.0% ($n = 124$). Over periods, there was no difference in in-hospital mortality or 30-day mortality. Also, the 1-year mortality did not change over period (P1 = 25.2%, P2 = 23.4%, P3 = 22.5%; $p = 0.635$). The 3-year survival in the first period of 51% (95% CI 45–56%) was comparable with the 3-year survival of 56% in the second period (95% CI 52–60%, $p = 0.262$) (Fig. 2).

Table 1   Patient characteristics

	Total (*n* = 1555)	P1 (*n* = 385)	P2 (*n* = 589)	P3 (*n* = 581)	*P* value*
Age; mean (SD)	83.1 (6.4)	82.6 (6.5)	83.0 (6.5)	83.5 (6.3)	0.106
Gender; *n* (%)					0.094
Male	437 (28.1)	110 (28.6)	148 (25.1)	179 (30.8)	
Female	1118 (71.9)	275 (71.4)	441 (74.9)	402 (69.2)	
ASA score; *n* (%)					< 0.001
1–2	510 (32.8)	72 (18.8)	167 (28.5)	271 (46.7)	
3	892 (57.4)	275 (71.8)	349 (59.7)	268 (46.2)	
4–5	146 (9.4)	36 (9.4)	69 (11.8)	41 (7.1)	
Charlson Comorbidity Index; *n* (%)					0.998
0	364 (23.4)	94 (24.4)	136 (23.1)	134 (23.1)	
1–2	733 (47.1)	181 (47.0)	279 (47.4)	273 (47.0)	
3–4	339 (21.8)	80 (20.8)	130 (22.1)	129 (22.2)	
≥ 5	119 (7.7)	30 (7.8)	44 (7.5)	45 (7.7)	
Pre fracture living; *n* (%)					0.677
Independent, with/without home care services	1107 (71.2)	268 (69.8)	420 (71.3)	419 (72.1)	
Residential home/assisted living	207 (13.3)	49 (12.8)	77 (13.1)	81 (13.9)	
Institutionalized in nursing home	240 (15.4)	67 (17.4)	92 (15.6)	81 (13.9)	
Fracture type; *n* (%)					0.529
Neck of femur	829 (53.3)	205 (53.2)	307 (52.1)	318 (54.7)	
Intertrochanteric	663 (42.6)	165 (42.9)	253 (43.0)	245 (42.2)	
Subtrochanteric	61 (3.9)	15 (3.9)	29 (4.9)	17 (2.9)	
Other	1 (0.1)	0 (0.0)	0 (0.0)	1 (0.2)	
Surgical treatment; *n* (%)					< 0.001
DHS/cannulated screws	241 (15.5)	91 (23.6)	83 (14.1)	68 (11.7)	
Hemiarthroplasty	597 (38.4)	126 (32.7)	216 (36.7)	255 (43.9)	
PFNA	712 (45.8)	168 (43.6)	288 (48.9)	256 (44.1)	
Other	4 (0.3)	0 (0.0)	2 (0.3)	2 (0.3)	
Hemoglobin in mmol/l at admission; mean (SD)	7.9 (1.0)	7.9 (1.1)	7.9 (1.0)	7.8 (1.1)	0.098
Anemia at admission**; *n* (%)	635 (40.8)	145 (37.7)	232 (39.4)	258 (44.4)	0.075
Dementia; *n* (%)	325 (20.9)	85 (22.1)	119 (20.2)	121 (20.8)	0.780
Osteoporosis; *n* (%)	190 (12.2)	44 (11.4)	71 (12.1)	75 (12.9)	0.780
BI at admission; median (IQR)	17.0 (13.0–20.0)	16.0 (13.0–19.0)	17.0 (13.0–20.0)	17.0 (14.0–20.0)	0.567
BI at discharge; median (IQR)	10.0 (7.0–13.0)	11.0 (7.0–13.0)	10.0 (7.0–13.0)	10.0 (7.0–12.5)	0.230
PMS at admission; median (IQR)	6.0 (4.0–9.0)	6.0 (4.0–9.0)	6.0 (4.0–9.0)	6.0 (4.0–9.0)	0.342

