Optimizing Geriatric Trauma Care

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Optimizing Geriatric Trauma Care

Optimaliseren van Geriatrische Trauma Zorg

(met een samenvatting in het Nederlands)

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Voor Anette,

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CONTENT

1

General introduction

General introduction and outline of the thesis

A BRIEF HISTORY OF HIP FRACTURE MANAGEMENT

Historically, a fractured hip would be treated with bed rest while applying traction to the injured leg (1). This would allow the bone to heal, restore length and reduce pain. Unfortunately, unlike just about any bone in the body, the femoral neck never seemed to heal. Furthermore, inappropriate treatment could even accelerate death.

In 1822, Sir Astley Cooper (1768-1841) was the first to describe the two most common fractures of the upper end of the femur, medial fracture and pertrochanteric fracture. However, like many surgeons at the time, he did not believe that these fractures could heal. This led to his famous quote '*treat the patient and let the fracture go*'. Almost a century later, the first successful closed nailing of fractures of the femoral neck was performed (2). Surgical fixation led to improved pain control, less deformities and, perhaps most important, faster mobilization. After that, many new techniques and implants were developed.

After a century of innovation in hip fracture management, the rate of improvement in the outcome of hip fracture patients seemed to be levelling off. In 2014, Mundi et al. published a systematic review of randomized controlled trials on hip fracture management published between 1950 and 2013. They found similar mortality and reoperation rates in surgically treated hip fracture patients over the past 31 years. With an average 1-year mortality rate around 20% over the last four decades they emphasized the need to improve outcomes. They believed that orthogeriatric care pathways could play an important role in the improvement of hip fracture management (3).

HISTORY OF ORTHOGERIATRIC TRAUMA CARE

When it comes to the development orthogeriatric trauma care, two orthopedic surgeons deserve particular attention: dr. Cosin and dr. Devas, and one physician, dr. Bobby Irvine.

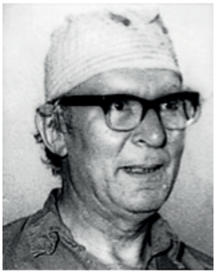
Lionel Cosin (1910-1994)

Lionel Cosin was a general surgeon and geriatrician who worked during the second world war as superintendent in the Emergency Medical Service at Orsett Hospital in Essex (4). If new patients with femoral neck fractures were deemed as chronically ill, not fit for surgery and in need of permanent care, Cosin decided to perform surgery on these patients anyway and admitted them to the ward and provided early rehabilitation therapy supervised by physiotherapists. This led to the discharge of many patients who would have otherwise remained bedridden.

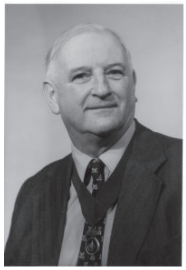
Lionel Cosin

Michael Devas (1920-1999) and Bobby Irvine (1920-2002)

Michael Devas, an orthopedic surgeon, worked closely with his colleague Bobby Irvine, a consultant geriatrician at the Hastings Health Authority in the 1950s (5). Together they advocated for interdisciplinary collaboration which translated into combined physician-surgeon ward rounds and later on they would establish the first orthogeriatric unit in Hastings (6,7). Devas favored early operation for frail elderly as well as early rehabilitation (8). In 1974, he would publish the concept and principles of Geriatric Orthopedics in the British Medical Journal, which remain essentially unchanged years later (9).



Michael Devas



Bobby Irvine

ORTHOGERIATRIC CARE MODELS

Over the last decades, many orthogeriatric care models for hip fracture patients were developed. In 2010, Kammerlander et al performed a literature review that studied different orthogeriatric care models which he could categorize into four groups defined by the intervention:

1. Orthopedic ward and geriatric consultant service
2. Orthopedic ward and daily consultative service
3. Geriatric rehabilitation ward and orthopedic consultant service
4. Orthopedic ward and integrated care

Kammerlander showed that the group with integrated care could show the lowest in-hospital mortality rate, the lowest length of stay, and the lowest mean time to surgery (10). In 2014, Grigoryan et al. performed a systematic review and meta-analysis on the effect of orthogeriatric care models (routine geriatric consultation, geriatric ward with orthopedic consultation and shared care) on outcome in hip fracture patients. The study showed that all sorts of orthogeriatric collaboration led to a significant decrease of mortality and hospital length of stay. In addition, Kates evaluated literature on hip fracture programs and found that elements of highly organized hip fracture programs include standardized order sets, use of a clinical care pathway, co-management with a medical physician and orthopedic surgeon, early surgery, early mobility with weight bearing permitted, early discharge planning and the use of lean business principles to optimize patient care (11). In this thesis, we will focus on integrated orthogeriatric care pathways (12).

ORTHOGERIATRIC CARE PATHWAYS IN THE NETHERLANDS

Orthogeriatric care pathways in the Netherlands were initially introduced in 2006, when two geriatricians (Klaren-Florijn, MD and Regtuijt, MD) and two trauma surgeons (van der Velde, MD, PhD and Hegeman, MD, PhD) shared a combined vision regarding geriatric trauma care. This led to the establishment of the Center for Geriatric Traumatology (CvGT). It would be the first integrated orthogeriatric care pathway in the Netherlands (13). The concept was based on the 'Rochester model', a comprehensive program that combines co-management of the patient by orthopedic trauma-surgeons and geriatricians with lean business principles to create an improved model of patient care (14,15).

Since then, many hospitals in the Netherlands have implemented multidisciplinary care pathways. The desire to improve the care for this population led to the Dutch Hip Fracture Audit (DFHA), which was founded in 2016 (16). The DHFA is a multidisciplinary national registry to improve to quality of care for patients with a hip fracture. This registry made it possible to compare different trauma centers, serves as a benchmark and makes it possible to study geriatric care pathways on a larger scale.

FUTURE PROJECTIONS

These days, a hip fracture is still the most catastrophic type of osteoporotic fracture due to its associated risk of morbidity, mortality, loss of independence, subsequent fracture, and its economic burden to the healthcare system (17–19). In 1990, there were an estimated 1.6 million osteoporotic hip fractures world-wide (20). Furthermore, the number of osteoporotic hip fractures is estimated to increase to 2.6 million by the year 2025 and will almost double to 4.5 million by the year 2050. People aged 65 or over are projected to account for almost one in three people globally by 2050 and with 86% of the hip fractures occurring in this population, the socioeconomic burden will become a serious challenge in the next decades (17,21).

In the Netherlands, approximately 200 million euros was spent on osteoporosis-related fractures in 2010. 55% of these costs were due to osteoporosis-related hip fractures. Projections of incidence and healthcare costs over time indicate that this burden will increase by 40–50 % between 2010 and 2030 (22).

OPTIMIZING GERIATRIC TRAUMA CARE

Flow is a critical component of process management. Patient flow is the movement of a patient through a healthcare facility. It contains all medical care, resources and internal systems that are needed to guide patients from admission to discharge while maintaining quality. Optimizing patient flow makes the movement of patients through care pathways faster and more efficient while improving patient safety and their outcome.

Integrated care pathways are the first step, however, implementing a validated care pathway doesn't automatically lead to the optimal situation. There are many barriers that could potentially affect a successful implementation that will affect patient flow as well (23). To reduce delays and unclog bottlenecks, assessing and improving flow between and among hospital departments, and throughout the entire system, rather than in isolated departments is vital.

AIMS AND OUTLINE OF THIS THESIS

As described above, the field of geriatric trauma care is gaining more importance. The rapid change of age distribution in western societies require new approaches towards geriatric trauma care. This raises the following important questions: what are the outcomes of the implementation of traumageriatric care pathways in the Netherlands and Switzerland? Do cultural clinical practices influence traumageriatric care pathways? Do modifications to existing traumageriatric care pathways improve care? These questions lead to the aim of my thesis.

Overall aim of this thesis

Optimizing geriatric trauma care: from implementation of traumageriatric care pathways to modification of existing traumageriatric pathways for hip fracture patients.

To achieve this aim, the first part (Part I) of this thesis will focus on the implementation and effectiveness of geriatric care pathways. The second part (Part 2) evaluates modifications to existing traumageriatric care pathways with a purpose to improve patient flow and patient outcome.

PART I. PART I. THE EFFECT OF TRAUMAGERIATRIC CARE PATHWAYS FOR HIP FRACTURE PATIENTS IN THE NETHERLANDS AND SWITZERLAND

First, the importance of multidisciplinary care is discussed in **chapter 2**. Second, the implementation of a geriatric care pathway in Switzerland was investigated in **chapter 3**. In **chapter 4**, the implementation of a geriatric care pathway in the Netherlands was evaluated. An inter-hospital comparison of different approaches towards geriatric trauma care was studied in **chapter 5**. In **chapter 6**, two geriatric care pathways in the Netherlands and Switzerland were compared.

PART II. MODIFICATIONS OF EXISTING TRAUMAGERIATRIC CARE PATHWAYS WITH A PURPOSE TO IMPROVE PATIENT FLOW AND PATIENT OUTCOME

The next chapters discuss different interventions in the geriatric care pathways to optimize flow and patient outcome. The Parker Mobility Score was investigated as a predictor for discharge disposition after surgery in **chapter 7**.

The implementation of a resuscitation protocol *Preoperative Hemodynamic Preconditioning* in a geriatric care pathway was studied in **chapter 8**. Inter-rater agreement in pPOSSUM scores of geriatric patients was investigated in **chapter 9**.

PART III. GENERAL DISCUSSION AND SUMMARY

Chapter 10 presents the general discussion and recommendations for future research corresponding to the results of the studies in this thesis. **Chapter 11** (English) and **Chapter 12** (Dutch) present a summary with the main findings of this thesis.

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PART I

The effect of traumageriatric care pathways for hip fracture patients in the Netherlands and Switzerland

2

Hip fracture in elderly patients; additional value of a multidisciplinary approach and concentration of care

van der Vet P, Kusen J, van Dijk M, Houwert RM, Verleisdonk EJMM, van der Velde D. Heupfractuur bij ouderen

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ABSTRACT

Management of elderly patients with a proximal femoral fracture is an increasing challenge for the Dutch healthcare system. Proximal femoral fractures in the elderly have high morbidity and mortality rates. Furthermore, healthcare costs for this group of patients are rising. Referral, operation, and postoperative care demand efficient collaboration between healthcare professionals. Every step in this chain of events is crucial for optimal treatment results. Multidisciplinary orthogeriatric trauma care shows promising results. In addition, high volume care results in better outcome of geriatric trauma patients.

DAMES EN HEREN,

De oudere patiënt met een heupfractuur vormt een toenemende uitdaging voor de traumazorg in Nederland. Heupfracturen bij ouderen gaan gepaard met een hoge mortaliteit, hoge morbiditeit en hoge kosten (1). Door de toenemende vergrijzing is de piekincidentie nog niet bereikt. Aan de hand van 3 casussen willen wij de meerwaarde van een multidisciplinaire benadering en concentratie van zorg illustreren voor de oudere patiënt met een heupfractuur.

Patiënt A, een 91-jarige vrouw, was gevallen tijdens het boodschappen doen. De huisarts wilde een heupfractuur uitsluiten en stuurde haar dezelfde dag in naar ziekenhuis A, een level 2-traumacentrum zonder multidisciplinaire geriatrische traumazorg. Ze woonde zelfstandig en liep zonder hulpmiddelen; ze kreeg enkele malen per week thuishulp. De voorgeschiedenis vermeldde hypercholesterolemie, stabiele angina pectoris en hypertensie. Ze gebruikte hiervoor amlodipine, losartan, simvastatine en triamtereen/hydrochloorthiazide.

In het ziekenhuis werd de diagnose 'gedislokeerde collum femorisfractuur' gesteld. Vóór opname werd met patiënte op de SEH een reanimatiegesprek gevoerd. Zij gaf aan dat zij hier nog niet over had nagedacht en de reanimatiecode werd de volgende ochtend vastgesteld in samenspraak met de familie. Patiënte gaf hierbij aan niet meer gereanimeerd te willen worden.

De volgende dag werd patiënte geopereerd, waarbij traumachirurg een kop-halsprothese plaatste. Postoperatief waren er geen complicaties en patiënte kon vlot mobiliseren. Na enkele dagen had zij echter last van orthostatische hypotensie, flauwvallen en algehele malaise. De internist werd in consult gevraagd. Bij controle van haar thuismedicatie en navraag bij de huisarts bleken de klachten te berusten op een te hoge dosering van amlodipine. In plaats van eenmaal daags 5 mg had patiënte tweemaal daags 5 mg gekregen. Dit was gebaseerd op de dosering die het laatst in het ziekenhuissysteem was genoteerd. Dit incident werd besproken met patiënte en haar familie en er werd een melding van gemaakt volgens het gangbare protocol 'Melding incidenten patiëntenzorg' binnen het ziekenhuis.

Na aanpassing van de amlodipinedosering herstelde patiënte vlot. Na een 10-daagse opname werd ze ontslagen naar een verpleeghuis, waar ze kortdurend revalideerde.

Patiënt B was een 88-jarige vrouw die thuis was uitgegleden. Ze werd gezien op de SEH van ziekenhuis B, een level 2-traumacentrum met een zorgpad voor multidisciplinaire geriatrische traumazorg. Zij woonde alleen, maar dit ging moeizaam omdat ze een beginnend dementieel beeld had; ze ontving al uitgebreide thuishulp. De thuisverpleegkundige had haar bijna 24 h na de val gevonden. De voorgeschiedenis vermeldde acuut hartfalen, mitralisklepinsufficiëntie, een linkerventrikelfunctie van 15% en COPD. Patiënte gebruikte acenocoumarol en hydrochloorthiazide.

In het ziekenhuis was patiënte onderkoeld, met een rectaal gemeten temperatuur van 35°C. Radiologisch onderzoek toonde een collum femoris fractuur rechts. Daarnaast was er sprake van een nierfunctiestoornis, mogelijk door de combinatie van dehydratie en gebruik van hydrochloorthiazide, en een urineweginfectie. Er had al eerder een gesprek plaatsgevonden met de huisarts waar een niet-reanimerenbeleid was besproken. Direct werd een klinisch geriater in consult gevraagd. Ook werd de anesthesioloog preoperatief betrokken bij de behandeling.

De geriater stopte de hydrochloorthiazide en schreef antibiotica voor de urineweginfectie voor. De anesthesioloog, geriater en traumachirurg overlegden over de timing van de operatie en het pre- en perioperatief vochtbeleid. Om een delier gedurende de opname te voorkomen werd patiënte behandeld met haloperidol. De verlengde stollingstijd (INR: 2,3) werd gecoupeerd.

De volgende dag werd patiënte aangemeld voor operatie, waarbij een kop-halsprothese werd geplaatst onder spinale anesthesie. De dagen na de operatie stelde de klinisch geriater de vochtbalans dagelijks bij en kon patiënte toenemend gemobiliseerd worden. Na 6 dagen werd zij overgeplaatst naar een verpleeghuis in de buurt. De medicatie was gedurende de klinische opname aangepast aan de nieuwe situatie. Alle betrokken specialisten stelde een gezamenlijke ontslagbrief op met adviezen over medicatie, een mobilisatieschema en een toekomstige inventarisatie van de valneiging.

Patiënt C, een 74-jarige vrouw, was uitgegleden op straat en werd vanwege een vermoeden van een heupfractuur door de ambulance binnengebracht op de SEH. Zij was een actieve dame en wandelde dagelijks minimaal 1 uur. De voorgeschiedenis vermeldde hypertensie en perifeer arterieel vaatlijden. Als thuismedicatie gebruikte zij acetylsalicylzuur, amlodipine en metoprolol.

Wij stelden de diagnose 'gedislokeerde collum femorisfractuur'. In samenspraak met patiënte en na overleg tussen de traumachirurg en de orthopedisch chirurg werd gekozen voor plaatsing van een totale heupprothese (THP). Daags na de val opereerde de orthopedisch chirurg patiënte. Het postoperatieve beloop verliep ongecompliceerd en patiënte kon na 4 dagen uit het ziekenhuis worden ontslagen.

BESCHOUWING

Deze 3 casussen laten zien dat de verwijzing, operatie en postoperatieve zorg van ouderen met een heupfractuur goede samenwerking vereisen, zowel tussen de eerste en tweede lijn als tussen de verschillende specialismen in het ziekenhuis. Elke stap in deze keten is cruciaal voor het uiteindelijke behandelresultaat. Daarom is juist voor deze patiëntengroep multidisciplinaire zorg van groot belang. Dit komt naar voren in het verschil tussen de casus van patiënt A en die van patiënt B. Hoewel patiënt B met meer medische problemen in het ziekenhuis werd opgenomen, ging ze door de optimale multidisciplinaire samenwerking eerder met ontslag. Wij lichten dit hieronder stapsgewijs toe en bespreken het belang van concentratie van zorg.

DE VERWIJZING

Voor een adequate verwijzing zijn een medicatie- en een reanimatiebeleid van belang. Zoals de casus van patiënt A illustreert is een goede medicatieoverdracht van de eerste naar de tweede lijn cruciaal. Medicatiefouten zijn een veelvoorkomende oorzaak van vermijdbare schade in de zorg. Een deel daarvan is toe te schrijven aan een incompleet en onjuist overzicht van de gebruikte medicatie. In het ziekenhuis zijn deze fouten hoofdzakelijk het gevolg van discrepanties tussen de thuis- en opnamemedicatie (2). Deze fouten kunnen worden verminderd door medicatieverificatie bij opname, met name bij ongeplande, al dan niet trauma gerelateerde opnames.

De taak van de eerste lijn is te zorgen voor een volledige overdracht bij verwijzing en die van de tweede lijn is medicatie zorgvuldig te controleren en eventueel te optimaliseren waar nodig. De klinisch geriater als medebehandelaar kan hier een cruciale rol in spelen, zoals duidelijk wordt uit casus van patiënt B.

Tevens moeten zorgverleners zich blijvend bewust zijn van de potentiële risico's op recidiverend vallen bij het gebruik van bepaalde medicatie. Sommige medicijnen verhogen niet alleen het initiële risico op vallen, maar geven ook een blijvend verhoogd valrisico, zelfs in vergelijking met het risico op incidentele valincidenten (3).

In onze regio (Utrecht) vindt voor een oudere patiënt met een heupfractuur standaard een reanimatiegesprek plaats op de SEH. Zowel voor de arts als de patiënt kan zo'n gesprek lastig zijn, zeker als dit onderwerp voor het eerst besproken wordt (4). Dit kan tot gevolg hebben dat het reanimatiegesprek wordt uitgesteld totdat bijvoorbeeld de familie beschikbaar is, zoals bij patiënt A. Maar bij deze patiëntengroep is dit niet wenselijk, omdat zij een mortaliteit gedurende opname heeft van 4-7% in onze regio, afhankelijk van de comorbiditeit (5). Ook hier ligt een mogelijkheid voor intensievere samenwerking met de eerste lijn. Wij willen graag een lans breken voor het proactief bespreken van eventuele behandelwensen en beperkingen door de huisarts, zoals bij patiënt B gebeurde.

DE OPERATIE

Recent is de richtlijn 'Proximale femurfracturen' gereviseerd, waarin wordt geadviseerd bij een oudere patiënt met een gedislokeerde collum femorisfractuur in principe een endoprothese te plaatsen (6). Waar in het verleden frequent werd gekozen voor een kop-halsprothese, is de huidige tendens om sneller een totale heupprothese te plaatsen. Functionele resultaten (pijn) en kwaliteit van leven na een THP zijn op de lange termijn beter dan na een kop-halsprothese (6,7). De indicaties voor een THP volgens de richtlijn staan in de tabel (6).

TABEL Indicaties voor plaatsing van een totale heupprothese volgens de richtlijn 'Proximale femurfracturen'[6]

indicatie
gedislokeerde mediale collum-femorisfractuur
leeftijd 61-80 jaar
geen cognitieve beperking
ASA-klasse 1 of 2 voor anesthesie zonder optimalisatie
patiënt loopt buitenshuis zonder of met hooguit 1 hulpmiddel
fractuur in pathologisch veranderd botweefsel
kenmerken van vergevorderde artrose
na gezamenlijke besluitvorming

ASA = American Society of Anesthesiologists.

Leeftijd is tegenwoordig een relatief begrip. Patiënt C was weliswaar 74 jaar, maar ze was lichamelijk en geestelijk veel jonger. De richtlijn laat zien dat de overweging om een THP te plaatsen niet louter is gebaseerd op getallen, maar dat de fysieke en geestelijke toestand van patiënt medebepalend zijn voor de indicatie (6).

Voor een kop-halsprothese geldt dat de patiënt na de operatie volledig mag belasten. Voor de kwetsbare oudere patiënt is dat essentieel ter voorkoming van complicaties. Een THP vereist dat de patiënt coöperatief is. Gezien het risico op een posterieure luxatie dient een strikt behandelprotocol gevolgd te worden en is een goed instrueerbare en mobiele patiënt essentieel.