ASA American Society of Anesthesiologists physical status classification, *BI* Barthel Index, *PMS* Parker Mobility Score, *DHS* dynamic hip screw, *PFNA* proximal femur nail antirotation, *SD* standard deviation, *IQR* interquartile range

*Differences were tested between the three different periods

**Defined as hemoglobin levels < 7.45 mmol/l in female and < 8.07 mmol/l in male [16]

Discussion

The aim of this study was to investigate if the outcomes of the orthogeriatric treatment model are consistent over the first 10 years after its implementation. Our results show in general consistent outcomes in terms of mortality and most of the complications, except for postoperative anemia, delirium, and urinary tract infection. This study is one of the few studies concerning the consistency of care and the long-term outcomes of the orthogeriatric treatment model [20].

We found that there was no difference in mortality over the first 10 years after the implementation. The mortality observed is comparable with mortality rates of 2.3–13.9% in-hospital mortality, 3.3–17.2% 30-day mortality, and 5.9–50.0% 1-year mortality mentioned in earlier studies [2, 3].

Most of the complication rates were also consistent over time. The inconsistent complication rates found were probably influenced by altered diagnosis and treatment protocols. For instance, the diagnosis urinary tract infection was based upon urine sediment analysis in the first years. However, the

Table 2   In-hospital logistics

	Total ($n = 1555$)	P1 ($n = 385$)	P2 ($n = 589$)	P3 ($n = 581$)	P value*
Length of stay at ED in minutes; mean (SD)	98.6 (49.0)	101.0 (47.9)	101.5 (50.7)	94.1 (47.8)	0.020
Time to surgery in hours**; median (IQR)	18.6 (8.3–25.4)	16.5 (6.5–24.6)	17.9 (8.2–25.2)	19.7 (11.2–27.3)	< 0.001
Surgery within 24 h**; n (%)	1082 (70.2)	280 (72.9)	431 (73.8)	371 (64.7)	0.001
Surgery within 48 h**; n (%)	1482 (96.2)	372 (96.9)	567 (97.1)	543 (94.8)	0.085
Length of hospital stay in days; median (IQR)	7.7 (5.8–11.0)	9.8 (6.0–15.8)	7.9 (5.9–11.0)	6.9 (5.6–8.9)	< 0.001

ED emergency department, *SD* standard deviation, *IQR* interquartile range

*Differences were tested between the three different periods

**After arrival to the hospital

diagnostic value of urine sediment analysis in patients with a catheter pointed out to be limited as a result of contamination. Therefore, pretreatment positive urine culture was considered as the golden standard in the last years. As a consequence, the number of urinary tract infection following the definition given in Appendix 1 decreased. The increased number of postoperative anemia in the third period is a consequence of the altered treatment for fractured neck of femur, as can be expected due to more perioperative blood loss in patients undergoing a hemiarthroplasty [21, 22]. It is important to realize that the altered treatment has led to an increase of postoperative anemia, because anemia could also lead to an increase of other complications. Therefore, the use of tranexamic acid to reduce the total blood loss might be a next step in further optimizing the care for elderly hip fracture patients [23].

The number of postoperative anemia was highest in patients treated with PFN. This is in line with previous studies that have shown that intramedullary fixation devices made a higher incidence of blood transfusions, probably due to the type of fracture (extracapsular) and the opening of the