Doordat tegenwoordig eerder gekozen voor een THP wordt, is een intensievere samenwerking nodig tussen traumachirurgen en orthopedisch chirurgen. Idealiter worden alle patiënten die eventueel in aanmerking komen voor een THP besproken in een multidisciplinair overleg tussen beide specialismen.

DE ZIEKENHUISZORG

Er zijn goede resultaten beschreven van eigen bodem over multidisciplinaire geriatrische traumazorg waarbij de nadruk ligt op het voorkómen van complicaties (1,8). Deze zorg wordt gekenmerkt door intensieve medebehandeling door de anesthesioloog en klinisch geriater, waarbij de afdeling Traumachirurgie fungeert als casemanager. Pre- en postoperatieve pijnbestrijding vindt protocollair plaats door de afdeling Anesthesie.

Tijdens de dagelijkse visites staat de klinisch geriater de traumachirurg bij. De klinisch geriater is verantwoordelijk voor het inschatten en behandelen van een delier of het risico hierop, het behandelen van comorbiditeit, het voorkómen en behandelen van complicaties, het optimaliseren van medicatie bij polyfarmacie, het analyseren van valproblematiek en het adviseren over de indicatiestelling voor een vervolginstelling. 2 keer per week vindt een multidisciplinair overleg plaats (8).

Deze multidisciplinaire zorg resulteert in minder complicaties gedurende opname, een vaker gestelde diagnose ‘delier’ en behandeling hiervan, minder consulten van andere specialisten en minder heropnames binnen 30 dagen (8). Deze veelbelovende resultaten uit Almelo moeten verder worden gevalideerd in prospectief multicentrisch onderzoek. Ook op de lange termijn zijn goede resultaten beschreven, met een daling van de 1-jaarsmortaliteit van 12% vergeleken met een historisch cohort (1).

Na een heupfractuur moeten patiënten snel gemobiliseerd worden. Een goede infrastructuur op een speciale geriatrische traumatologieafdeling is daarbij essentieel, met goede afstemming met de fysiotherapie, continuïteit van medische zorg door een speciaal daarvoor opgeleide physician assistant of verpleegkundig specialist, betrokken diëtisten, een huiskamer waar gezamenlijk de lunch wordt gebruikt en een goede relatie met omringende verpleeg- en verzorgingshuizen.

TOEKOMST: CONCENTRATIE VAN ZORG?

De richtlijn 'Proximale femurfracturen' stelt dat het voor een oudere patiënt met een heupfractuur niet acceptabel is meer dan één nacht in het ziekenhuis door te brengen zonder operatie (6). In onze regio hebben we de duur van opname tot operatie vergeleken tussen een level 1- en level 2-traumacentrum (5). Deze studie laat zien dat 85% van de patiënten in het level 2-centrum binnen 24 h wordt geopereerd, vergeleken met maximaal 65% in het level 1-traumacentrum. Ook zijn er significant minder niet-chirurgische complicaties in het level 2-centrum. Dit verschil wordt onder andere veroorzaakt door de geriatrische medebehandeling in het level 2-traumacentrum, zoals beschreven in de casus van patiënt B. Er was geen verschil tussen beide centra in chirurgische complicaties.

Deze uitkomsten komen overeen met grote databasestudies. Een databasestudie naar de relatie tussen het volume en de uitkomst bij 40.000 geriatrische traumapatiënten toont dat een toename van het aantal geriatrische patiënten dat wordt behandeld in een traumacentrum, gerelateerd is aan minder complicaties en een lagere mortaliteit (9). Deze resultaten worden ondersteund door een databasestudie uit Finland: bij 22.000 geriatrische patiënten met een heupfractuur was er een gunstig effect van het volume op het aantal niet-chirurgische complicaties (10). Ook hier werd geen relatie gezien tussen het volume en chirurgische complicaties.

Bovenstaande resultaten in combinatie met de beschikbare literatuur hebben in onze regio geresulteerd in een verschuiving van oudere patiënten met een heupfractuur van level 1- naar level 2-centra.

LEERPUNTEN

- **Heupfracturen bij ouderen gaan gepaard met een hoge mortaliteit, hoge morbiditeit en hoge kosten.**
- **Voor de verwijzing, operatie en postoperatieve zorg van ouderen met een heupfractuur is goede samenwerking nodig, zowel tussen de eerste en tweede lijn als tussen de verschillende specialismen in het ziekenhuis.**
- **Hoog-volumezorg heeft een positief effect op de uitkomst van geriatrische traumapatiënten.**

DAMES EN HEREN,

De behandeling van de oudere patiënt met een heupfractuur vereist optimale samenwerking tussen zowel de eerste en tweede lijn als de verschillende specialismen in het ziekenhuis. Multidisciplinaire geriatrische traumazorg laat veelbelovende resultaten zien, waarbij hoog-volumezorg een positieve invloed heeft op de uitkomst van geriatrische traumapatiënten.

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3

The implementation of a Geriatric Fracture Centre for hip fractures to reduce mortality and morbidity: an observational study

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ABSTRACT

Introduction: The aim of this study was to evaluate the effect of an orthogeriatric treatment model on elderly patients with traumatic hip fractures (THF). The Geriatric Fracture Centre (GFC) is a multidisciplinary care pathway with attention for possible age-related diseases, discharge management and out-of-hospital treatment.

Methods: A prospective cohort study with a historical cohort group was conducted at a level I trauma center in Switzerland. Patients over the age of 70 years with THFs who underwent surgical treatment at GFC in 2013 and 2016 were included. Primary outcomes were mortality and complications. Secondary outcomes were hospital length of stay (HLOS), time to surgery and place of discharge.

Results: A total of 322 patients were included in this study. In 2016, mortality showed a reduction of 2.9% at 30 days ($p = 0.42$) and 3.4% at 90 days ($p = 0.42$) and 0.1% at 1 year ($p = 0.98$). The number of patients with a complicated course showed a decrease of 2.2% in 2016 ($p = 0.69$). A significant increase in the diagnosis of delirium by 11.2% was seen in 2016 ($p < 0.001$). The median HLOS was significantly reduced by 2 days ($p < 0.001$). An increase of 21.1% was seen in patients who were sent to rehabilitation in 2016 ($p < 0.001$). Daytime surgery increased by 10.2% ($p = 0.04$).

Conclusion: The implementation of the GFC led to improved processes and outcomes for geriatric patients with THFs. Increased awareness and recognition led to an increase in the diagnosis of complications that would otherwise remain untreated. Expanding these efforts might lead to more significant effects and an increase in the reduction of morbidity and mortality in the future.

INTRODUCTION

The population of elderly patients has grown in the recent decades due to life expectancy increases. As a result, the incidences of hip fractures in elderly patients are rising (1).

Frail elderly patients often experience limitations in performing activities of daily living (ADL) and have reduced physiological capabilities to withstand major injuries like hip fractures without further loss of function and further compromise of health status (2). The literature shows that up to 25% of patients die within the first year after a hip fracture. This risk increases with age (3). Patients over the age of 50 years have a five- to eightfold increased risk for all-cause mortality during the first 3 months after hip fractures (4). Additionally, comorbidity and polypharmacy complicate treatment and increase the risks of complications and losses of functionality (5,6). The costs of treatment are high and are expected to rise in the future (7). There is sufficient literature to justify paying extra attention to the needs of this frail population.

In Switzerland, more than half of patients with hip fractures needed help with ADL before the fracture, and well over one-third were diagnosed with, or were suspected of having dementia. Many of them had co-morbidities. One year after a hip fracture, 30% of the patients who were ADL independent prior to the fracture, required assistance with ADL (8).

To improve care for this patient population, various comanaged approaches to optimize care and provide appropriate support to the growing number of geriatric fracture patients were developed to reduce mortality and morbidity (9,10).

In central Switzerland, a GFC did not yet exist. Therefore, in 2015, the first certified (DGU®) Geriatric Fracture Centre of central Switzerland was established (11). Geriatric care pathways were developed for the treatment of fractures in the elderly population. In this study, we evaluated the impact of the implementation of a geriatric care pathway for patients with traumatic hip fractures (THF). We hypothesized that the implementation of the GFC concept would reduce mortality, morbidity, and hospital length of stay (HLOS). Primary outcomes were mortality and complications. Secondary outcomes were HLOS, time to surgery and place of discharge.

METHODS

This article was written in accordance with the STROBE criteria (12).

Study design

A single center combined retrospective and prospective cohort study in elderly trauma patients was conducted. Ethical approval for the quality improvement project was given by the responsible ethical commission (Ethikkommission Nordwest- und Zentralschweiz, EKNZ 2014-343).

Study population

We retrospectively analyzed all patients over the age of 70 years with THFs in 2013. This cohort was used as baseline.

Prospectively, an analysis of all patients over the age of 70 years admitted with THFs between January 2016 and December 2016 was performed. Patients were excluded if they had periprosthetic fractures or if the fractures were treated non-operatively. Patients who were treated in 2014 and 2015 were excluded to reduce the interference of the transition period to a Geriatric Fracture Centre (GFC).

Geriatric Fracture Centre concept

The GFC officially became a certified geriatric trauma center in 2015 after completing the certification process necessary for a hospital to receive the designation 'AltersTraumaZentrum, DGU®'. The criteria for this certificate were endorsed by the German trauma organization (Deutsche Gesellschaft fur Unfallchirurgie, DGU®) (13). The GFC was co-directed by a trauma surgeon and a geriatrician with shared leadership responsibilities as described by Friedman et al. (10). The multidisciplinary team consisted of trauma surgeons, geriatricians, anesthetists, physiotherapists, rheumatologists, nurses, social (discharge) workers, psychiatrists and dieticians who worked together to provide a pathway with the potential to optimize outcome for each individual patient both during hospital admittance and after discharge. The GFC was carried out hospital-wide and every member of the team was committed to implementing these new improvements. During the planning of each step of treatment, the individual values of both patients and relatives were considered. The patients received well-coordinated treatment that, alongside the acute problem, involved attention for possible age-related diseases, discharge management and out-of-hospital treatment.

Geriatric care pathway for traumatic hip fractures

The geriatric care pathway provided extra care in both the pre-, peri- and postoperative phase.

Preoperative pathway

Preoperatively, the pPossum score was calculated by the anesthesiologist or a resident on admission. The pPossum scoring system is a method of calculating expected surgical outcome defined as risk of mortality (14). All patients followed the same pathway, with allowances for individual patient needs if deemed necessary after comprehensive geriatric assessment. A case manager was involved in care planning throughout the duration of the hospital admission. The patients' medications were evaluated, and all patients received extensive blood testing (type and screen, coagulation, electrolytes, [para]thyroid hormones, vitamin deficiencies, liver enzymes, [pre]albumin and renal lab). Furthermore, specific attention was given to screen for and prevent delirium (confusion assessment method) and nutrition risk scores (NRSs) during admission (15,16). Surgery was scheduled within 24 h after arrival, when possible, preferably during daytime. If surgery was delayed, patients received preoperative physiotherapy that focused on respiratory therapy and on maintaining strength in the upper extremities.

Perioperative pathway

The aim of surgical treatment was to achieve direct postoperative full-weight bearing. Therefore, surgical concepts with minimal iatrogenic injury and implants designed for patients that are likely to have osteoporosis were used.

Postoperative pathway

Postoperatively, patients did not receive non-steroidal anti-inflammatory drugs (NSAIDs) or benzodiazepines. At the first postoperative day, routine blood tests and mini-mental state examinations (MMSEs) were performed (17). Mobilization began on the first postoperative day, since it reduces incidences of delirium and pneumonia, improves function, and is associated with lower mortality (18). Daily visits by the treating surgeon and a geriatrician took place until discharge. The geriatrician was responsible for the patients' comprehensive geriatric assessment. A dietician was actively involved during the recovery period at the ward. The hospital's pain management team was on standby for consultation when needed. Depending on the patients' medical conditions and other contextual factors, they were referred either to their homes, rehabilitation clinics, nursing homes (temporary or permanent) or to nearby acute geriatric rehabilitation clinics. The entire multidisciplinary team, the patients and their relatives were involved in the decision-making process.

Multidisciplinary follow-up visits with the involvement of the geriatrician, surgeon and physiotherapist were scheduled. Thereby, the geriatrician was responsible for the comprehensive geriatric assessments of the patients, and the surgeon assessed the surgical outcomes. Furthermore, a dedicated physiotherapist performed standardized fall risk—e.g., mobility—assessments and talked with the patients about their individual goals. Osteoporosis screening was either performed by the geriatrician or the dedicated physiotherapist. According to the findings of the multidisciplinary evaluation, further steps considering the rehabilitation process were discussed and planned. The general practitioner and the treating physiotherapist received letters containing the evaluations and recommended actions.

Data collection

Data were collected through MedFolio, a web-based clinical electronic patient documentation (EPD) system, which was developed for use of both clinicians and clinical support staff. All extracted data were added into pre-formatted Excel spreadsheets.

Baseline data included: age, sex, American Society of Anesthesiologists (ASA) classification and fracture type according to the Arbeitsgemeinschaft für Osteosynthesefragen (AO) (19,20).

The following perioperative data were retrieved: time to surgery (hours); time of surgery (daytime: 7:00–18:59, out-of-office hours 19:00–6:59); type of surgery (hemiarthroplasty, total hip prosthesis, intramedullary nail, sliding hip screw (including Dynamic Hip Screw [Depuy Synthes, Oberdorf Switzerland], Targon FN [B-Braun AG, Melsungen, Germany] and/or the use of cannulated screws).

Postoperative outcomes were: HLOS (days), number of complications per patient, number of patients with complicated courses and types of complications.

Postoperative complications were divided into two groups: surgical-related and non-surgical-related complications. Surgical-related complications included: wound infection (CDC guidelines), hematoma, acute anaemia (defined as blood loss requiring transfusion), revision of implant due to loss of reduction, screw cut-out/through, nail breakage, loss of fixation, joint infection, pulmonary embolism, and gastrointestinal bleeding.

Non-surgical-related complications included pneumonia (according to CDC guidelines), delirium (based on CAM and/or DOS), urinary tract infection (UTI) (according to CDC guidelines), cardiac failure (according to ESC guidelines), decubital ulcer, renal insufficiency, reanimation and cerebrovascular incident (CVI) (21-23).

Each complication that occurred fewer than five times in the entire cohort less was grouped under 'other'. Furthermore, data on place of discharge (home, nursery home, rehabilitation) were gathered for analysis.

Mortality was analyzed through patient documentation at 30 days, 90 days and 1 year after surgery.

Statistical analysis

Categorical variables were expressed as percentages, and numerical data as median and interquartile range (IQR). Categorical variables were compared by the Chi-squared test or Fisher's exact test (two-tailed), and continuous variables by the Mann–Whitney *U* test. A two-sided *p*-value of < 0.05 was considered statistically significant. Data were analyzed with the SPSS software package version 25.0 (IBM Corp., Armonk, NY, USA), for Windows.

RESULTS

Participants

A total of 350 patients over 70 years of age with THFs underwent operations in 2013 and 2016. Of the 164 patients analyzed in 2013, 154 were included. In 2016, 186 patients were analyzed, and 168 were included. In total, 322 patients were included for analysis. Further information on in- and exclusion is shown in Fig. 1.

Baseline characteristics

No significant differences were noted between the groups in terms of patient characteristics (Table 1).

Primary outcomes

Perioperative outcomes and postoperative complications and outcome measures can be found in Tables 2 and 3, respectively.

In 2016, mortality showed a reduction of 2.9% at 30 days (13.6% vs. 10.7%; $p = 0.42$) and 3.4% at 90 days (19.5% vs. 16.1%; $p = 0.42$). No difference was seen in mortality at 1 year in 2016 (29.9% vs. 29.8%; $p = 0.98$).

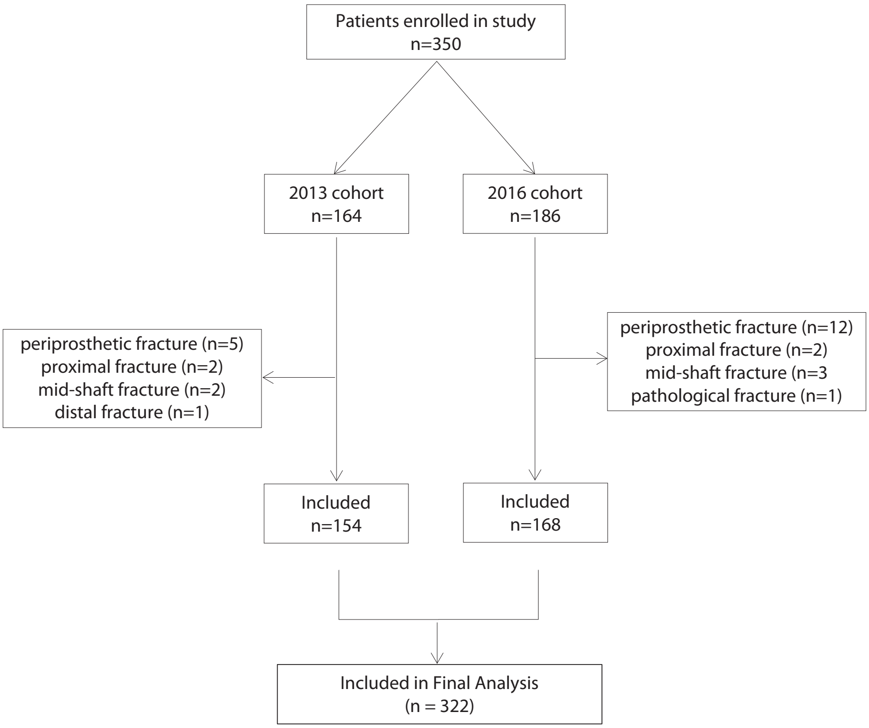

Fig. 1 Flowchart of patient inclusion

Table 1 Baseline characteristics

	2013 (*N* = 154)	2016 (*N* = 168)	*p*-value
Age (years) median (IQR)	86 (81–90)	85 (82–89.75)	0.87
Gender			0.70
Male, *n* (%)	43 (27.9)	44 (26.2)	
Female, *n* (%)	111 (72.1)	124 (73.8)	
ASA classification			0.09
ASA classification 1, *n* (%)	0 (0)	0 (0)	
ASA classification 2, *n* (%)	42 (27.3)	38 (22.6)	
ASA classification 3, *n* (%)	102 (66.2)	107 (63.7)	
ASA classification 4, *n* (%)	10 (6.5)	23 (13.7)	
Type of fracture			0.40
Femoral neck, *n* (%)	70 (45.5)	81 (48.2)	
PTF, *n* (%)	76 (49.3)	83 (49.4)	
Subtrochanteric, *n* (%)	8 (5.2)	4 (2.4)	

Numbers are noted in percentages of the total number of patients at the hospital.
N number of patients, *n* number of patients, *ASA classification* American Society of Anesthesiologists Physical Status Classification System, *ASA classification 1* a normal healthy patient, *ASA classification 2* a patient with mild systemic disease, *ASA classification 3* a patient with severe systemic disease, *ASA classification 4* a patient with severe systemic disease that is a constant threat to life, *PTF* pertrochanteric fracture

The number of patients with a complicated course and the number of complications per patient did not show significant decrease. When delirium was omitted as a complication, patients with complicated courses showed a reduction of 8.4% in 2016; however, this was not significant (54.3% vs, 45.9%; $p = 0.15$).

Surgical-related complications: no significant differences were seen in the surgical-related complications anemia, hematoma and other.

Non-surgical-related complications: delirium was diagnosed significantly more often in 2016 (1.9% vs. 13.1%; $p < 0.001$). Categories of pneumonia, UTI, cardiac failure and 'other' showed no significant differences.

Secondary outcomes

Hospital length of stay was reduced by 2 days in 2016 ($M = 9$ vs. $M = 7$; $p < 0.001$). Time to surgery showed no reduction in 2016 ($M = 15{:}34$ vs. $M = 18{:}51$; $p = 0.32$). A difference was also seen in places of discharge. In 2016, fewer patients were sent back home (14.9% vs. 4.8%; $p = 0.002$) or to a nursing home (74.0% vs. 63.1%; $p = 0.04$). In 2016, and more patients were sent to a rehabilitation facility (11.0% vs. 32.1%; $p < 0.001$).

Additional outcomes

In 2016, there were significantly more daytime surgeries (51.9% vs. 63.1%; $p = 0.04$).