Table 3   Complications and mortality

	Total ($n = 1555$)	P1 ($n = 385$)	P2 ($n = 589$)	P3 ($n = 581$)	P value*
Anemia (postoperative); n (%)	320 (20.6)	61 (15.8)	114 (19.4)	146 (25.2)	0.001
Arrhythmia; n (%)	67 (4.3)	22 (5.7)	25 (4.2)	20 (3.4)	0.234
Cerebrovascular accident; n (%)	9 (0.6)	3 (0.8)	4 (0.7)	2 (0.3)	0.699
Delirium; n (%)	426 (27.4)	108 (28.1)	135 (22.9)	183 (31.5)	0.004
Heart failure; n (%)	93 (6.0)	25 (6.5)	39 (6.6)	29 (5.0)	0.445
Myocardial infarction; n (%)	13 (0.8)	3 (0.8)	7 (1.2)	3 (0.5)	0.466
Pneumonia; n (%)	140 (9.0)	26 (6.8)	59 (10.0)	55 (9.5)	0.195
Pulmonary embolism; n (%)	3 (0.2)	0 (0.0)	1 (0.2)	2 (0.3)	0.628
Renal failure; n (%)	70 (4.5)	20 (5.2)	29 (4.9)	21 (3.6)	0.419
Urinary tract infection; n (%)	113 (7.3)	38 (10.1)	49 (8.3)	25 (4.3)	0.001
Reoperation ≤ 60 days; n (%)	60 (3.9)	10 (2.6)	22 (3.7)	28 (4.8)	0.210
Reason for reoperation ≤ 60 days; n (%)					0.958
Deep wound infection	25 (1.6)	3 (0.8)	10 (1.7)	12 (2.1)	
Dislocation implant hemiarthroplasty	4 (0.3)	0 (0.0)	2 (0.3)	2 (0.3)	
Failure implant PFNA	11 (0.7)	3 (0.8)	3 (0.5)	5 (0.9)	
Failure implant DHS/cannulated screws	9 (0.6)	2 (0.5)	3 (0.5)	4 (0.7)	
Wound dehiscence	2 (0.1)	0 (0.0)	1 (0.2)	1 (0.2)	
Hematoma	6 (0.4)	1 (0.3)	2 (0.3)	3 (0.5)	
Not related to hip fracture	1 (0.1)	0 (0.0)	1 (0.2)	0 (0.0)	
In-hospital mortality; n (%)	77 (5.0)	26 (6.8)	26 (4.4)	25 (4.3)	0.171
Mortality ≤ 30 days; n (%)	124 (8.0)	26 (7.3)	43 (7.3)	53 (9.1)	0.435
Mortality ≤ 1 year; n (%)	336 (23.5)	97 (25.2)	138 (23.4)	131 (22.5)	0.635
3-year survival; % (95% CI)		51 (45–56)	56 (52–60)		0.262

DHS dynamic hip screw, *PFNA* proximal femur nail antirotation, *CI* confidence interval

*Differences were tested between the three different periods
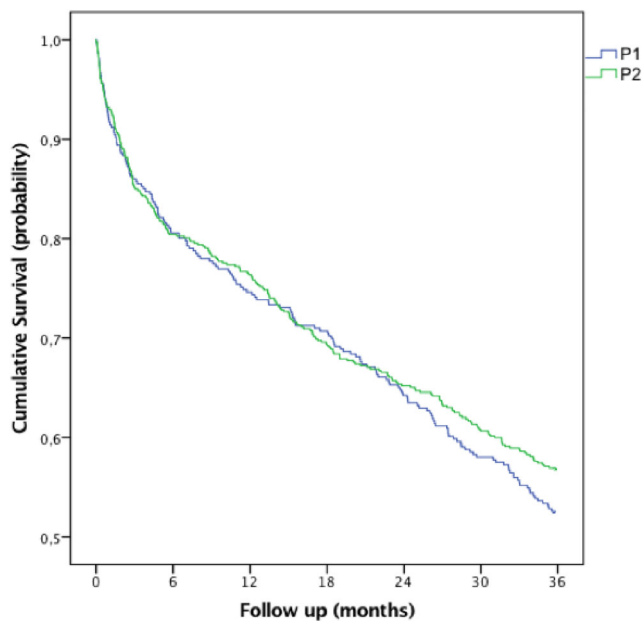
Fig. 2 Kaplan-Meier survival curve

medullary cavity and proximal reaming [24–27]. In our study, the number of postoperative anemia in patients treated with PFN was consistent over time. However, the hemoglobin level before surgery tended to be lower, and the number of preoperative anemia tended to be higher in the third period; there was no significant difference found over period in these patient characteristics. For this reason, it was not possible to find a relationship between a preoperative low hemoglobin level and/or anemia and postoperative.