Table 2 Perioperative outcomes

	2013 (*N* = 154)	2016 (*N* = 168)	*p*-value
Time to surgery			
Time to surgery (hh:mm) median (IQR)	15:34 (8:03–25:27)	18:51 (9:09–24:50)	0.32
Time of surgery			0.04
Daytime (7:00–18:59), *n* (%)	80 (51.9)	106 (63.1)	
Out-of-office hours (19:00–6:59), *n* (%)	74 (48.1)	62 (36.9)	
Type of surgery			0.51
Hemiarthroplasty, *n* (%)	58 (37.7)	68 (40.5)	
Total hip prothesis, *n* (%)	5 (3.2)	6 (3.6)	
Pertrochanteric fixation nail, *n* (%)	70 (45.5)	77 (45.8)	
Dynamic hip screw/targon fixation nail, *n* (%)	16 (10.4)	16 (9.5)	
Other *n* (%)	5 (3.2)	1 (0.6)	

Numbers are noted in percentages of the total number of patients at the hospital.
N number of patients, *n* number of patients, *IQR* interquartile range

Table 3 Postoperative outcomes

	2013 (*N* = 154)	2016 (*N* = 168)	*p*-value
HLOS (days) median (IQR)	9 (7–12)	7 (5–10)	< 0.001
Complications			
Patients with complicated courses, *n* (%)	85 (55.2)	89 (53.0)	0.69
Complications per patient			0.66
0 complications, *n* (%)	69 (44.8)	79 (47.0)	
1 complication, *n* (%)	60 (39.0)	58 (34.5)	
≥ 2 complications, *n* (%)	25 (16.2)	31 (18.5)	
Surgical-related complications			
Anemia, *n* (%)	66 (42.9)	61 (36.3)	0.23
Hematoma, *n* (%)	6 (3.9)	2 (1.2)	0.16
Other, *n* (%)	4 (2.6)	5 (3.0)	1.00
Non-surgical-related complications			
Pneumonia, *n* (%)	8 (5.2)	7 (4.2)	0.66
Delirium, *n* (%)	3 (1.9)	22 (13.1)	< 0.001
Urinary tract infection, *n* (%)	13 (8.4)	20 (11.9)	0.31
Cardiac failure, *n* (%)	7 (4.5)	12 (7.1)	0.32
Other, *n* (%)	6 (3.9)	4 (2.4)	1.00
Discharge disposition			
Home, *n* (%)	23 (14.9)	8 (4.8)	0.002
Nursing home, *n* (%)	114 (74.0)	106 (63.1)	0.04
Rehabilitation, *n* (%)	17 (11.0)	54 (32.1)	< 0.001
Mortality			
30-day mortality, *n* (%)	21 (13.6)	18 (10.7)	0.42
90-day mortality, *n* (%)	30 (19.5)	27 (16.1)	0.42
1-year mortality, *n* (%)	46 (29.9)	50 (29.8)	0.98

Numbers are noted in percentages of the total number of patients at the hospital. *N* number of patients, *n* number of patients, *SD* standard deviation, *IQR* interquartile range, *HLOS* hospital length of stay. *Cardiac failure* consists of myocardial infarction, decompensatio cordis and reanimation. Other consists of complications with a total incidence ≤ 5

DISCUSSION

Summary of main results

The goal of the GFC concept was the optimization of treatment for geriatric patients both during admission and after discharge by means of implementing a multidisciplinary care pathway. This retrospective and prospective cohort study analyzed the effect of the concept on the following performance indicators: mortality, complications, HLOS, place of discharge, time to surgery and timing of surgery.

Our study found no significant reduction in mortality and no reduction of the number of patients with a complicated course. However, a reduction of approximately 3% in short- and intermediate-term mortality was noted. HLOS was reduced significantly, significantly more patients were sent to rehabilitation, time to surgery was less than 24 h and significantly more patients were treated during daytime hours.

Primary outcomes

Literature showed that the implementation of a clinical pathway for hip fracture patients may lead to reductions in mortality and complications (24-28). Thus far, a direct comparison between studies with various clinical pathways has proven difficult because of differences in study design, variety in the composition of pathways and the use of different outcome measures (9). However, recent studies comparing different orthogeriatric care models showed that an integrated co-managed care model, as implemented in this study, was more successful than a geriatric consultation service (29,30).

This study did not show a significant decrease in mortality at 30 and 90 days and at 1 year. However, a reduction of approximately 3% at 30 and 90 days was noted.

The question arises of whether all geriatric patient aged 70 years and above and with two or more comorbidities will benefit from this model of care. In addition, better identification of the subpopulations that benefit from a multidisciplinary approach could lead to better resource allocation, which may further reduce costs and streamline processes. However, with the traditional performance indicators analyzed in this study, this question is difficult to answer. Since hip fracture patients are among the frailest, a bias towards increased mortality is inherent (31). Therefore, the effect of the GFC concept on patients who survive may not be measured adequately with these indicators, and consequently, they do not properly reflect the GFC's true impact and potential. While multiple studies have shown that geriatric care models show improvements regarding mortality, complications and HLOS, little is known about the long-term outcomes of patients who were treated within a geriatric care model (25,28). Therefore, future studies should also focus on the effect of geriatric care models on functional recovery and quality of life after surgery to determine the impacts of these models on patients who survived THFs.

The number of patients with complicated courses and complications per patient did not change. Both surgical- related complications and non-surgical-related complications did not show significant differences, except for a significant increase of delirium diagnoses in 2016. A recent Cochrane review also found that comprehensive geriatric assessment may make little or no difference for major postoperative complications (32).

The increase in patients diagnosed with delirium after the implementation of the GFC may be related to the increased awareness, routine CAM screening for early signs of delirium and a more structured registration. Another reason that the number of complications did not decrease significantly could be due to the fact that data from 2013 were retrospectively analyzed. This may have led to an underestimation of patients who were diagnosed with delirium during admission. When patients who were diagnosed with delirium as a single complication were omitted, the number of patients with a complicated course showed a reduction of 8.4% in 2016. Folbert et al. found a similar increase in delirium diagnoses after the implementation of a geriatric care pathway (33).

Secondary outcomes

As previously mentioned, all performance indicators that can be attributed directly to the implementation of a GFC showed improvements. Previous literature showed that the implementation of a GFC led to a decrease in HLOS and time to surgery (24,25). This study found that HLOS was reduced significantly, by 2 days. Other studies demonstrated that the reduction in HLOS by orthogeriatric care models led to an additional reduction in costs (34,35). Furthermore, this reduction in HLOS is especially noteworthy because significantly more patients were sent to a rehabilitation facility, which usually leads to longer HLOS due to paucity in rehabilitation institutions; therefore, a well-organized pathway facilitated more efficient processes. A significant shift in place of discharge was seen after GFC implementation. In 2013, 11.0% of the patients went to rehabilitation after discharge; this number was 32.1% in 2016.

Time to surgery remained relatively low despite the fact that more operations were performed during the daytime. A meta-analysis on this topic found that a surgical delay of more than 48 h increases the risk of death (36). Therefore, it is questionable whether the achieved reduction in time to operation is clinically relevant given that the time to surgery was already less than 24 h in 2013.

Lastly, this study found that daytime surgeries increased significantly in 2016. Daytime surgery was preferred to minimize circadian rhythm disruption, to decrease the risk of delirium. Most importantly, patient visits by a geriatrician and other specialists within the multidisciplinary team could be carried out directly upon admission during daytime surgeries, while admission during out-of-office hours causes a delay in this process. Nonetheless, nighttime surgery should not be a reason to postpone hip surgery in hip fracture patients who would otherwise benefit from early operations (37).

Limitations

This study had a non-randomized prospective design and a historical control group with its known and unknown forms of bias. Furthermore, the patient population was relatively small.

This study focused primarily on in-hospital treatment and short-term outcomes of the GFC. Data on long-term out- comes, such as mobility, place of discharge at 1-year follow-up and quality of life assessments are needed to assess the long-term effects of the GFC. A cost-effectiveness analysis was not performed.

CONCLUSION

This study of the first DGU®-certified GFC for hip fracture patients in central Switzerland was a success in terms of the implementation itself. All performance indicators that could be affected directly by the hospital such as HLOS, discharge disposition and timing of surgery showed improvements. Increased awareness and recognition led to an increase in the diagnoses of some complications that would otherwise have remained untreated. In conclusion, the implementation of the GFC has led to beneficial results and expanding these efforts might lead to larger effects in the reduction of morbidity and mortality.

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4

Orthogeriatric Trauma Unit Improves Patient Outcomes in Geriatric Hip Fracture Patients

Schuijt HJ, Kusen J, van Hernen JJ, van der Vet P, Geraghty O, Smeeing DPJ, van der Velde D. Orthogeriatric Trauma Unit Improves Patient Outcomes in Geriatric Hip Fracture Patients.

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ABSTRACT

Introduction: An aging population in developed countries has led to an increase in osteoporotic hip fractures and these numbers 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.

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 were significantly fewer 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, $p = 0.029$).

Conclusion: 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.

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.

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.

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-bearing 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), 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) (12).

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 (a) 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.

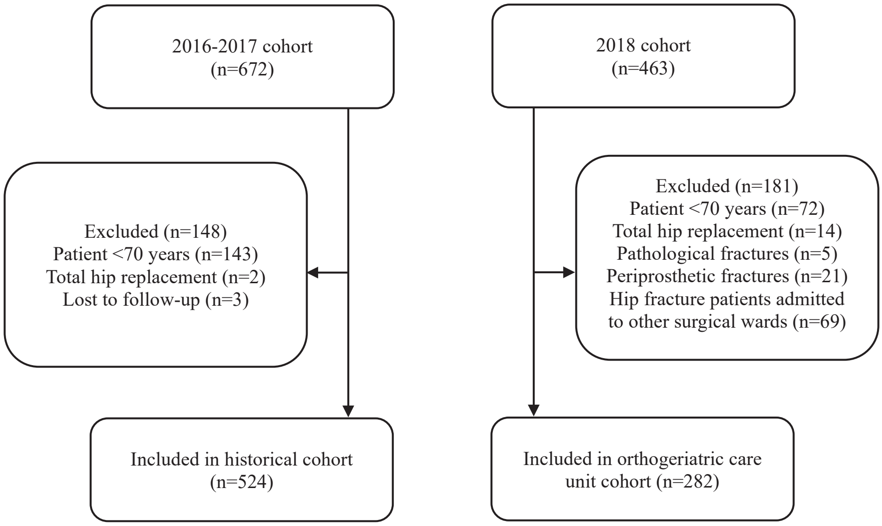


Figure 1. Patient flowchart.

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

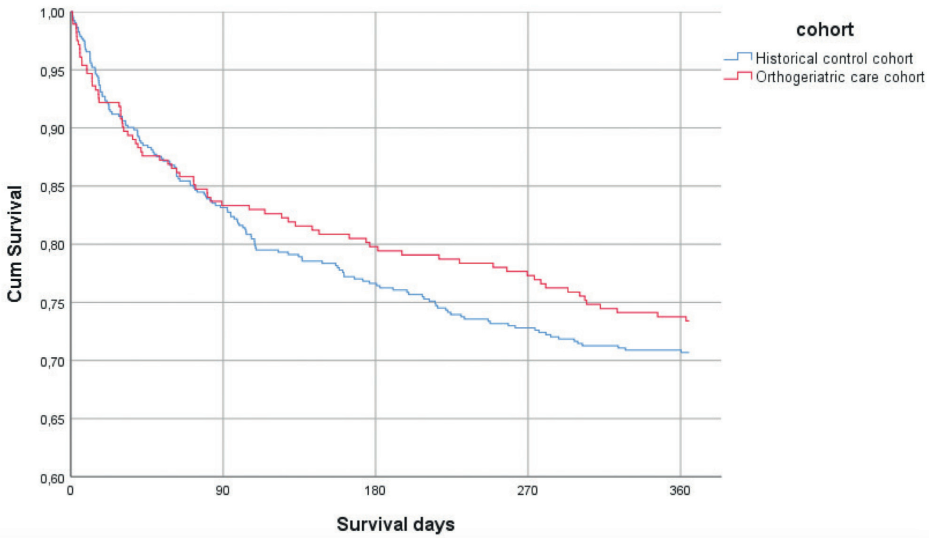


Figure 2 Kaplan Meier analysis. Survival functions between the three cohorts (log-rank test p=0.428)

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.

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 analysis

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

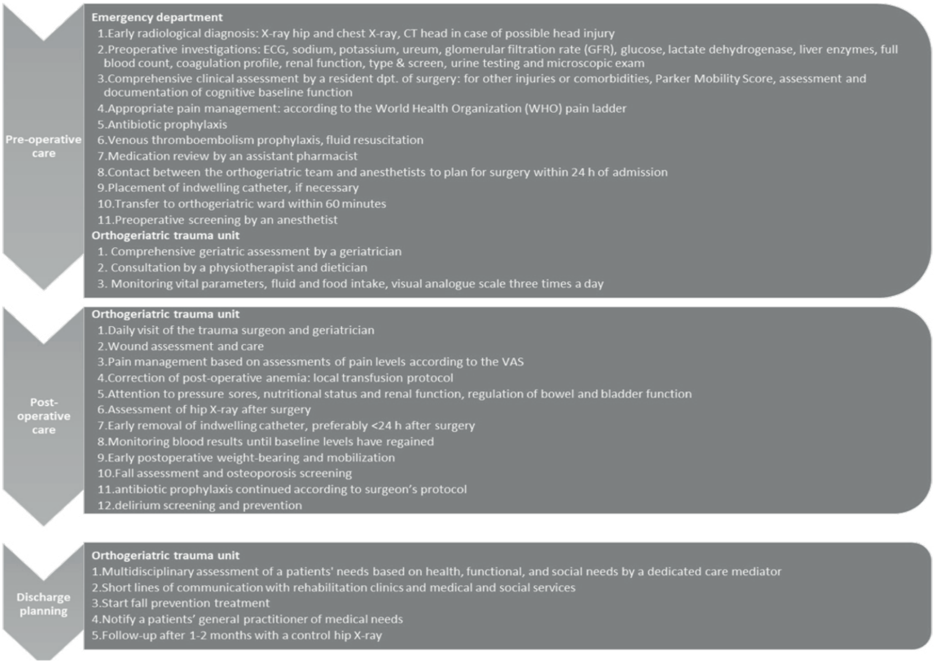
Strengths and limitations

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, which is in turn associated with poorer patient outcomes (29–31). 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.



Supplemental figure 1: Care pathway for geriatric hip fracture patients in the orthogeriatric trauma unit

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5

Different approaches towards geriatric trauma care for hip fracture patients: an inter-hospital comparison

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ABSTRACT

Purpose: Hip fractures in geriatric patients have high morbidity and mortality rates. The implementation of a multidisciplinary geriatric care pathway (GCP) may improve treatment for this patient population. This study focusses on two level II hospitals with a different treatment protocol. A comparison was made between a multidisciplinary GCP and extensive standard care with a focus on geriatric hip fracture patients to assess if a multidisciplinary GCP leads to lower mortality and morbidity.

Methods: This retrospective cohort study included patients aged 70 years or older with a unilateral proximal hip fracture who underwent surgery between January 2014 and December 2015. The primary outcome measures complications and 30-day mortality. Secondary outcome measures were time to surgery, hospital length of stay (HLOS) and secondary surgical interventions.

Results: This study included a total of 898 patients. No differences were found between major postoperative complications, 30-day mortality, HLOS or the amount of secondary surgical interventions.

Conclusion: Mortality, major complications, HLOS and the amount of secondary surgical interventions showed no differences between both hospitals. This inter-hospital comparison of two types of geriatric care models showed no outcome that favors one specific geriatric care model over another. This provides opportunities for future studies to get a better understanding of what specific factors of geriatric care models contribute most to an improvement in the treatment of this patient population and decide which approach is most cost effective.

INTRODUCTION

Hip fractures in the elderly are frequently encountered in current orthopedic trauma care. The incidence of hip fractures in the Netherlands is high and increases with age (1). Costs for hip fractures in the Netherlands are estimated at 472 million euros annually (2). The in-hospital mortality after a hip fracture ranges from 2 to 14% and 6-month mortality has been reported up to almost 23% (3,4). Hip fractures in elderly patients often result in poor functional outcome and a decline in quality of life. In addition, most patients who are at higher risk of institutionalization after discharge become permanently institutionalized (5). With the current ageing population, the incidence of hip fractures is expected to increase even more. Therefore, interventions to improve post-surgical outcomes are essential.

Comorbidities and polypharmacy are common in elderly patients and increase the risk of complications in this patient category. Previous studies have, therefore, focused on the multidisciplinary cooperation between orthopedics, trauma surgeons and ortho-geriatricians (6–9). These studies predominantly showed clear benefits of the implementation of geriatric care pathway in an intra-hospital setting. Favorable results after implementation of a geriatric trauma care pathway in the same hospital are reported in the Netherlands as well (10). However, thus far, few inter-hospital comparisons about geriatric care models have been studied.

Therefore, in this study a comparison between a level 2 trauma center with a geriatric care pathway was made to a level 2 trauma center with a standard protocol for geriatric patients with a hip fracture. Primary outcomes were in-hospital complications and 30-day mortality.

METHODS

A dual-center retrospective cohort study was performed. Ethical approval was granted from a central ethics committee (VCMO, Nieuwegein W17.007) for both participating hospitals.

Between January 2014 and December 2015, all patients aged above 70 years with a unilateral hip fracture who were treated by the department of surgery of either hospital were identified and included in the database. Patients were excluded if they were younger than 70 years, the fracture was treated non-operatively, the hip fracture was not an isolated injury or if no data were found in the electronic patient documentation (EPD). Surgical treatment was performed according to Dutch guidelines (11).

Participants were analyzed through the EPD system of both Diakonessenhuis Hospital Utrecht (DHU, level II trauma center) and St. Antonius Hospital Nieuwegein (AHN, level II trauma center). All EPDs were accessed through HiX or intraZIS, both of which are web-based clinical patient record systems, developed for use by both clinicians and clinical support staff. Data were reviewed and extracted from the surgery department's clinical notes and patient reports, radiology imaging documents, operation room data and laboratory measurements. Upon identification of all eligible patients, two independent authors (JK and PV) extracted all data into preformatted excel spreadsheets for all included patients.

Hospitals were compared at three moments in time: preoperatively (baseline characteristics), perioperatively and postoperatively. The following preoperative data were collected: age upon admission, gender, American Society of Anesthesiologists (ASA) classification, prefracture living situation, mobility, use of anticoagulation, temperature and hemoglobin level upon admission, type and side of fracture (12).

The perioperative collected data were time between admission and surgical intervention (days), reasons for postponement of surgery, type of implant, operation time and type of anesthetic.

Postoperatively, data were collected on hospital length of stay (HLOS) and hemoglobin level. Furthermore, the number of patients with a complicated course and the number of complications per patient were analyzed. Intra-hospital complications (as noted in the EPD) were divided into five main categories: delirium, thrombo-embolic events (cerebrovascular accident, deep venous thrombosis, and pulmonary embolism), infection (superficial wound infection, pneumonia, and urinary tract infection), cardiac complications (myocardial infarction, arrhythmia, and congestive heart failure) and other complications, such as red blood cell transfusion, electrolyte imbalance and decubitus ulcer. Furthermore, secondary surgical intervention as result of a complication of the initial operation and the reason for secondary surgical intervention were collected. In addition, the mortality rate after 30 days was collected.

Treatment protocols

The geriatric care pathway in DHU offers standard geriatric trauma consultation service and a specialized, combined geriatric and traumatology ward. In addition, there are specified protocols for both nurses and doctors in the emergency department (ED), ward and operating theatres resulting in a standard treatment for geriatric patients. All trauma patients over 70 years were screened by a geriatrician during admission using the comprehensive geriatric assessment (CGA) technique. This is defined as a "multi-dimensional interdisciplinary diagnostic process focused on determining a frail older person's medical, psychological and functional capability to develop a coordinated and integrated plan for treatment and long-term follow-up" (13). During weekends, consultation of a geriatrician was available. Both geriatrician and trauma surgeon visit the patients in the ward daily. Daily emergency operation time slots are reserved to ensure possibility to operate patients immediately after admission and diagnosis. Surgery was performed preferably during office hours. Afterwards, cooperation between hospital and nursing homes or assisted living facilities is established to reduce hospital length of stay. A specialized 'transfer' nurse investigates the possibilities for transfer to a nursing home or assisted living facilities.

The AHN treatment of geriatric hip fractures was basedon a standard care system. There were no geriatric pathways, and the geriatric consultancy was done by nurse practitioners with specific attention to delirium. AHN did not have dedicated timeslots for geriatric patients with a hip fracture; patients were treated in order of urgency and surgery was performed during in- and out of office hours.

Postoperatively, patients did not go to a specialized combined geriatric and traumatology ward. In AHN, patients received standard care on the wards. After discharge, transfer nurses helped patients with a quick transition to a place best fit for the needs of the specific patient.

In both hospitals, a team of orthopedic trauma surgeons performed surgery. Although both hospitals were teaching hospitals, a senior trauma surgeon either performed or supervised each surgery. Furthermore, in both hospitals' patients with a vitamin K antagonist were bridged according to the standard local protocol. Bridging with LMWH during the perioperative period was performed in case of a CHADSVASC score of 4 and higher. In case of acute anemia, patients received blood transfusions according to Dutch guidelines in both hospitals (14). Postoperatively, there were no differences in physiotherapy between the hospitals.

Statistical analysis

Parametric data were reported as means (M) with standard deviation (SD), and non-parametric data were reported as medians with corresponding interquartile range (IQR). The comparisons of the study groups were performed by the exact Fisher test for qualitative parameters. The Mann–Whitney *U* test was used for non-parametric continuous variables. A two-sided *p*-value of < 0.05 was considered statistically significant.

Data were stratified by ASA score to reduce the impact of the different fitness assessment scores before surgery on the outcome measures. Stratification was performed in two groups. Group 1 consisted of patients that were either healthy (ASA 1) or had mild systemic disease (ASA 2). Group 2 consisted of patients with severe systemic disease (ASA 3) or severe systemic disease that is a constant threat to life (ASA 4). Data were analyzed with SPSS version 21.0 (IBM Corp., Armonk, NY, USA), for Mac.

RESULTS

A total of 898 patients were included in this retrospective analysis. A flowchart providing inclusion and exclusion criteria for patients with a traumatic hip fracture is shown in Fig.1.

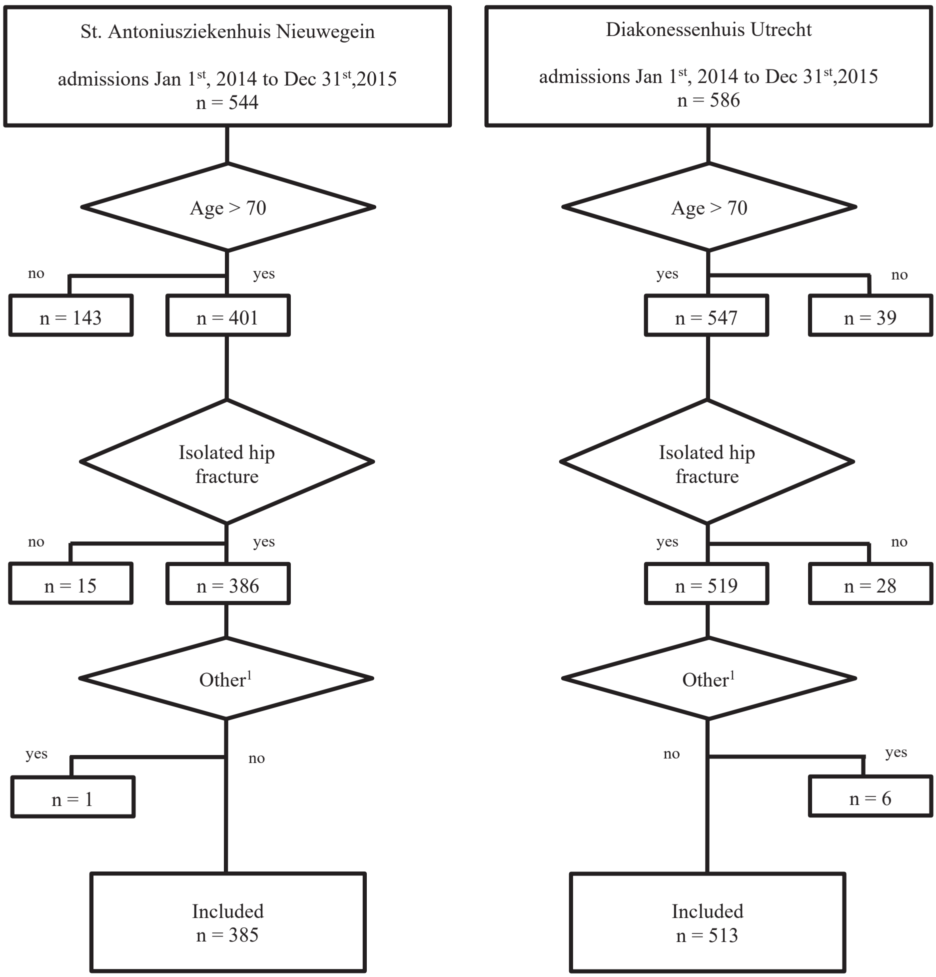

Figure 1. Flowchart of inclusion- and exclusioncriteria

[1.] Data of these patients was either completely missing or insufficient.

Table 1 Baseline characteristics of patients with a hip fracture

	AHN (*N* = 385)	DHU (*N* = 513)	*p*-value
Age (years) median (IQR)	85 (79–89)	85 (80–90)	0.115
Gender			
Male *n* (%)	116 (30.1)	143 (27.9)	0.503
Female *n* (%)	269 (69.9)	370 (72.1)	
ASA classification			
ASA classification 1 *n* (%)	12 (3.1)	23 (4.5)	0.484
ASA classification 2 *n* (%)	192 (49.9)	210 (40.9)	< 0.0001
ASA classification 3 *n* (%)	150 (40.0)	251 (48.9)	0.038
ASA classification 4 *n* (%)	5 (1.3)	28 (5.5)	0.002
Missing *n* (%)	26 (6.7)	1 (0.2)	
Prefracture living			
Home *n* (%)	239 (62.1)	286 (55.8)	0.423
Health care institution *n* (%)	87 (22.6)	95 (18.5)	0.313
Nursing home *n* (%)	48 (12.5)	86 (16.8)	0.029
Missing *n* (%)	11 (2.8)	46 (8.9)	
Mobility			
Ambulant *n* (%)	174 (45.2)	271 (52.8)	< 0.0001
Mobility accessories *n* (%)	152 (39.5)	84 (16.4)	< 0.0001
Wheelchair *n* (%)	11 (2.9)	11 (2.1)	1.000
Bedridden *n* (%)	5 (1.3)	1 (0.2)	0.112
Missing *n* (%)	43 (11.1)	146 (28.5)	
Anticoagulation			
None *n* (%)	168 (43.6)	284 (55.4)	< 0.0001
Anti-platelet agents *n* (%)	139 (36.1)	137 (26.7)	0.003
VKA *n* (%)	68 (17.7)	82 (16.0)	0.470
DOAC *n* (%)	2 (0.5)	4 (0.8)	1.000
Missing *n* (%)	8 (2.1)	6 (1.1)	
Temperature in ED mean (SD)	36.8 (0.69)	36.9 (0.64)	0.096
Hb upon admission in ED mean (SD)	7.87 (1.05)	7.72 (1.04)	0.083
Type of fracture			0.040
Femoral neck *n* (%)	238 (61.8)	281 (54.8)	
PTF *n* (%)	147 (38.2)	232 (45.2)	
Fracture side			0.686
Left *n* (%)	194 (50.4)	266 (51.9)	
Right *n* (%)	191 (49.6)	247 (48.1)	

N number of patients, *n* number of patients. Numbers are noted in percentages of the total number of patients at the hospital. *ASA classification* American Society of Anesthesiologists Physical Status Classification System, *ASA classification 1* a normal healthy patient, *ASA classification 2* a patient with mild systemic disease, *ASA classification 3* a patient with severe systemic disease. *ASA classification 4* a patient with severe systemic disease that is a constant threat to life, *VKA* vitamin K antagonists, *DOAC* direct oral anticoagulants, *ED* Emergency Department, *PTF* pertrochanteric fracture.

Baseline characteristics

Baseline characteristics are shown in Table 1. A significant difference was found in ASA classification, living arrangements before admittance and mobility. Differences in anti-coagulation use were also found between the two hospitals; patients in AHN used more anti-platelet agents. DHU treated more pertrochanteric fractures and AHN treated more femo- ral neck fractures.

Table 2 Perioperative outcomes

	AHN (*N* = 385)	DHU (*N* = 513)	*p*-value
Surgical intervention			
Day of admission *n* (%)	124 (32.2)	95 (18.5)	< 0.0001
1st admission day *n* (%)	212 (55.1)	320 (62.4)	0.028
2nd admission day and after *n* (%)	49 (12.7)	98 (19.1)	0.011
Reason for postponement of surgery			
Cardiac *n* (%)	8 (2.1)	10 (1.9)	1.000
Pulmonary *n* (%)	10 (2.6)	3 (0.6)	0.020
GCS *n* (%)	1 (0.3)	0 (0.0)	0.429
Anticoagulation *n* (%)	5 (1.3)	53 (10.3)	< 0.0001
Dialysis *n* (%)	1 (0.3)	0 (0.0)	0.429
Diagnosis to be confirmed *n* (%)	3 (0.8)	0 (0.0)	0.033
Scheduling operation *n* (%)	49 (12.7)	35 (6.8)	0.001
Other *n* (%)	21 (5.5)	11 (2.1)	0.029
Initial conservative treatment *n* (%)	6 (1.6)	0 (0.0)	0.109
Type of implant			
Hemiarthroplasty *n* (%)	198 (51.4)	214 (41.7)	0.004
DHS *n* (%)	35 (9.1)	43 (8.4)	0.721
Gamma nail-TFN *n* (%)	147 (38.2)	239 (46.6)	0.012
Cannulated screws *n* (%)	5 (1.3)	17 (3.3)	0.079
Operation time (min) mean (SD)	65.9 (70.9)	43.0 (61.6)	< 0.0001
Type of anesthetic			
Spinal *n* (%)	46 (12.2)	466 (92.3)	< 0.0001
General *n* (%)	330 (87.8)	39 (7.7)	< 0.0001
Missing *n* (%)	9 (2.4)	8 (1.6)	

Numbers are noted in percentages of the total number of patients at the hospital.
N number of patients, *GCS* Glasgow Coma Scale, *DHS* dynamic hip screw, *TFN* trochanteric fixation nail.

Perioperative outcomes and complications

More patients were treated on the day of admission in AHN (AHN 32.2% vs. DHU 18.5%; $p < 0.001$) whereas in DHU more patients were treated on the first day after admission (AHN 55.1% vs. DHU 62.4%; $p = 0.028$) (Table 2). A pulmonary cause was more often reason for postponement of surgery in AHN (AHN 2.6% vs. DHU 0.6%; $p = 0.002$). Anticoagulation use delayed time to surgery significantly more often in DHU (AHN 1.3% vs. DHU 10.3% n; $p < 0.001$).

Table 3 Postoperative complications and outcome measures

	AHN (*N* = 385)	DHU (*N* = 513)	*p*-value
HLOS median (IQR)	7 (5–10)	7 (5–9)	0.874
Hb postoperatively mean (SD)	6.72 (1.18)	6.45 (1.04)	< 0.0001
Patients with a complicated course *n* (%)	184 (47.8)	263 (51.3)	0.312
Number of complications per patient mean (SD)	0.81 (1.09)	0.76 (0.93)	0.878
Intra-hospital complications			
Delirium *n* (%)	88 (22.9)	94 (18.3)	0.111
Thrombo-embolic events			
Cerebrovascular accident *n* (%)	1 (0.3)	1 (0.2)	1.000
Deep venous thrombosis *n* (%)	0 (0.0)	0 (0.0)	1.000
Pulmonary embolism *n* (%)	2 (0.5)	2 (0.4)	1.000
Infection			
Superficial *n* (%)	7 (1.8)	3 (0.6)	0.109
Pneumoniae *n* (%)	27 (7.0)	39 (7.6)	0.797
Urinary tract infection *n* (%)	23 (6.0)	35 (6.8)	0.681
Cardiac complications			
Myocardial infarction *n* (%)	1 (0.3)	2 (0.4)	1.000
Arrhythmia *n* (%)	20 (5.2)	15 (2.9)	0.116
Congestive heart failure *n* (%)	14 (3.6)	10 (1.9)	0.144
Other complications			
RBC transfusion *n* (%)	74 (19.2)	68 (13.3)	0.016
Electrolyte imbalance *n* (%)	18 (4.7)	67 (13.1)	< 0.0001
Decubitus ulcer *n* (%)	9 (2.3)	5 (1.0)	0.112
Secondary surgical intervention			
Patients with ≥ 1 secondary surgical interventions *n* (%)	18 (4.7)	32 (6.2)	0.378
Reason for secondary surgical intervention			
Secondary bleeding *n* (%)	8 (2.1)	1 (0.2)	0.006
Secondary fracture *n* (%)	0 (0.0)	9 (1.8)	0.012
Deep surgical site infection *n* (%)	12 (3.1)	14 (2.7)	0.841
Inadequate postoperative outcome/implant failure *n* (%)	1 (0.3)	10 (2.0)	0.029
30-Day mortality *n* (%)	32 (8.3)	43 (8.4)	1.000

Numbers are noted in percentages of the total number of patients at the hospital. *N* number of patients, *HLOS* hospital length of stay, *RBC* red blood cell.

Operation time was longer in AHN (AHN M = 65.9, vs. DHU M = 43.0; $p < 0.001$). In DHU, spinal anesthetics was the preferred method of anesthesia (92.3%) whilst in AHN general anesthesia was used more often (87.8%).

Postoperative outcome and complications

No differences were found between hospital length of stay, 30-day mortality or postoperative complications, except that significant more electrolyte imbalances were diagnosed in DHU (4.7% vs. 13.1%; $p < 0.0001$) (Table 3). Hemoglobin level after surgery was significantly higher in AHN, although this was not clinically relevant. AHN showed significantly more secondary bleedings (AHN 2.1% vs. DHU 0.2%; $p = 0.006$). DHU showed significantly more secondary fractures (AHN 0.0% vs. DHU 1.8%; $p = 0.012$) and inadequate postoperative outcome/implant failure (AHN 0.3% vs. DHU 2.0%; $p = 0.029$). Further analysis showed that half of the implant failures in DHU were due to a postoperative fall resulting in a new fracture with implant failure.

Stratification measures in ASA scores did not lead to other outcomes.

DISCUSSION

The primary goal of this study was to find out if the benefits of a geriatric care pathway would also hold up in a direct comparison to a similar level II trauma center without a dedicated pathway. In this study, a geriatric care pathway did not further lower the rates of mortality, major complications and HLOS when compared to an extensive standard care system. However, compared to other hospitals with geriatric care models both AHN and DHU performed similar and sometimes better when it comes to the number of patients with a complicated course and HLOS (10,15–18). The 30-day mortality, however, appeared to be slightly higher in AHN and DHU when compared to other hospitals with geriatric care models (10,15–18). This may be because the mean age in this study was relatively high compared to the patient populations in these studies.

Preoperatively, a difference was seen in time to surgery between both hospitals. DHU treated significantly less patients on the day of admission, but significantly more patients were treated on the first admission day. In DHU, patients who could not be treated on the same day were scheduled on the next day before 12:00. This means that these patients' time to surgery was a maximum of 36 h. Therefore, depending on the time of admission, a large part of patients who were treated on the first admission day still received surgery within 24 h. In AHN, patients were not necessarily treated before 12:00 on the next day, meaning that patients' time to surgery was a maximum of 48 h on the first admission day. In this light, the significant difference in the number of patients treated within 24 h as portrayed in Table 3 was most likely overstated.

In both hospitals, surgery was postponed for various reasons. It is known that the postponement of surgery could lead to a higher complication rate (19). Nevertheless, this study did not find a significant difference in the complication rate.

Anesthesia techniques showed that AHN preferred general anesthesia whereas DHU preferred spinal anesthesia. A Cochrane review showed no significant differences between both techniques except that, in patients without prophylaxis with potent anticoagulant drugs, the risk of deep venous thrombosis was less when spinal anesthesia was administered (20). Chakladar et al. showed that spinal anesthesia was financially preferable in hip fracture surgery (21). However, AHN, which is a specialized cardiac center, preferred general anesthesia because they believed it provided a more stable operative course and that the ensuing hemodynamic stability would lead to less hypotensive episodes.

Postoperatively, DHU diagnosed significantly more electrolyte imbalances. This may be because the co-management laboratory tests were more frequently ordered or tested.

Although both care models showed no paramount significant differences in outcome, they did perform similar to other geriatric care models as abovementioned. This raises the question as to what the important factors in these models may be that lead to improvements in patient outcome. The fact that both hospitals created an increased awareness amongst their staff members may have contributed to better monitoring of patient vitals for geriatric complications and faster interventions when required.

The question arises, regarding these results, if a hospital could do with less. Is an extensive pathway with the involvement of a clinical geriatrician necessary or could a department also be as productive and effective with a specialized physician assistant? Both hospitals had medical personnel who were trained to look after geriatric patients and no big differences were seen in patient outcome. This may indicate that an increased awareness, for example the prevention and diagnosing of delirium in geriatric patients, could improve patient outcomes independent of whether a clinical geriatrician or a specialized physician assistant is involved.

Should there be no significant difference in what type of medical personnel assesses these geriatric patients, then perhaps the monitoring of certain factors by itself may increase patient outcome. If both approaches show similar results, a cost-effectiveness analysis may help in deciding which model is economically justifiable. Unfortunately, not much is known about the cost-effectiveness of geriatric care models. Prestmo et al. suggested that a CGA model probably led to a very small reduction of total cost compared to usual care while a systematic review that included mainly retrospective studies reported larger reductions in costs (22). More data on cost-effectiveness may give us better insight into which efforts are actually worthwhile to improve outcome. The increasing strain on the healthcare system due to the ageing population forces us to look critically at these different geriatric models so that cost-effectiveness can be optimized in the future.

Strength and limitations

There are several limitations to this study. One of which is its retrospective design with its known and unknown forms of bias. To date it is shown by many studies using intra-hospital designs that specific geriatric treatment paths are beneficial for geriatric hip fracture patients specifically. However, this study did not show the benefits of a geriatric care pathway when compared to a hospital with geriatric consultation. The inhomogeneity of the cohorts at baseline may be a contributing factor to the fact that there was no clear benefit of the geriatric care pathway: differences were seen in ASA classification between both hospitals. The ASA scoring system is a known determinant for complication rate (23). Despite that, this study found no differences in complication rate. As abovementioned, stratification for ASA score did not lead to differences in mortality or complications. Moreover, DHU treated more trochanteric fractures. This may have affected the complication rate because trochanteric fracture has a worse outcome compared to femoral neck fractures (24). Furthermore, the fact that AHN was a cardiac referral center could have led to a reduction of the complication rate by itself.

No validated instrument for the registration of mobility was used in both hospitals and no data on postoperative mobility and place of discharge were available. Furthermore, this study lacked data on long-term follow-up such as long-term mortality, functionality after surgery and institutionalization. And lastly, quality of life should receive more attention in future studies to assess patient satisfaction.

Despite these limitations, this is an analysis of one of the largest cohorts of geriatric patients with a hip fracture. These data provide relevant insights in the way elderly patients with isolated hip fractures are treated within our trauma system. This evaluation of two geriatric care pathways helps to get a better understanding of what specific factors of geriatric care pathways contribute to the improvements in this patient population. Future research should clarify the cost-effectiveness of certain approaches.

CONCLUSION

This inter-hospital comparison of treatment protocols for geriatric patients with an isolated hip fracture did not show major differences in mortality and complications. However, both geriatric care models performed similar to models already described in the literature. These findings may contribute to the discussion of which factors are important to a geriatric care model. Future studies should focus on clarifying which factors in geriatric care models contribute most to an improved outcome and which approach is most cost effective.

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6

Efficacy of two integrated geriatric care pathways for the treatment of hip fractures: a cross-cultural comparison

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ABSTRACT

Introduction: Many studies have focused on the implementation and outcomes of geriatric care pathways (GCPs); however, little is known about the possible impact of clinical practices on these pathways. A comparison was made between two traumageriatric care models, one Swiss (CH) and one Dutch (NL), to assess whether these models would perform similarly despite the possible differences in local clinical practices.

Methods: This cohort study included all patients aged 70 years or older with a unilateral hip fracture who underwent surgery in 2014 and 2015. The primary outcomes were mortality and complications. Secondary outcomes were time to surgical intervention, hospital length of stay (HLOS), differences in surgical treatment and the number of patients who needed secondary surgical intervention.

Results: A total of 752 patients were included. No differences were seen in mortality at 30 days, 90 days and 1 year postoperatively. In CH, fewer patients had a complicated course (43.5% vs. 51.3%; $p = 0.048$) and fewer patients were diagnosed with delirium (7.9% vs. 18.3%; $p < 0.01$). More myocardial infarctions (3.8% vs. 0.4%; $p < 0.01$) and red blood cell transfusions (27.2% vs. 13.3%; $p < 0.01$) were observed in CH and HLOS in CH was longer (Mdn difference: − 2; 95% CI − 3 to − 2). Furthermore, a difference in anesthetic technique was found, CH performed more open reductions and augmentations than NL and surgeons in CH operated more often during out-of-office hours. Also, surgery time was significantly longer in CH (Mdn difference: − 62; 95% CI − 67 to − 58). No differences were seen in the number of patients who needed secondary surgical interventions.

Conclusion: This cross-cultural comparison of GCPs for geriatric hip fracture patients showed that quality of care in terms of mortality was equal. The difference in complicated course was mainly caused by a difference in delirium diagnosis. Differences were seen in surgical techniques, operation duration and timing. These clinical practices did not influence the outcome.