The percentage observed delirium increased in the last period. We found a significant relationship between the complications postoperative anemia and observed delirium which is in line with the results of Blandfort et al., who found that a higher postoperative hemoglobin level after hip fracture surgery reduced the risk of delirium [28]. Despite the trend of lower mean hemoglobin level at admission and increase in prevalent anemia, there was no significant difference over the period. Therefore, it is not possible in our study to find a relation between prevalent anemia or hemoglobin level at admission and postoperative delirium. The relatively low percentage of delirium found in the second period could be a consequence of the start of the treatment model at location H, where the health care professionals were not yet as well educated as they were at location A. This may have led to a less frequently diagnosed delirium. Earlier studies have shown that delirium is often misdiagnosed due to lack of knowledge and awareness in nurses and doctors [29]. In our study, health care professionals were educated over time. Early recognition and diagnosis through growing geriatric expertise within the various disciplines contributed to the increase in number of diagnosed cases of delirium. A recommendation that could be made for the future is to put even more focus on diagnosing delirium.

Overall, the exact number of postoperative anemia (20.6%) and urinary tract infections (7.3%) is relatively low in comparison to wide range presented in previous studies (anemia 24–44%, urinary tract infections 12–61%) [30, 31]. The incidence of delirium (27.4%) is comparable to previous studies (13–56%) [30, 32].

The in-hospital logistics were inconsistent over time. The length of stay at the ED reduced. Patients had to wait longer for surgery, and fewer patients were treated within 24 h after arrival at the hospital. This might be partly a result of the introduction of the direct oral anticoagulants, which has to be omitted during 48 h before hip fracture surgery can take place [33]. Other reason may be a lower threshold for delaying surgery in order to achieve a better medical condition of the patient to reduce the risk of perioperative complications (e.g., in case of a pneumonia) or limited capacity of operating rooms. Surgical treatment within 48 h should be pursued following the national guidelines and the guidelines of the American Academy of Orthopedic Surgeons (AAOS), because there is no evidence for fewer complications when performing surgery within 24 h [34, 35]. In our study, the number of patient treated within 48 h was consistent over time.

The length of hospital stay decreased significantly, which is mostly a result of the agreements made with the nursing homes in order to shorten waiting time until transfer to geriatric rehabilitation departments. Over time, the patient characteristics did not change, except for the ASA score. The decreased percentage of patients with ASA ≥ 3 suggests that the patient's overall health nowadays is better before the surgery, but it could also be influenced by inconsistency of grading the ASA score between anesthesiologists that has been demonstrated in multiple studies before [14]. Another changed baseline characteristics was the type of surgery. We found strong evidence supporting hemiarthroplasty for patients with displaced femoral neck fractures which led to a shift in the surgical treatment of the fractured neck of femur from dynamic hip screw (DHS)/cannulated screws towards hemiarthroplasty over the years [34].

Since the implementation of the CvGT, we collect data for process monitoring, quality assessment, and research. Due to the aging population, the number of hip fractures is expected to increase. Much work has been done to optimize the treatment of this vulnerable elderly group. It might be worthwhile to use the results of this study for benchmarking with other hospitals and for national and international research into long-term effectiveness.

In our perspective, recommendations for future research would be to investigate the economic effect of the orthogeriatric comanagement, the effects of the use of direct oral anticoagulants on the outcome of hip fracture patients, the prevention of the most common complications (e.g., postoperative anemia, delirium, and pneumonia), and the evaluation of patient-reported outcome measurements.

Strengths and weaknesses analysis

One of the strengths of this study is that it is one of the few studies concerning the long-term outcomes of the orthogeriatric treatment. It is the first study in the Netherlands presenting the consistency of care in the first 10 years after implementation of the orthogeriatric treatment model, with a large study population. This study shows valuable insights in logistics and the outcomes that can be used for optimizing care.

A limitation of the study is selection bias, because the fittest elderly were treated with a total hip prosthesis and are excluded in this series. Overestimation of the favorable results seems therefore unlikely. Other points of criticism are the lack of literature to compare the study results with the missing data on the impact of a hip fracture on quality of life and the patient perspective.

Conclusion

The orthogeriatric treatment model for older adults with a hip fracture led in general to consistent outcomes in the 10 years after implementation in terms of mortality and most of the complications, except for postoperative anemia, delirium, and urinary tract infection. Length of hospital stay shortened, while surgery is more often delayed to 24–48 h after arrival at the hospital. Monitoring clinical outcomes of the orthogeriatric treatment model over time is recommended in order to optimize and maintain the quality of care for this frail patient population.

Compliance with ethical standards

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