INTRODUCTION

Geriatric care pathways (GCPs) for geriatric hip fracture patients have become increasingly popular over the years (1). Worldwide, many hospitals have implemented a GCP or a similar model of care. The effects of GCPs on the reduction of complications and mortality have been studied extensively and literature supports the implementation of GCPs over usual care (2). Nonetheless, little is known about the possible impact of national clinical practices on these pathways.

Since there are differences between GCP models, it is interesting to study these differences to optimize these models of care. Many studies have concentrated on GCPs in a single country (3). However, not much has been published on differences in GCPs between countries. Therefore, in this study, two similar traumageriatric care models in Switzerland and the Netherlands with known high-level health care systems were compared. It was hypothesized that both GCPs for the treatment of hip fractures would lead to comparable outcomes independent of cultural clinical practices. Primary outcomes were mortality and complications, secondary outcomes were time to surgical intervention, hospital length of stay (HLOS) and the number of patients who needed secondary surgical interventions.

METHODS

This article was written in accordance with the STROBE statement (4).

A cross-national dual-center cohort study was performed. Ethical approval was granted from a central ethics committee in both countries (Netherlands: Verenigde Commissies Mensgebonden Onderzoek (VCMO), Nieuwegein W17.007 and Switzerland: Ethikkommission Nordwest- und Zentralschweiz (EKNZ), 2014–343).

In 2014 and 2015, all patients aged 70 and above with a unilateral proximal hip fracture who were treated surgically by the department of surgery of either hospital were identified and included in the database. Patients were excluded if the fracture was not an isolated injury. Total hip prostheses were not included because these were performed by a different specialty in the Netherlands. Surgical treatment was performed according to local guidelines (5,6).

Participants were analyzed through the electronic patient documentation (EPD) systems retrospectively after 1 year. The Dutch hospital (NL) was a level II trauma center and the Swiss hospital (CH) was a level I trauma center. All EPDs were accessed through HiX (Chipsoft, Amsterdam, the Netherlands) (NL) or MedFolio (Nexus AG, Donaueschingen, Germany) (CH), both of which are web-based clinical patient record systems. Data were reviewed and extracted from the surgery department's clinical notes and patient reports, radiology imaging documents and operation room data. Upon identification of all eligible patients, two independent authors (JK and PV) extracted all data into preformatted excel spreadsheets (Microsoft® Office Excel 2010, Microsoft® Corporation, Redmond, USA).

Data were collected at three points in time, namely at baseline (when entering into the hospital), perioperatively and postoperatively (from end of surgery to discharge; secondary surgical interventions and mortality up to 1 year after surgery).

The following baseline data were collected: age, gender, American Society of Anesthesiologists (ASA) classification, prefracture living situation (home, health care institution, nursing home), mobility (ambulant, mobility accessories, wheelchair, bedridden), antithrombotic agents (none, antiplatelet agents, vitamin K antagonist (VKA), direct oral anticoagulant (DOAC)) and type of fracture (femoral neck, pertrochanteric fracture (PTF)) (7,8).

The perioperative collected data were time between admission and surgical intervention (days), type of implant (hemi-arthroplasty, intramedullary nail, sliding hip screw [including Dynamic Hip Screw by Depuy Synthes, Oberdorf Switzerland and Targon FN by B-Braun AG, Melsungen, Germany] and the use of cannulated screws by Depuy Synthes, Oberdorf Switzerland), surgical time (time between first incision and wound closure), cement augmentation (yes or no), open or closed reduction and internal fixation (ORIF, CRIF), surgery during office hours (07:00–18:00) or during out-of-office hours and type of anesthetic administered (spinal, general or combined anesthesia). In both countries, open reduction included the use of reposition clamps, unilateral plating, and cerclages to obtain (near to) anatomical reduction. The use of percutaneous reduction tools (for instance the minimal invasive cerclage passer, percutaneous use of a ball spike) were not considered to be open reduction tools.

Postoperatively, mortality rates were collected after 30 days, 90 days and at 1 year using national registries. HLOS was measured in days. Additionally, the number of patients with a complicated course (defined as one or more intra-hospital complications) and the number of complications per patient were analyzed. Intra-hospital complications (as noted in the EPD) were divided into: delirium (according to Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition [DSM-5] guidelines and the Delirium Observation Score in NL, and according to the American Psychiatric Associations (APA) definitions and the Confusion Assessment Method in CH), thrombo-embolic events (cerebrovascular accident [according to the World Health Organization [WHO] guidelines], deep venous thrombosis, and pulmonary embolism [according to the European Society of Cardiology [ESC] guidelines]), infection (superficial wound infection, pneumonia, and urinary tract infection [according to the Centers for Disease Control and Prevention [CDC] guidelines]), cardiac complications (myocardial infarction, arrhythmia [atrial fibrillation] and congestive heart failure [according to ESC guidelines]) and other complications (acute anemia [defined as blood loss requiring transfusion postoperatively], electrolyte imbalance, and decubital ulcer) (8–13). In NL, the Dutch '4-5-6 rule' was used for determining the need for a blood transfusion (Appendix A. See Table 5), whereas in Switzerland it was based on experts' opinion (14). Lastly, incidence of secondary surgical intervention and its reason (secondary bleeding, secondary fracture, deep surgical site infection [according to CDC guidelines], inadequate postoperative outcome, and implant dislocation) were collected.

Care pathway concepts

Both GCPs are integrated traumageriatric care ward models (15). The GCP in NL offers standard geriatric consultation services and a specialized, combined geriatric and traumatology ward. In addition, there are specified protocols for both nurses and doctors in the emergency department (ED), on the wards and in the operating theaters, resulting in standard treatment for geriatric patients. Cooperation between hospital and nursing homes or assisted living facilities is established to reduce HLOS. A specialized transfer nurse investigates the possibilities for transfer to a nursing home or assisted living facility.

In CH, the integrated traumageriatric ward was co-directed by a trauma surgeon and a geriatrician with shared leadership responsibilities according to the Deutsche Gesellschaft für Unfallchirurgie (DGU®) guidelines (16). Both hospitals provided a pathway that has the potential to optimize the outcome for each individual patient both during hospital admittance and after discharge. The GCPs were carried out hospital wide and every member of the team was committed to participating. The patients received well-coordinated treatment that, along with treating the acute problem, involved attention for possible age-related diseases, discharge management and out-of-hospital treatment. More detailed information about the GCPs can be found in Table 1.

Follow-up

After multidisciplinary evaluation, further steps concerning the rehabilitation process were planned. The general practitioner and the treating physiotherapist received a letter

Table 1 Comparison of geriatric care pathways

	CH	NL	Remarks
Preoperative pathway			
Comprehensive geriatric assessment	y	y	NL: during admission, CH: on ward
Medication review	y	y	
Extensive bloodtesting[1]	y	y	
Physical examination	y	y	With attention for cardiac/pulmonic pathology
Imaging and electrocardiography	y	y	
Early transfer to ward < 90 min	n	y	
Delirium screening and prevention	y	y	NL: DOS score and the DSM-V CH: CAM test and the APA classification[2]
Strive to perform surgery within 24 h	y	y	
PHP protocol[3]	y	n	
Preoperative physiotherapy in case of delay[4]	y	n	
During surgery			
Surgery performed/supervised by trauma surgeon	y	y	
Strive for direct postoperative weight-bearing[5]	y	y	
Surgery performed during outside-of-office hours	y	n	
Emergency operation time slots	n	y	CH treated patients in order of urgency
Postoperative pathway			
Routine blood-testing	y	y	
Routine complication checks[6]	y	y	
Early mobilization[7]	y	y	
Early discharge (planning)[8]	y	y	
Further investigation cause of falling[9]	y	y	
Co-managed ward	y	y	
Daily ward visits by surgeon and geriatrician	y	y	
Dexa-scan	y	y	If suspected for osteoporosis

y yes, *n* no

[1]Type and screen, coagulation, electrolytes, thyroid hormones, vitamin deficiencies, liver enzymes, albumin and renal lab

[2] DOS score: delirium observation score, DSM-V: Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, CAM: confusion assessment method, APA American psychologist association. Assessment by the geriatrician in both hospitals took place once a day, and assessment by nurses took place multiple times a day, during rounds.

[3]In CH, patients with a predicted mortality > 5%, who are considered to be at higher risk, were preoperatively hemodynamically preconditioned (PHP)

[4]If surgery was delayed in CH, patients received preoperative physiotherapy that focused on respiratory therapy and on maintaining strength in the upper extremities.

[5]Surgical concepts with minimal iatrogenic injury and implants designed for patients that are likely to have osteoporosis were used.

[6]Wound leakage, signs of infection, delirium, and decubitus

[7]Under physiotherapist supervision

[8]Discharge planning started on the first postoperative day to reduce the incidence of delirium and pneumonia, improves function and is associated with lower mortality (12)

[9]All patients were assessed whether further investigation of the cause was necessary (fear of falling, memory clinic)

containing both the evaluation and the recommended actions. In CH, routine follow-up took place 6 weeks, 3 months and 1 year postoperatively. In the NL, routine follow-up usually took place 6 weeks after surgery and, if no complications occurred, a consult by phone was performed at 3 months postoperatively. In selected cases, no follow-up took place due to comorbidities.

STATISTICAL ANALYSIS

Parametric data were reported as means (M) with standard deviation (SD), and non-parametric data were reported as medians with interquartile ranges [Q1;Q3]. Normality was assessed through the Shapiro–Wilks test. Categorical data are shown in absolute numbers (*n*) and percentages (%). Categorical variables were compared by the Chi-squared test or Fisher's exact test (two-tailed). The Mann–Whitney *U* test was used for non-parametric continuous variables. A two-sided *p*-value of<0.05 was considered statistically significant. Missing values were excluded from analysis. A 95% confidence interval (CI) was calculated for primary and secondary outcomes. For non-parametric data, we used the Hodges–Lehman test. Data were analyzed with SPSS version 24.0 for Windows (IBM Corp., Armonk, NY).

RESULTS

Baseline characteristics

This study involved 752 patients, 239 patients in CH and 513 patients in NL. Baseline characteristics are presented in Table 2. At baseline, differences were seen in ASA classification, mobility, and the use of antithrombotic agents before admission.

Perioperative outcomes

Perioperative outcomes are shown in Table 3. No difference was seen in the number of days to surgical intervention. A difference in the type of implants was noted. In CH, surgical time was longer (Mdn: 101 vs. Mdn: 37; $p<0.01$; Mdn difference: −62; 95% CI −67 to −58). Furthermore, cement augmentation was solely performed in CH (15.1% vs. 0.0%; $p < 0.01$). Surgeons in CH performed more open reduction techniques when using intramedullary nails (36.2% vs. 2.7%; $p < 0.01$). In CH, surgery was performed more often during out-of-office hours (46.9% vs. 0.0%; $p<0.01$). Finally, a significant difference between the type of anesthesia administered to patients in both hospitals was observed.

Table 2 Baseline characteristics for patients with a hip fracture

	CH	NL	p-value
	(n = 239)	(n = 513)	
Age (years) median (IQR)	86 (9)	85 (10)	0.68
Gender			0.43
Male n (%)	60 (25.1)	143 (27.9)	
Female n (%)	179 (74.9)	370 (72.1)	
ASA classification			< 0.01
ASA classification 1 n (%)	3 (1.3)	23 (4.5)	
ASA classification 2 n (%)	41 (17.2)	210 (40.9)	
ASA classification 3 n (%)	181 (75.7)	252 (49.1)	
ASA classification 4 n (%)	14 (5.9)	28 (5.5)	
Prefracture living			< 0.01
Home n (%)	133 (55.6)	317 (61.8)	
Health care institution n (%)	25 (10.5)	104 (20.3)	
Nursing home n (%)	81 (33.9)	92 (17.9)	
Mobility			< 0.01
Ambulant n (%)	90 (38.5)	284 (64.8)	
Mobility accessories n (%)	131 (56.0)	137 (31.3)	
Wheelchair n (%)	8 (3.4)	15 (3.4)	
Bedridden n (%)	5 (2.1)	2 (0.5)	
Missing n	5	75	
Anticoagulation			< 0.01
None n (%)	103 (43.1)	290 (56.5)	
Antiplatelet agents n (%)	93 (38.9)	137 (26.7)	
VKA n (%)	29 (12.1)	82 (16.0)	
DOAC n (%)	14 (5.9)	4 (0.8)	
Type of fracture			0.10
Femoral neck n (%)	116 (48.5)	282 (55.0)	
PTF n (%)	123 (51.5)	231 (45.0)	

Numbers are noted in percentages of the total number of patients at the hospital (missing values were excluded from analysis). *n* number of patients, *IQR* interquartile range, *ASA classification* American Society of Anesthesiologists Physical Status Classification System, *ASA classification 1* a normal healthy patient, *ASA classification 2* a patient with mild systemic disease, *ASA classification 3* a patient with severe systemic disease, *ASA classification 4* a patient with severe systemic disease that is a constant threat to life, *VKA* Vitamin K antagonists, *DOAC* direct oral anticoagulants, *PTF* pertrochanteric fracture.

Postoperative outcomes

Postoperative outcomes are listed in Table 4. No differences were seen in 30-day, 90-day and 1-year mortality. In CH, there were fewer patients with complicated courses (43.5% vs. 51.3%; p =0.048). Regarding type of complication, CH diagnosed fewer deliriums than NL (7.9% vs. 18.3%; p<0.01). CH observed more myocardial infarctions (3.8% vs. 0.4%; p = 0.01) and more RBC transfusions were administered (27.2% vs. 13.3%; p<0.01).

Table 3 Perioperative outcomes

	CH	NL	*p*-value
	(n = 239)	(n = 513)	
Time to surgical intervention			0.15
Day of admission *n* (%)	56 (23.4)	95 (18.5)	
1st admission day *n* (%)	148 (61.9)	320 (62.4)	
2nd admission day and after *n* (%)	35 (14.6)	98 (19.1)	
Type of implant			0.03
Hemiarthroplasty *n* (%)	109 (45.6)	214 (41.7)	
Sliding hip screw *n* (%)	22 (9.2)	43 (8.4)	
Intramedullary nail *n* (%)	107 (44.8)	239 (46.6)	
Cannulated screws *n* (%)	0 (0.0)	17 (3.3)	
Plate osteosynthesis *n* (%)	1 (0.4)	0(0.0)	
Operation duration (minutes) mean (SD)	109.23 (47.74)	39.27 (14.69)	< 0.01
Augmentation *n* (%)	36 (15.1)	0 (0.0)	< 0.01
Open surgery/closed surgery (HHA excluded) *n* (%)	47 (36.2)/83 (63.8)	8 (2.7)/291 (97.3)	< 0.01
Surgery during office hours/outside-of-office hours *n* (%)	127 (53.1)/112 (46.9)	513 (100.0)/0 (0.0)	< 0.01
Type of anesthesia			< 0.01
Spinal *n* (%)	36 (15.1)	466 (92.3)	
General *n* (%)	136 (56.9)	39 (7.7)	
Combination *n* (%)	66 (27.6)	0 (0.0)	
Monitored anesthesia care *n* (%)	1 (0.4)	0 (0.0)	
Missing *n*	0	8	

Numbers are noted in percentages of the total number of patients at the hospital (missing values were excluded from analysis) *n* number, *SD* standard deviation, *HHA* hip hemiarthroplasty

Furthermore, CH diagnosed fewer electrolyte imbalances than the NL (1.7% vs. 13.1%; $p<0.01$). HLOS was longer in CH (Mdn: 9 vs. Mdn: 7; $p < 0.01$; Mdn difference: −2 95% CI −3 to −2). No differences were observed in the number of secondary surgical interventions. A difference was seen in reasons for secondary surgical interventions.

Open versus closed reduction in CH

Open versus closed reduction in CH are listed in appendix B (See Table 6). The population within CH that received open surgery had a longer HLOS (Mdn: 9 vs. Mdn: 10; $p = 0.047$; Mdn diff: −1; 95% CI −1 to 0). Although it was not a significant difference, more patients who received open surgery had complicated courses (44.6% vs. 61.7%; $p = 0.06$). Furthermore, more arrhythmias were seen in patients who received open surgery (1.2% vs. 10.6%; $p = 0.02$). No differences in mortality or in the number of RBC transfusions were noted. We found no differences in the number of surgical site infections.

Table 4 Postoperative complications and outcome measures

	CH	NL	*p*-value
	(n = 239)	(n = 513)	
HLOS median (IQR)	9 (6)	7 (4)	< 0.01
Patients with a complicated course n (%)	104 (43.5)	263 (51.3)	0.048
Intra-hospital complications			
Delirium n (%)	19 (7.9)	94 (18.3)	< 0.01
Thrombo-embolic events			
Cerebrovascular accident n (%)	0 (0.0)	1 (0.2)	1.00
Deep venous thrombosis n (%)	0 (0.0)	0 (0.0)	–
Pulmonary embolism n (%)	2 (0.8)	2 (0.4)	0.60
Infection			
Superficial n (%)	4 (1.7)	3 (0.6)	0.22
Pneumoniae n (%)	12 (5.0)	39 (7.6)	0.34
Urinary tract infection n (%)	16 (6.7)	35 (6.8)	0.95
Cardiac complications			
Myocardial infarction n (%)	9 (3.8)	2 (0.4)	< 0.01
Arrhythmia n (%)	9 (3.8)	15 (2.9)	0.54
Congestive heart failure n (%)	9 (3.8)	10 (1.9)	0.14
Other complications			
RBC transfusion n (%)	65 (27.2)	68 (13.3)	< 0.01
Electrolyte imbalance n (%)	4 (1.7)	67 (13.1)	< 0.01
Decubitus ulcer n (%)	1 (0.4)	5 (1.0)	0.67
Secondary surgical intervention			
Patients with ≥ 1 secondary surgical interventions n (%)	21 (8.8)	32 (6.2)	0.20
Reason for secondary surgical intervention			0.02
Secondary bleeding n (%)	1 (0.4)	1 (0.2)	
Secondary fracture n (%)	4 (1.7)	10 (1.9)	
Deep surgical site infection n (%)	3 (1.3)	14 (2.7)	
Inadequate postoperative outcome[1] n (%)	8 (3.3)	3 (0.6)	
Implant dislocation[2] n (%)	5 (2.1)	4 (0.8)	
Mortality			
30-day mortality n (%)	27 (11.3)	43 (8.4)	0.19
90-day mortality n (%)	42 (17.6)	88 (17.2)	0.87
1-year mortality n (%)	61 (25.5)	146 (28.5)	0.42

Numbers are noted in percentages of the total number of patients at the hospital. n number, HLOS hospital length of stay, IQR interquartile range, RBC red blood cell

[1]Inadequate reduction in postoperative radiographs requiring revision surgery.

[2]Dislocation of hip implants shortly after the initial surgery (missing values were excluded from analysis)

During office hours vs. outside-of-office hours surgery in CH

A sub-analysis of surgery done during office hours vs. surgery done outside-of-office hours in CH did not show differences in terms of HLOS, operation duration, complications, and mortality.

DISCUSSION

This cross-national study of 752 geriatric hip fracture patients in two hospitals from Switzerland and the Netherlands found that even though operation technique, timing and duration of surgery, type of anesthesia and HLOS were significantly different, no differences were found in 30-day, 90-day, and 1-year mortality.

The mortality rates in this study are in line with those reported in earlier literature regarding GCPs (17).

As opposed to NL, open reduction using clamps and cerclage wiring to achieve an anatomical reduction and to increase stability as well as cement augmentation techniques to increase implant anchorage were performed regularly in CH. This may have contributed to the difference in operation duration, which was almost an hour longer in CH. Previous literature reports that longer surgery time may lead to a higher risk of surgical site infection, more blood loss and a higher complication rate (18). Apart from anemia, though, we did not find a higher complication or infection rate in CH. Additionally, CH performed more surgery during out-of-office hours. However, the sub-analysis showed that surgery performed during out-of-office hours did not lead to differences in HLOS, complications and mortality. This observation is consistent with the literature (19,20). An advantage of surgery during office hours is that patient visits by a geriatrician and other specialists within the multidisciplinary team could be carried out directly upon admission. Spinal anesthesia was the preferred technique in NL whereas in CH, general anesthesia or combination technique was preferred. A Cochrane review found no significant differences between both techniques aside from a lower risk of deep venous thrombosis in patients without prophylactic anticoagulation therapy who received spinal anesthesia (21).

Another notable finding is that CH had fewer patients with a complicated course. This difference was mainly caused by the higher delirium diagnosis rate in the NL. According to both GCP protocols, daily visits of a geriatrician and physician assistant took place in both hospitals. It is known that, although overall complication rates may decrease after the implementation of an integrated care pathway, delirium diagnosis could improve due to an increase in delirium awareness (22,23). Moreover, previous literature showed that delirium incidences range between 4 to 53%, indicating large differences in delirium diagnoses between centers (24). The higher number of patients who received therapeutic RBC transfusions in CH could have been the result of more blood loss due to longer operative time and operation technique. A recent systematic review found that patients on antiplatelet therapy have higher rates of blood transfusion. CH reported a higher number of patients on antiplatelet therapy, which could have attributed to the higher number of RBC transfusions (25). In addition, NL had a protocol for blood transfusions ('4- 5-6 rule') whereas in CH, blood transfusions were based on experts' opinions, which may have led to more transfusions due to a more liberal approach (14). A recent study on transfusion practices in Swiss hospitals highlighted this lack of adherence to current transfusion guidelines (26). Furthermore, high transfusion rates are associated with an increase in complications and mortality (27). Despite the abovementioned differences in complications, HLOS was longer in CH. Due to scarcity of beds in CH's affiliated rehabilitation clinic, waiting time increased HLOS for some patients. In NL, rehabilitation usually took place at a separate institution; therefore, it had less impact on HLOS. Another reason was that the number of open surgeries (without hip hemiarthroplasties) in CH was higher. The sub-analysis of ORIF versus CRIF surgery in CH confirmed that ORIF led to a longer HLOS and resulted in 17.1% more patients with a complicated course.

Strength and limitations

There are several limitations to this study. First, its retrospective design, with its known and unknown forms of bias. Second, it would have been interesting to evaluate the value of anatomic reduction in geriatric hip fractures, but no data was available on functional outcome. Also, we did not have data on quality of life or other patient reported outcome measures nor did we have data on rehabilitation. Rehabilitation, though, is known to affect long-term outcomes (28). It would also have been interesting to collect data on intraoperative blood loss and pre- and intraoperative blood transfusion to better understand the cause for the observed difference in postoperative blood transfusions. Third, baseline data differed between groups. No matching was performed as these findings could be logically explained. ASA classification, for example, has been known to differ due to inter-rater variability, even more so between different countries. Since we compared two countries with different care protocols,

this may explain the found differences in ASA classification (29). The use of antithrombotic agents also differed; this may be due to different anticoagulation protocols between the two countries. Lastly, with respect to operation duration, we did not account for any combining of procedures, which may have caused a bias in operation duration. The main goal was to investigate whether an overall difference in operation duration existed rather than the difference in operation duration in specific types of surgery. Interestingly, no increase in complications was seen in CH despite the longer operation duration (30).

To our knowledge, this study is the first cross-cultural comparisons of integrated GCPs for hip fracture patients. Therefore, these results provide relevant insights in the way integrated GCPs for patients with a hip fracture perform. Comparisons like these may help to make further adaptations to the existing integrated GCPs to optimize efficiency and improve patient outcomes.

CONCLUSION

This cross-cultural comparison of two integrated GCPs found that mortality rates between both GCPs were comparable. The differences in complication rates were most likely caused by a difference in delirium awareness between both hospitals. Differences in clinical practices such as operation technique, operation duration and operative timing did not affect the early or late mortality rates. Future studies should further analyze the advantages and disadvantages of these clinical practices to optimize traumageriatric care pathways for the frail elderly.

Appendix A Dutch 4-5-6 rule

Hb < 4 mmol/L	• Acute blood loss in a healthy individual (< 60 years)
Hb < 5 mmol/L	• Acute blood loss in a healthy individual (> 60 years)
	• Acute blood loss in polytrauma
	• Preoperative (< 60 years) with an expected blood loss > 500 mL
	• Fever
	• Postoperative (e.g. open heart surgery)
	• Mild/severe systemic disease
Hb < 6 mmol/L	• Life-threatening severe systemic disease
	• Inability to increase cardiac output
	• Septic/toxic patients
	• Severe long disease
	• Cerebrovascular disease

Hb = hemoglobin

Appendix B Sub-analysis open vs. closed surgery in CH

	CH closed	CH open	*p*-value
	(n = 83)	(n = 47)	
In-office/outside-of-office hours	28 (33.7)/55 (66.3)	23 (48.9)/24 (51.1)	0.09
HLOS median (IQR)	9 (6)	10 (6)	0.047
Patients with a complicated course n (%)	37 (44.6)	29 (61.7)	0.06
Intra-hospital complications			
Delirium n (%)	8 (9.6)	4 (8.5)	1.00
Thrombo-embolic events			
Cerebrovascular accident n (%)	0 (0.0)	0 (0.0)	–
Deep venous thrombosis n (%)	0 (0.0)	0 (0.0)	–
Pulmonary embolism n (%)	0 (0.0)	1 (2.1)	0.36
Infection			
Superficial n (%)	2 (2.4)	1 (2.1)	1.00
Pneumoniae n (%)	5 (6.0)	2 (4.3)	1.00
Urinary tract infection n (%)	4 (4.8)	5 (10.6)	0.28
Cardiac complications			
Myocardial infarction n (%)	2 (2.4)	2 (4.3)	0.62
Arrhythmia n (%)	1 (1.2)	5 (10.6)	0.02
Congestive heart failure n (%)	2 (2.4)	2 (4.3)	0.62
Other complications			
RBC transfusion n (%)	27 (32.5)	21 (44.7)	0.17
Electrolyte imbalance n (%)	1 (1.2)	2 (4.3)	0.30
Decubitus ulcer n (%)	0 (0.0)	0 (0.0)	–
Secondary surgical intervention			
Patients with ≥ 1 secondary surgical interventions n (%)	9 (10.8)	6 (12.8)	0.74
Reason for secondary surgical intervention			0.31
Secondary bleeding n (%)	0 (0.0)	1 (2.1)	
Secondary fracture n (%)	1 (1.2)	2 (4.3)	
Deep surgical site infection n (%)	0 (0.0)	1 (2.1)	
Inadequate postoperative outcome n (%)	5 (6.0)	1 (2.1)	
Implant failure n (%)	3 (3.6)	1 (2.1)	
Mortality			
30-day mortality n (%)	11 (13.3)	3 (6.4)	0.26
90-day mortality n (%)	14 (16.9)	8 (17.0)	0.99
1-year mortality n (%)	21 (25.3)	11 (23.4)	0.84

Numbers are noted in percentages of the total number of patients at the hospital. Hip hemiarthroplasties were not included in this analysis (missing values were excluded from analysis), n number, HLOS hospital length of stay, RBC red blood cell.

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PART II

Modifications of existing traumageriatric care pathways with a purpose to improve patient flow and patient outcome

7

Is the Parker Mobility Score in the older patient with a traumatic hip fracture associated with discharge disposition after surgery? A retrospective cohort study

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ABSTRACT

Purpose: The research questions for this study were as follows: (1) is the Parker Mobility Score (PMS) associated with discharge disposition and hospital length of stay (HLOS) of geriatric traumatic hip fracture patients? (2) Can the PMS be incorporated in a decision tree for the prediction of discharge disposition of geriatric traumatic hip fracture patients upon admittance.

Methods: A dual-center retrospective cohort study was conducted at two level II trauma centers. All patients aged 70 years and older with traumatic hip fractures undergoing surgery in 2018 and 2019 were included consecutively ($n = 649$). A χ^2 automatic interaction detection analysis was performed to determine the association of the PMS (and other variables) with discharge disposition and HLOS and predict discharge destination.

Results: The decision tree for discharge disposition classified patients with an overall accuracy of 82.1% and a positive predictive value of 91% for discharge to a rehabilitation facility. The PMS had the second most significant effect on discharge disposition ($\chi^2 = 22.409$, $p < 0.001$) after age ($\chi^2 = 79.094$, $p < 0.001$). Regarding the tree analysis of HLOS, of all variables in the analysis, PMS had the most significant association with HLOS ($F = 14.891$, $p < 0.001$). Patients who were discharged home had a mean HLOS of 6.5 days (SD 8.0), whereas patients who were discharged to an institutional care facility had a mean HLOS of 9.7 days (SD 6.4; $p < 0.001$).

Conclusion: This study shows that the PMS was strongly associated with discharge disposition and HLOS. The decision tree for the discharge disposition of geriatric traumatic hip fracture patients offers a practical solution to start discharge planning upon admittance which could potentially reduce HLOS.

INTRODUCTION

Due to an aging population the incidence of hip fractures will increase (1). This will put health care systems under increasing strain over the next few decades (2). To improve continuity and coordination of care for these patients, traumageriatric care pathways were developed to address this problem (3). Traumageriatric care pathways have shown to reduce hospital length of stay (HLOS) (4). Many factors are known to influence HLOS (5–7). A modifiable factor that affects HLOS is a delayed transfer of patients from the hospital to rehabilitation facility (5,6,8). This means that patients who are medically cleared cannot be discharged because they have to wait for placement in a rehabilitation facility. In addition, a prolonged HLOS increases the risk of hospital-related adverse events, leads to lower patient admission capacity for the hospital and is associated with increased costs (9,10). It is imperative to identify patients that require rehabilitation after surgery at an early stage (preferably upon admittance). If caregivers know which patients need to be discharged to a rehabilitation facility upon admission of the patients to the hospital, the transfer can be arranged during the admission rather than upon discharge. This fairly simple change in logistics may greatly reduce patient HLOS.

The Parker Mobility Score (PMS) is a tool for predicting mortality after hip fracture (Table 1.) (11). This score is based on patients' functional status prior to their fracture. Some studies investigated the relationship between functional status, discharge destination and HLOS in hip fracture patients, but few investigated the relationship of the PMS and discharge destination and HLOS (12–15). The research questions for this study were as follows: (1) is the Parker Mobility Score associated with discharge disposition and HLOS of geriatric traumatic hip fracture patients? (2) Can the Parker Mobility Score be incorporated in a decision tree for the prediction of discharge disposition of geriatric traumatic hip fracture patients upon admittance? The authors hypothesize that the PMS is associated with discharge disposition and HLOS.

METHODS

Registration and ethical approval for the quality improvement project was given by the responsible ethical commission (W19.132, R&D/Z19.066). This study is written in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement (16).

A dual-center cohort study was conducted at two level 2 trauma centers in the Netherlands. All patients aged 70 years and older with traumatic hip fractures undergoing surgery at the department of Traumatology of Antonius hospital Utrecht between 2018 and 2019 and Diakonessenhuis Utrecht in 2019 were eligible for inclusion. Exclusion criteria were; patients living in a nursing home prior to their fracture, in-hospital mortality, pathological fracture and if a long-term care request was already filed upon admittance (standard geriatric rehabilitation is not possible via long-term care law in the Netherlands).

Data were collected retrospectively by 4 independent researchers (2 researchers in Antonius hospital Utrecht, 2 researchers in Diakonessenhuis Utrecht). Patients' admission notes and the physiotherapists' clinical records were consulted in the web-based electronic patient records.

Only variables that were typically available during admission to the department of Emergency Medicine were collected for all patients; age, sex (m/f), body mass index (BMI, Quetelet index), living situation (alone/with others), living at a residency with the necessity to use stairs (yes/no), care at home (yes/no), a previous fracture in the last 5 year (yes/ no), chronic corticosteroid therapy (yes/no), anticoagulation therapy (direct oral anticoagulant, vitamin K antagonist, none), prefracture Parker Mobility Score (score total), American Society of Anesthesiologists Association (ASA) classification, fracture type (femoral neck, trochanteric fracture), a pre-existent diagnosis of diabetes mellitus (yes/no), hypertension (yes/no) and cerebral vascular incident (yes/no) upon presentation (11,17). Furthermore, data were collected on hemoglobin level (mmol/L) and blood creatinine level (mmol/L) during admission at the emergency department. Data on postoperative hospital length of stay (days) and discharge disposition (rehabilitation facility, no rehabilitation facility) were collected from the electronic patient records.

The Parker Mobility Score

The PMS is a validated assessment tool for mortality after hip fracture surgery that ranks prefracture mobility on a scale of 0–9 (11). A score of 9 means a person is completely independent in mobility at home and in the community, whereas a score of 0 means a person is non-ambulatory (Table 1.). In both hospitals, prefracture PMS were scored and documented by physiotherapists who visited the patients at the ward after surgery.

Table 1 Parker Mobility Score

	No difficulty	With an aid	With assistance	Not at all
Able to get about the house	3	2	1	0
Able to get out of the house	3	2	1	0
Able to go shopping, to a restaurant or to visit family	3	2	1	0

Statistical analysis

Descriptive statistics were used to report quantitative variables. Normality was determined for continuous variables by examining the boxplots and histograms. Normally distributed data were tested using a Students independent *t* test, while non-normally distributed data were tested with a Mann–Whitney U test. Qualitative variables were described with numbers and percentages and compared with a χ^2 test.

A χ^2 automatic interaction detection (CHAID) analysis was performed to construct two tree models, using tenfold cross-validation for internal validation of the model (18). All baseline variables were included in the tree models. For the dichotomous outcome discharge destination, a

classification tree model was used, whereas a regression tree model was used for the continuous outcome HLOS. The analysis allowed for up to 3 levels of depth within the tree. The threshold for significance was set at 0.05. All analyses were done using IBM SPSS Statistics Subscription with the IBM SPSS Decision Trees regression add-on (IBM 2020, Armonk, NY).

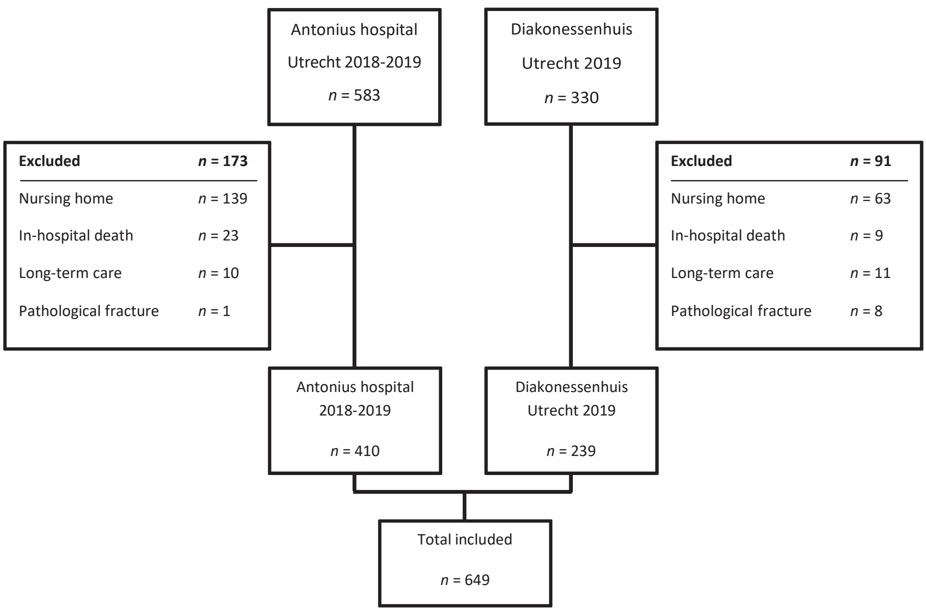


Fig. 1 Flowchart of patient inclusion

RESULTS

A total of 649 patients who met the inclusion criteria were consecutively included in this analysis (Fig. 1). At discharge from the hospital, 140 (21.6%) patients were discharged home and 509 (78.4%) patients were transferred to an inpatient rehabilitation facility. There were no differences at baseline in terms of BMI, serum creatinine level, DOAC therapy, chronic corticosteroid therapy, previous medical history, and type of fracture (Table 2). Patients who were discharged to an inpatient rehabilitation facility were older (median 84, IQR 79–89; p < 0.01) and more often female (58.6% vs. 73.7%; p < 0.01), had a higher ASA classification (p < 0.01) and lower serum hemoglobin levels (Mean 7.7, SD 1; p < 0.01), more often used vitamin K antagonists (7.9% vs. 15.9%; *p* = 0.02), had a lower PMS (median 6, IQR 5–9; p < 0.01) and HLOS was longer (median 8 IQR 6–11; p < 0.01).

Discharge disposition

The decision tree for discharge disposition classified patients with an overall accuracy of 82.1% and a positive predictive value (PPV) of 91% for discharge to an institutional care facility. The first distribution (far left box) represents the overall frequency of discharge disposition among those presenting to the ED with a traumatic hip fracture (Fig. 2). Age, PMS, living situation, the necessity to use stairs at home and sex were associated with discharge disposition. Of all variables in the analysis, age had the most significant effect on the discharge disposition (χ^2 = 79.094, p < 0.001). This variable generated 3 nodes (node 1, 2 and 3): age 70–78, age 79–82 and age > 82 with the rate of being discharged to a rehabilitation facility in each age group being 58.1%, 78.2%, and 91.2%, respectively. The first node shows the variable that affected the discharge disposition and the PMS (χ^2 = 22.409, p < 0.001). 80.3% of patients with a PMS ≤ 7 and 45.7% of the patients with a PMS > 7 were transferred to a rehabilitation facility. This analysis shows that the discharge disposition of patients aged 70–78 who were scored with a PMS > 7 was affected by their living situation (χ^2 = 9.941, p < 0.01). 65.9% of patients living alone and 36.0% of patients living together were transferred to a rehabilitation facility. The second node shows that the PMS had the most significant effect on the discharge disposition of patients aged 79–82 (χ^2 = 15.394, *p* = 0.01). This variable created three nodes: 68.4% of patients with a PMS ≤ 5, 100.0% of PMS 6–8 and 69.3 of PMS > 8 were sent to a rehabilitation facility. Discharge disposition of patients aged 79–82 with a PMS > 8 was affected by the necessity to use stairs (χ^2 = 9.812, p < 0.01). 83.7% of the patients with no stairs and 50.0% of the patients with stairs at home were transferred to a rehabilitation facility. Node three shows that the living situation had the most significant effect on the discharge disposition of patients aged > 82 (χ^2 = 8.890, p < 0.01). 93.8% of patients living alone and 82.7% of patients living together were transferred to a rehabilitation facility. Discharge disposition of patients aged > 82 who were living alone was affected

Table 2 Baseline characteristics of patients discharged home and to a rehabilitation clinic

	Missing *n* (%)	Home (*n* = 140)	Rehabilitation (*n* = 509)	*p*-value
Age (years) *median* (IQR)	0 (0.0)	77 (73–81.75)	84 (79–89)	< 0.01
BMI *median* (IQR)	51 (7.9)	23.80 (21.84–26.42)	23.90 (21.23–26.36)	0.66
Sex	0 (0.0)			< 0.01
Male *n (%)*		58 (41.4)	134 (26.3)	
Female *n (%)*		82 (58.6)	375 (73.7)	
ASA classification	50 (7.7)			< 0.01
ASA classification 1 *n* (%)		13 (9.9)	22 (4.7)	
ASA classification 2 *n* (%)		70 (53.4)	175 (37.4)	
ASA classification 3 *n* (%)		45 (34.4)	250 (53.6)	
ASA classification 4 *n* (%)		3 (2.3)	20 (4.3)	
Living situation				
Living alone *n* (%)	1 (0.2)	43 (30.7)	329 (64.8)	< 0.01
Stairs at home *n* (%)	7 (1.1)	75 (54.0)	180 (35.8)	< 0.01
Care at home *n* (%)	1 (0.2)	61 (43.9)	273 (53.6)	0.04
Lab results				
Serum hemoglobin Level *mean* (SD)	0 (0.0)	8.0 (0.98)	7.7 (1.00)	< 0.01
Serum creatinine level *mean* (SD)	1 (0.2)	81.30 (44.91)	86.28 (45.98)	0.24
Anticoagulation therapy				
DOAC *n* (%)	0 (0.0)	12 (8.6)	46 (9.0)	0.86
Vitamin K antagonist *n* (%)	0 (0.0)	11 (7.9)	80 (15.7)	0.02
Chronic corticosteroid therapy *n* (%)	0 (0.0)	3 (2.1)	10 (2.0)	0.89
Previous medical history				
Fracture < 5 years *n* (%)	0 (0.0)	16 (11.4)	76 (14.9)	0.29
Diabetes mellitus *n* (%)	0 (0.0)	27 (19.3)	113 (22.2)	0.46
Hypertension *n* (%)	0 (0.0)	65 (46.4)	263 (51.7)	0.27
Cerebral vascular incident *n* (%)	0 (0.0)	19 (13.6)	83 (16.3)	0.43
Type of fracture	12 (1.8)			0.91
Femoral neck *n* (%)		76 (55.1)	272 (54.5)	
PTF *n* (%)		62 (44.9)	227 (45.5)	
PMS (%) *median* (IQR)	0 (0.0)	9 (7–9)	6 (5–9)	< 0.01
HLOS (days) *median* (IQR)	0 (0.0)	5 (4–7)	8 (6–11)	< 0.01

n number of patients. Numbers are noted in percentages of the total number of patients at the hospital, *IQR* interquartile range, *BMI* body mass index, *ASA classification* American Society of Anesthesiologists Physical Status Classification System, *ASA classification 1* a normal healthy patient, *ASA classification 2* a patient with mild systemic disease, *ASA classification 3* a patient with severe systemic disease, *ASA classification 4* a patient with severe systemic disease that is a constant threat to life, *SD* standard deviation, *DOAC* direct oral anticoagulant, *PTF* pertrochanteric fracture, *PMS* Parker Mobility Score, *HLOS* hospital length of stay.

by sex ($\chi^2 = 16.494$, $p < 0.001$). 96.6% of females and 79.5% of males were transferred to a rehabilitation facility. Hospital length of stay PMS, vitamin K antagonist, age and living situation were found to explain a patients' HLOS. Of all variables in the analysis, PMS had

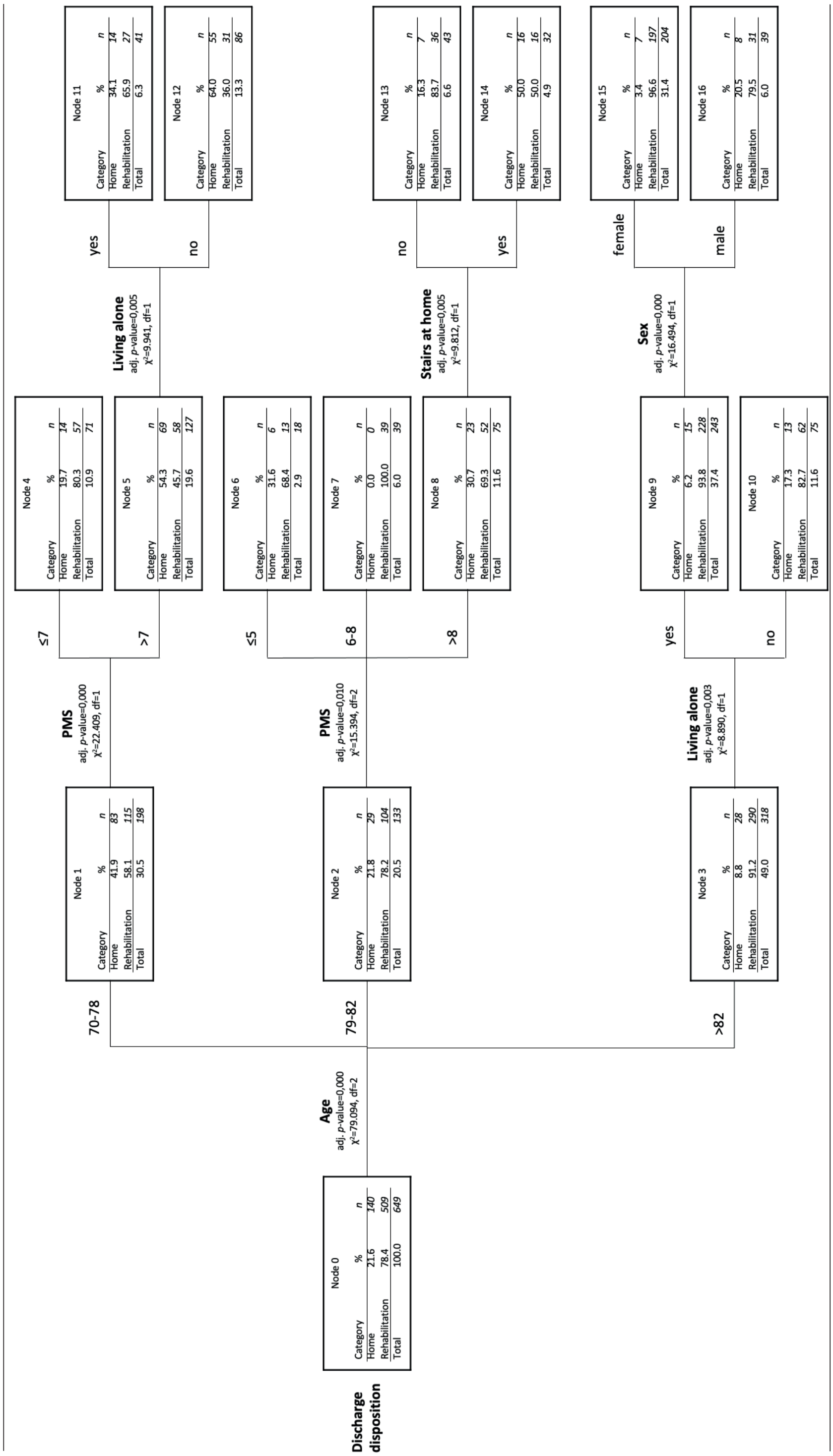


Fig. 2 Tree diagram discharge disposition

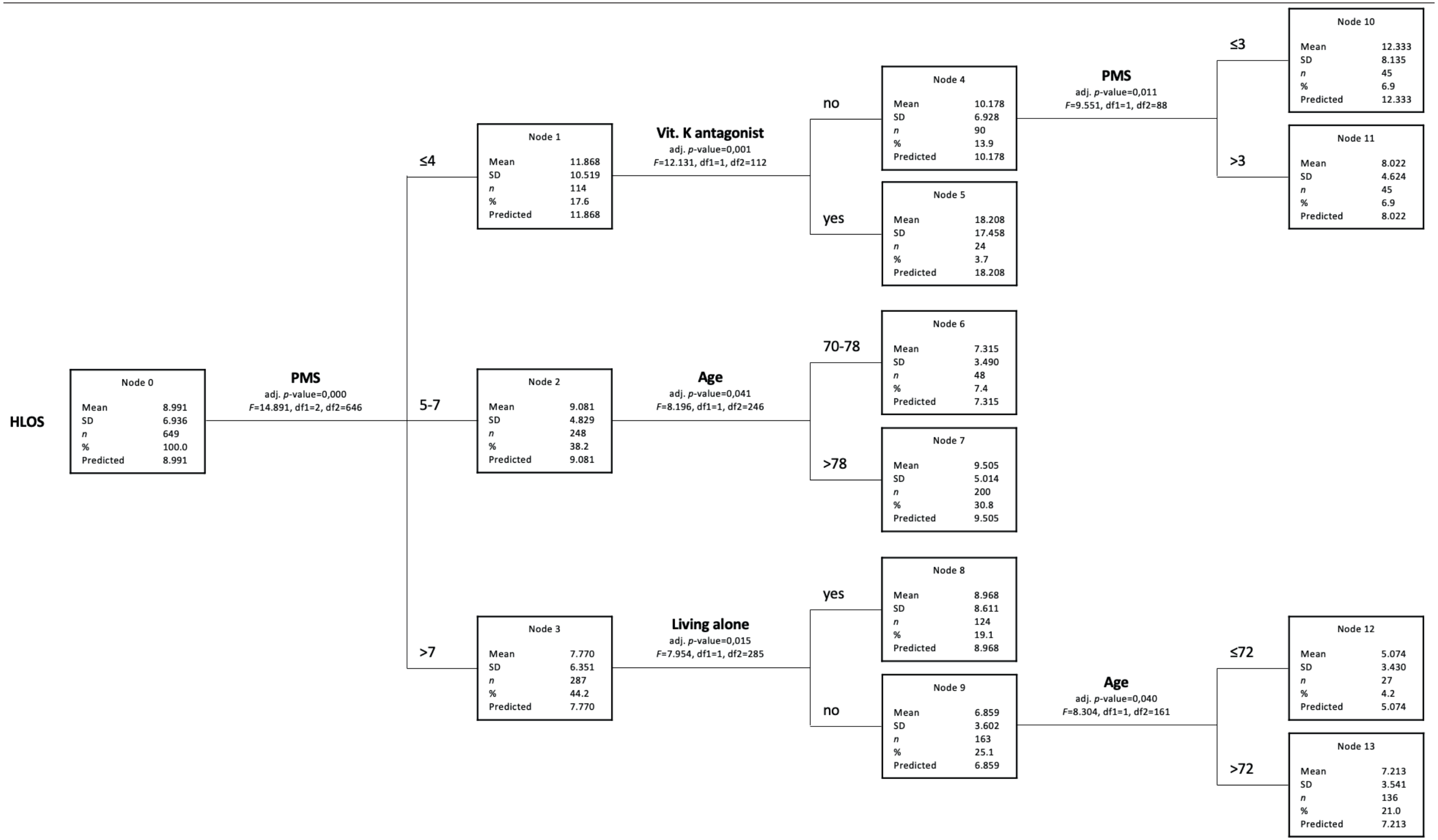


Fig. 3 Tree diagram hospital length of stay

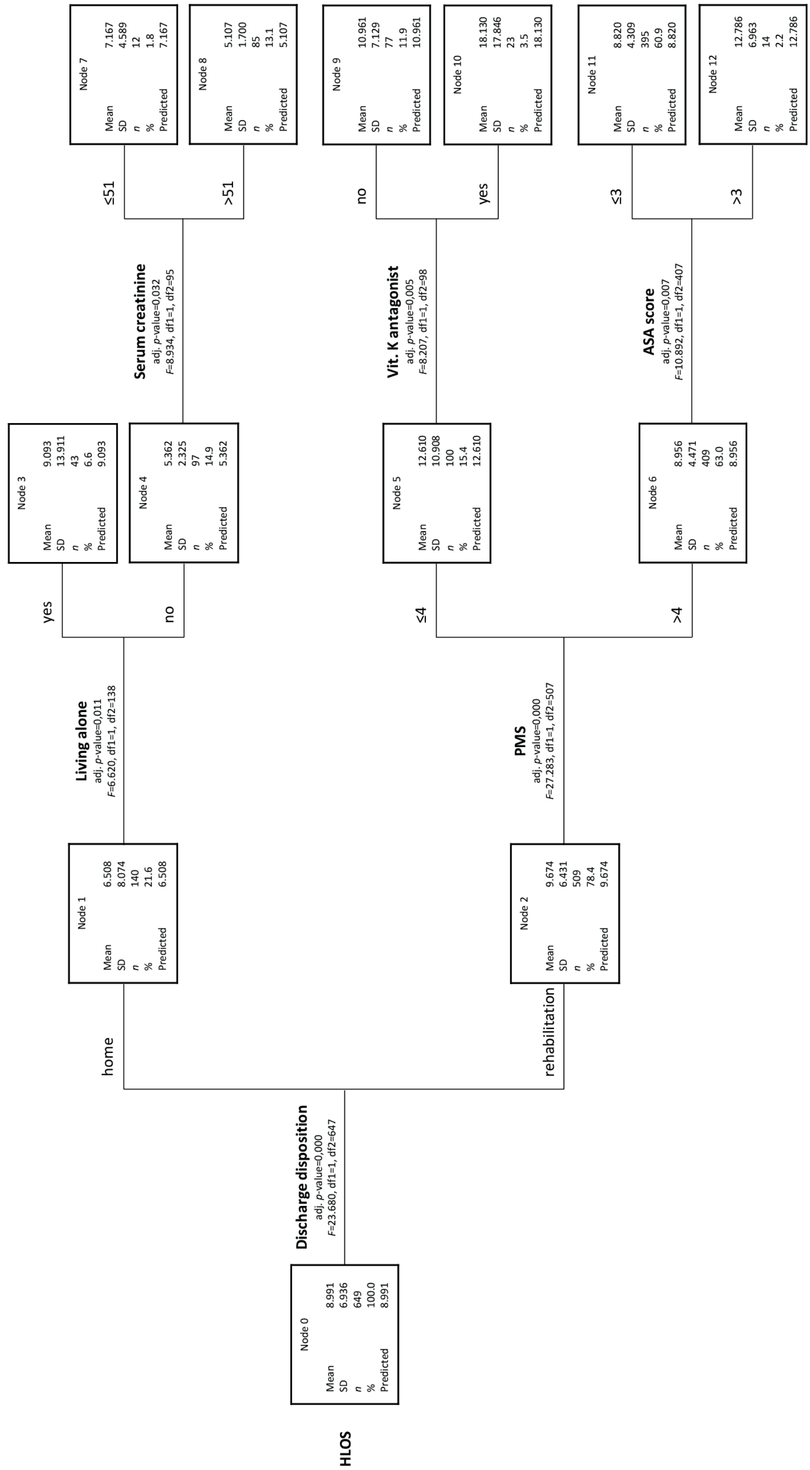


Fig. 4 Tree diagram hospital length of stay (discharge disposition included)

the most significant association with HLOS (F = 14.891, p < 0.001) (Fig. 3). This variable generated 3 nodes (node 1, 2 and 3): PMS ≤ 4, PMS 5–7 and PMS > 7. A PMS ≤ 4 is associated with longer HLOS (M 11.9 SD) with a decreasing HLOS as the PMS increases (M 9.1 in PMS 5–7 and M 7.8 in PMS > 7). The first node shows that a longer HLOS and a PMS ≤ 4 were associated with vitamin k antagonist therapy (F = 12.131, *p* = 0.001). Patients who were treated with a vitamin k antagonist are associated with a longer HLOS (M 18.2) than patients who were not treated with vitamin k antagonists (M 10.2). A longer HLOS with a PMS ≤ 4 and no vitamin k antagonist therapy were associated with PMS. Patients with a PMS ≤ 3 were associated with a longer HLOS (M 12.3) than patients with a PMS > 3 (M 8.0). The second node shows that HLOS and PMS 5–7 were associated with age (F = 8.196, *p* = 0.04). Patients aged 70–78 were associated with a shorter HLOS (M 7.3) compared to patients aged > 78 (M 9.5). The third node shows that a shorter HLOS and PMS > 7 were associated with living situation (F = 7.954, *p* = 0.02). People living alone are associated with a longer HLOS (M 9.0) than patients living together (M 6.9). A shorter HLOS with a PMS > 7 and patients living together were associated with age (F = 8.304, *p* = 0.04). Patients aged ≤ 72 were associated with shorter HLOS (M 5.1) than patients aged > 72 (M 7.2).

Sub-analysis HLOS decision tree with discharge disposition included

When discharge disposition was included in the tree model, it had the most significant association with HLOS (F = 23.680; p < 0.001) (Fig. 4). Patients who were discharged home had a mean HLOS of 6.5 days (SD 8.0), whereas patients who were discharged to an institutional care facility had a mean HLOS of 9.7 days (SD 6.4; p < 0.001).

DISCUSSION

This study showed that the discharge disposition of geriatric hip fracture patients can be classified successfully upon admittance using a clinical decision tree model. In both decision tree analyses; PMS has proven to be strongly associated with discharge disposition and HLOS. The sub-analysis showed that discharge to a rehabilitation facility led to a longer mean HLOS of 3 days, as opposed to patients who were discharged home. These findings suggest that early discharge planning could potentially lead to a mean reduction of HLOS by 3 days. Early discharge planning can only be done if the discharged destination can be predicted at an early stage. This can be achieved by use of the decision tree model presented in this study (Fig. 2).

Comparison with previous literature

To our knowledge, this is the first study that investigated the potential of the PMS, incorporated in a tree diagram, in categorizing patients based on their expected discharge disposition. Categorizing patients using a simple functional assessment tool, such as the PMS, and a practically applicable decision tree could greatly improve clinical workflow at the ED. Previously identified risk factors for discharge disposition in patients in need of hip surgery are age, living situation and sex (19–21). However, most of these studies did not particularly focus on geriatric patients with a traumatic hip fracture like in this study. Although prefracture mobility has been shown to be a predicting factor for rehabilitation after discharge, only one study focused on the PMS in the prediction of discharge disposition (15,22). Kristensen et al. found that older age, having a low PMS (<7) and an intertrochanteric fracture were predictive factors for not being discharged home. Unfortunately, they did not discriminate between discharge to a rehabilitation facility or a nursing home. We believe that patients who are discharged to a rehabilitation facility or a nursing home follow different placement processes with different waiting times. Since the focus was primarily on patients with true rehabilitation potential, patients living in a nursing home upon admittance were excluded. A recent study about the development of a prediction model for discharge disposition in (specifically) hip fracture patients did not find functional status to be associated with discharge disposition (23). They found that advanced age and an increasing ASA score were the greatest risk factors for discharge to a post-acute care facility (PAC). No previous literature mentioned the necessity to use stairs at home to be associated with discharge disposition.

Clinical decision tools have been developed to predict discharge disposition and, although tested on elective hip arthroplasties, these tools have shown to decrease HLOS (21,24). If there was an estimated > 50% likelihood of being discharged to a PAC facility, the process of placement started preoperatively, resulting in a decrease in HLOS by a day (21).

Pedersen et al. compared different prefracture functional status tools (Barthel-20, Barthel-100, Cumulated Ambulation Score (CAS) and PMS) for subgroup identification in treatment and rehabilitation (25). They found that Barthel-20, Barthel-100, and Parker Mobility Score, correlated with outcome at 4-month post-fracture and were valid predictors. Interestingly, the PMS only shares one item (walking inside) with the other assessment tools: PMS focusses on walking ability whereas the other tools focus on activities of daily living (ADL) as well. Because of this, the PMS is a shorter instrument than the Barthel-indices which makes it more suitable for use in everyday clinical practice at the ED. Besides that, the PMS has a proven high inter-tester reliability in hip fracture patients and the AO Foundation, Switzerland encourages the use of the PMS as a simple validated bedside assessment tool in traumageriatric care (26,27).

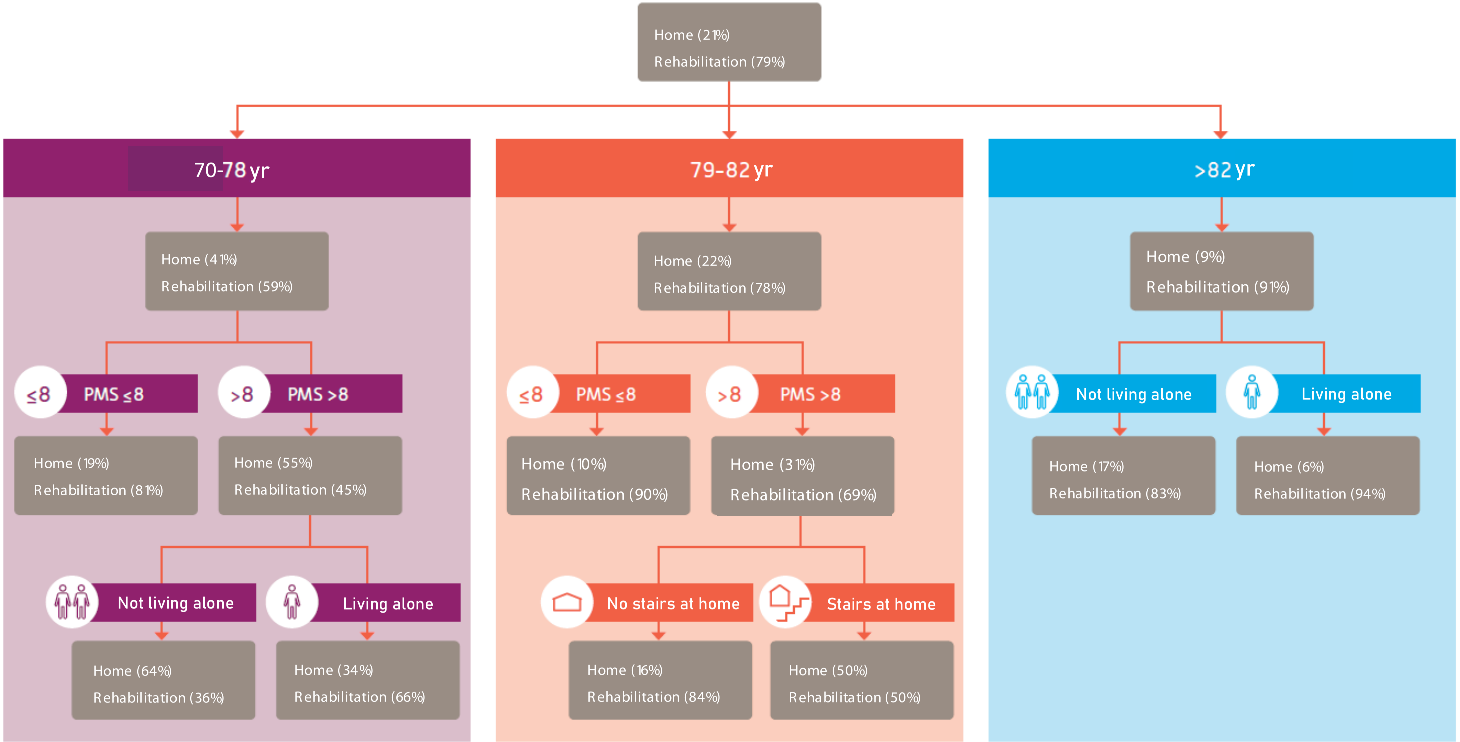
Strength and limitations

This study is one of the first studies to classify discharge disposition and HLOS specifically for geriatric traumatic hip fracture patients using the PMS. A strength of this study is that it provides a practical solution to an important operational problem. The decision tree for the prediction of discharge disposition, containing PMS as a strong associated variable, makes it possible to start discharge planning at an early stage. This could potentially reduce waiting time for placement in a rehabilitation facility. Another strength is that the model classified discharge disposition with a PPV of 91% and an overall accuracy of 82.1%. The high PPV indicates that the decision tree model was very well suited for the identification of the patient population with a longer HLOS and rehabilitation potential. Given all the external factors that play a role in the discharge process, we found the accuracy of the model to be acceptable. The decision tree for discharge disposition can most likely be implemented in other trauma centers as well because the variables associated to discharge disposition are independent of the hospital and the rehabilitation facilities (Appendix A). Yet, factors such as proximity and availability of rehabilitation facilities could still influence the magnitude of the effect of early discharge planning on the reduction of HLOS.

This study has a retrospective design with its known forms of bias. Regarding patient data acquisition, although the PMS was already used by the physiotherapists, it was only introduced as part of the electronic patient documentation from Diakonessenhuis Utrecht at the start of 2019. Therefore, only patients presenting in 2019 were included from this hospital. In the age > 82 group, the PMS was not among the three most strongly associated variables. PMS was in fact significantly associated, however, to maintain clinical applicability we chose to stop after three levels of depth. Another limitation of the study may be that this study mainly focused on functional status and no data were collected on cognitive status. Yet, because the decision tree was developed to be used at the ED, thorough cognitive assessment is often not possible and was, therefore, left out.

CONCLUSION

This study shows that the PMS was strongly associated with discharge disposition and HLOS. The decision tree for the discharge disposition of geriatric traumatic hip fracture patients with the PMS as an important variable offers a practical solution to start discharge planning upon admittance. Future studies should focus on the implementation of decision trees for discharge disposition to reduce HLOS for geriatric traumatic hip fracture patients and monitor its effect on HLOS and costs.



Parker Mobility Score

Walking ability	No difficulty	Alone with an assistant device	With help from another person	Not at all
Able to walk inside house	3	2	1	0
Able to walk outside house	3	2	1	0
Able to go shopping, to a restaurant or to visit family	3	2	1	0

Appendix A Decision model for the emergency department

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8

Does preoperative hemodynamic preconditioning improve morbidity and mortality after traumatic hip fracture in geriatric patients? A retrospective cohort study

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ABSTRACT

Introduction: Dehydration is a major problem in the older population with traumatic hip fractures (THF). A preoperative hemodynamic preconditioning (PHP) protocol may help in achieving hemodynamic stability to ensure adequate perfusion and oxygenation using only clinical parameters to assess cardiovascular performance.

Methods: A single-center retrospective study in geriatric trauma patients was conducted in a Level 1 Trauma Centre in Switzerland. Patients over the age of 70 with THFs and with Portsmouth Physiological and Operative Severity Score for the enUmeration of Mortality (pPOSSUM) scores ≥ 5% who underwent surgical treatment between February 2015 and October 2017 were included. It was hypothesized that patients whose hemodynamic stability was optimized before surgery would have fewer complications and reduced mortality postoperatively. Primary outcomes were complications and mortality. Secondary outcomes were hospital length of stay (HLOS) and place of discharge.

Results: 100 patients were included in the PHP group and 79 patients were included in the non PHP group. The median age was 86.5 (82–90) in the PHP group and 86 (82–90) in the non PHP group. Patients who had been treated according to the PHP protocol showed a significant reduction in mortality at 30 days ($p = 0.02$). The PHP group showed an 8.1 and 3.5% reduced mortality at 90 days and at 1 year, respectively. The PHP group showed an 11.7% reduction of patients with complicated courses. No significant differences were seen in HLOS and discharge disposition.

Conclusion: The PHP group showed a significant reduction in short-term mortality, a reduction in long-term mortality, and a reduction in the number of patients with complicated courses. The PHP protocol is a safe, strictly regulated, non-invasive fluid resuscitation protocol for the optimization of geriatric patients with a THF that requires minimal effort.

INTRODUCTION

Frail, older patients have a reduced physiological capability to withstand a major trauma like a hip fracture (1). Comorbidities and polypharmacy complicate treatment. Moreover, these conditions facilitate complications and, therefore, negatively affect outcomes (2–4).

Dehydration upon admission is a significant problem in this patient population; 44% of the patients admitted to an emergency department are dehydrated (5). Patients with hip fractures may not always be able to assist themselves or call for help immediately after the incident. This may cause a delay between the trauma, the arrival of emergency services, and the start of surgery. Such delays increase the possibility of reduced hydration status for an extended period of time. Likewise, comorbidities and hemorrhage from the fracture site contribute to deteriorating physical conditions (6). All these factors may further worsen the already existing dehydration status.

After arriving at the hospital, hypovolemia may not always be evident when a patient is examined and the heart rate or blood pressure will not identify all patients with a dehydrated state (7). A protocol-driven approach to fluid management could help to avoid hypovolemia as well as excessive fluid administration in patients with hemodynamic instability.

Clinical parameters to assess cardiovascular performance, such as electrocardiography (ECG), pulse pressure variability (PPV), peripheral circulation temperature, oxygen oximetry, and diuresis, are commonly available. We hypothesized that a preoperative hemodynamic preconditioning (PHP) protocol on the basis of the abovementioned clinical parameters could be of use in achieving hemodynamic stability to ensure adequate perfusion and oxygenation in an older population.

The goal of the PHP protocol was to hemodynamically optimize a subpopulation of patients who have been classified as high risk for complications and mortality. The protocol consisted of monitoring a patient's hemodynamic status and applying controlled fluid resuscitation. It was hypothesized that patients whose hemodynamic stability was optimized before surgery would have fewer complications and a reduced mortality postoperatively. Primary outcomes were complications and mortality. Secondary outcomes were hospital length of stay (HLOS) and place of discharge.

METHODS

This study is written in accordance with the STROBE statement (8).

Study design

A single-center retrospective study in geriatric trauma patients was conducted in a Level 1 Trauma Centre in Switzerland. Ethical approval for the quality improvement project was given by the responsible ethical commission (Ethikkommission Nordwest- und Zentralschweiz, EKNZ 2014–343).

Study population

We analyzed all patients admitted consecutively for hip surgery treatment at the department of surgery of Lucerne Cantonal Hospital (level I trauma center) between February 2015 and October 2017. Inclusion criteria were an isolated traumatic hip fracture, Portsmouth Physiological and Operative Severity Score for the enUmeration of Mortality (pPOSSUM) ≥ 5%, and age 70 and over. Exclusion criteria were a missing pPOSSUM score and non-operative treatment (9).

The PHP protocol

The PHP flowchart is shown in Fig. 1. Upon admission, patients were scored with the pPOSSUM scoring system to assess whether their postoperative mortality risk was elevated (9). This scoring system uses a physiological score and an operative severity score to calculate the risk of surgical outcome in terms of mortality. All patients with a pPOSSUM score indicating a mortality prediction greater than 5% were considered as high-risk surgical patients and were, therefore, eligible for PHP. After initial screening, the final decision on whether to start fluid therapy was made by the on-call senior anesthesiologist who assessed the patients. This decision was based on subjective judgment. Capacity restraints could be a reason for not treating patients accordingly, due to force majeure.

All patients received an electrocardiogram (ECG) to determine the absence or presence of irregularities in heart rhythm. Pulse pressure variation (PPV) was calculated to assess patients' volume responsiveness, and transcutaneous pulse oximetry was used to measure patients' oxygen saturation (SpO2) (10,11). Extremity temperature (warm or cold) was assessed subjectively.

The goal of preoperative hemodynamic preconditioning (PHP) was to correct volume deficits associated with insufficient circulating blood volume and oxygen delivery. Fluid therapy consisted of the administration of a 250 ml bolus of Ringerfundin balanced solution (RF). Re-evaluations were conducted every 30 min with a maximum of six bolus

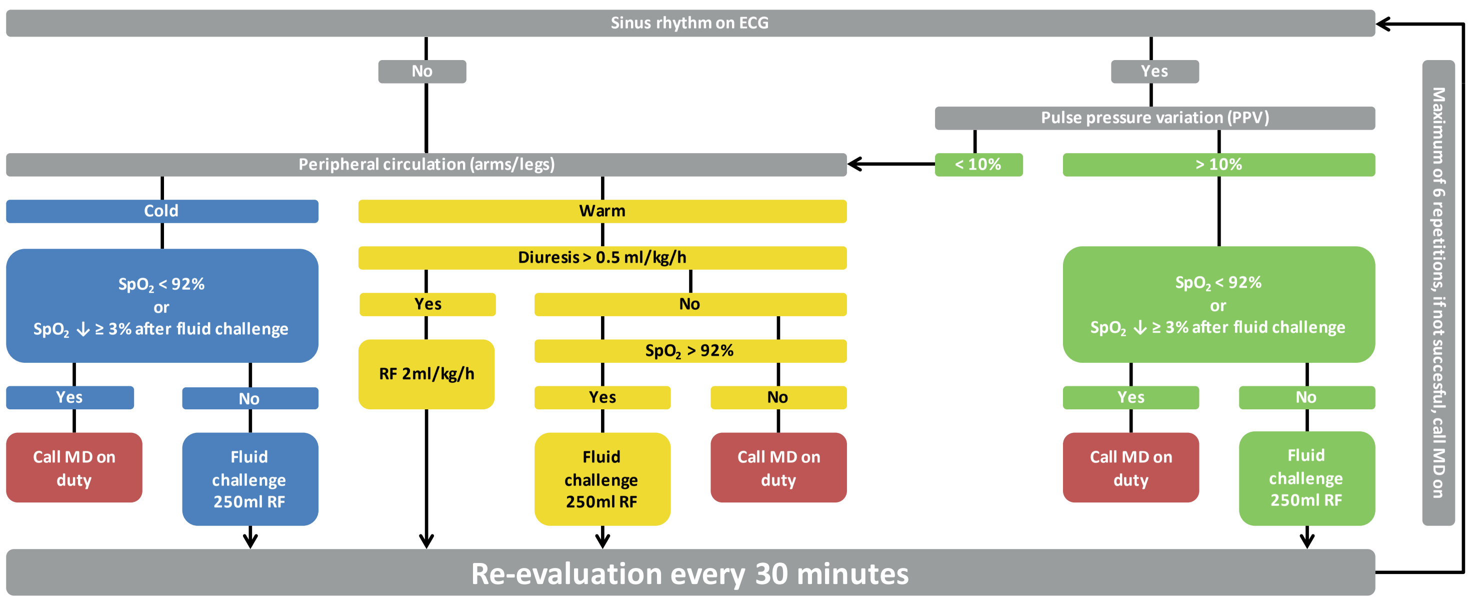

Fig. 1 PHP flowchart.
ECG: electrocardiography. RF: Ringerfundin balanced solution. MD: medical doctor. SpO2: blood oxygen saturation.

repetitions. Pharmacotherapy was not part of the PHP protocol. However, if a patient's situation was not stable, the on-call medical doctor (MD) was allowed to abandon the PHP protocol.

Patients were scheduled for surgery when the following criteria were met:

- MAP > 60 mm Hg (mean arterial pressure)
- PPV < 10
- adequate peripheral circulation (warm extremities)
- diuresis ≥ 0.5 ml/kg/h
- daytime (preferred).

All patients were administered femoral nerve blocks during intermediate care unit (IMCU) admission. Patients returned to the IMCU postoperatively. Criteria for discharge from the IMCU were the aforementioned preoperative criteria as well as a hemoglobin level above 80 g/L (5 mmol/L). Aside from the PHP protocol, both groups received similar care, including geriatric co-management and extensive laboratory testing [calcium, phosphate, (para)thyroid hormones, vitamin deficiencies, liver enzymes, and (pre) albumin].

Data collection

Data were collected by an independent researcher and entered into preformatted Excel spreadsheets. Both surgery and anesthesiology departments' clinical notes and patient reports were reviewed and extracted through a web-based clinical electronic patient documentation system.

Baseline data were collected on age, sex, American Society of Anesthesiologists Association (ASA) classification, fracture types according to the Arbeitsgemeinschaft für Osteosynthesefragen (AO), and the pPOSSUM score (9,10,12). The following perioperative data was retrieved: time to surgery (hours), time of surgery (daytime 7:00–18:59, out of office hours (nighttime) 19:00–6:59), and type of surgery. Types of surgery included hemiarthroplasty, total hip prosthesis, intramedullary nail, sliding hip screw (including Dynamic Hip Screw [Depuy Synthes, Oberdorf, Switzerland] and Targon FN [B-Braun AG, Melsungen, Germany]), and/or the use of cannulated screws. Postoperative outcomes were: HLOS in days, number of complications per patient, number of patients with complicated courses, and types of complications.

Postoperative complications were divided into two groups: surgical and non-surgical. Surgical complications included: wound infection (according to CDC guidelines), hematoma (if a surgical intervention was necessary) acute anaemia (defined as blood loss requiring transfusion), and revision of implant due to loss of reduction (13,14).

Non-surgical complications included: pneumonia (according to CDC guidelines), delirium (according to DSM-5 guidelines), urinary tract infection (UTI) (according to CDC guidelines), cardiac failure (according to ESC guidelines), renal insufficiency (according to KDIGO guidelines), decubitus (according to EPUAP guidelines), pulmonary embolism (according to ESC guidelines), gastrointestinal bleeding, and cerebrovascular incident (CVI) (according to WHO guidelines) (13–17).

Each complication that occurred fewer than five times in the entire cohort was grouped under 'other'. Furthermore, data on place of discharge (home, nursery home, and rehabilitation) were gathered for analysis.

Mortality data were obtained from the national registry of the federal office for statistics to compare 30-day, 90-day, and 1-year mortality.

Statistical analysis

Categorical variables are expressed as percentages and numerical data as median, range, or interquartile range (IQR). Categorical variables were compared by the Chi-squared test or Fisher's exact test (two-tailed) and continuous variables by the Mann–Whitney U test, as appropriate. A two-sided p-value of < 0.05 was considered statistically significant. Data were analyzed with the SPSS software package version 25.0 (IBM Corp., Armonk, NY) for Windows.

RESULTS

Participants

A total of 179 patients who met the inclusion criteria were included in this analysis. Out of 179 eligible patients, 100 were selected by the on-call anesthesiologist to participate in the PHP protocol. The remaining 79 who were scored with pPOSSUM > 5%, but were not selected by the on-call anesthesiologist were used as a control group. A flowchart detailing inclusion and exclusion criteria is shown in Fig. 2.

Baseline characteristics

Baseline characteristics and perioperative outcomes are shown in Tables 1 and 2. No significant differences were seen at baseline. The median pPOSSUM score showed no difference between the groups (M = 11.95 vs. M = 12.10; $p = 0.51$). Perioperatively, there were no significant differences in time to surgery, time of surgery, type of surgery, and postoperative recovery time.

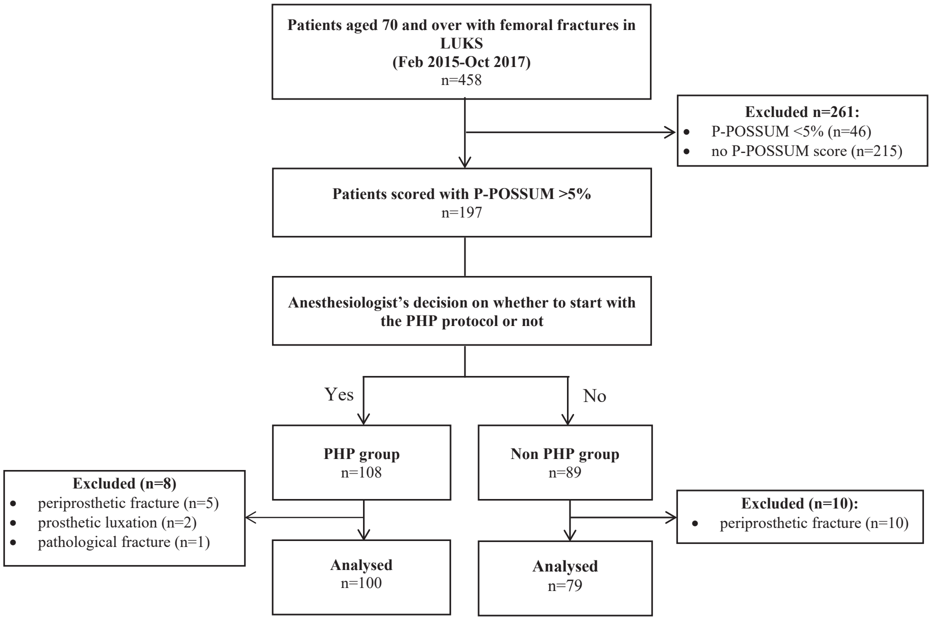

Fig. 2 Flowchart of patient inclusion

Table 1 Baseline characteristics

	PHP (*n* = 100)	Non PHP (*n* = 79)	*p*-value
Age (years) *median* (IQR)	86.5 (82–90)	86 (82–90)	0.90
Gender			
Male *n (%)*	41 (41.0)	31 (39.2)	
Female *n (%)*	59 (59.0)	48 (60.8)	0.81
ASA classification			0.16
ASA classification 1 *n* (%)	0 (0)	0 (0)	
ASA classification 2 *n* (%)	3 (3.0)	6 (7.6)	
ASA classification 3 *n* (%)	76 (76.0)	63 (79.7)	
ASA classification 4 *n* (%)	21 (21.0)	10 (12.7)	
Type of fracture			0.40
Femoral neck *n* (%)	43 (43.0)	34 (43.0)	
PTF *n* (%)	54 (54.0)	37 (46.8)	
Subtrochanteric *n* (%)	3 (3.0)	8 (10.1)	
pPOSSUM score (%) *median* (IQR)	11.90 (8.45–21.50)	12.10 (7.70–18.70)	0.51

Numbers are noted in percentages of the total number of patients at the hospital. *n* number of patients. *IQR* interquartile range. *ASA classification* American Society of Anesthesiologists Physical Status Classification System. ASA classification 1 a normal healthy patient. ASA classification 2 a patient with mild systemic disease. ASA classification 3 a patient with severe systemic disease. ASA classification 4: a patient with severe systemic disease that is a constant threat to life. *PTF* Pertrochanteric Fracture

Table 2 Perioperative outcomes

	PHP (*n* = 100)	Non PHP (*n* = 79)	*p*-value
Time to surgery			
Time to surgery (hh:mm) *median* (IQR)	19:41 (14:21–24:46)	21:23 (08:35–32:08)	0.96
Time of surgery			0.71
Daytime surgery (7:00–18:59) *n* (%)	66 (66.0)	50 (63.3)	
Nighttime surgery (19:00–6:59) *n* (%)	34 (34.0)	29 (36.7)	
Type of surgery			0.42
Hemiarthroplasty *n* (%)	35 (35.0)	30 (38.0)	
Total Hip Prothesis *n* (%)	5 (5.0)	2 (2.5)	
Pertrochanteric Fixation Nail *n* (%)	49 (49.0)	39 (49.4)	
Sliding hip screw *n* (%)	11 (11.0)	6 (7.6)	
Other *n* (%)	0(0)	2 (2.5)	
Postop recovery time (hh:mm) *median* (IQR)	02:57 (02:20-04:20)	3:25 (2:30–5:45)	0.07

Numbers are noted in percentages of the total number of patients at the hospital.
n number of patients, IQR interquartile range.

Primary outcomes

Primary and secondary outcomes are shown in Table 3. Patients who were treated according to the PHP protocol showed a significant reduction in mortality at 30 days (11.0% vs. 24.1%; $p = 0.02$). The PHP group showed an 8.1% and 3.5% reduced mortality at 90 days and at 1 year, respectively (21.0% vs. 29.1%; p = 0.21 and 37.0% vs. 40.5%; $p = 0.63$).

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The PHP group showed an 11.7% reduction in patients with complicated courses (63.0% vs. 74.7%; $p = 0.10$). Furthermore, a decrease in the number of complications per patient was seen, although this decrease was not significant. No significant differences were seen in types of complications.

Secondary outcomes

The HLOS showed no significant differences between groups (M = 8 vs. M = 8; $p = 0.43$) and no significant differences were seen in discharge disposition. However, in the PHP group, more patients were discharged home (12.0% vs. 3.8%; $p = 0.06$), while in the non PHP group, more patients were sent to rehabilitation (38.0% vs. 51.9%; $p = 0.06$).

Table 3 Postoperative outcomes

	PHP (*n* = 100)	Non PHP (*n* = 79)	*p*-value
HLOS (days) *median* (IQR)	8 (6–12)	8 (5–12)	0.43
Complications			
Patients with complicated courses *n* (%)	63 (63.0)	59 (74.7)	0.10
Complications per patient			
0 complications *n* (%)	37 (37.0)	20 (25.3)	0.10
1 complication *n* (%)	36 (36.0)	35 (44.3)	0.26
≥ 2 complications *n* (%)	27 (27.0)	24 (30.4)	0.62
Non-surgical complications			
Pneumonia *n* (%)	7 (7.0)	3 (3.8)	0.52
Delirium *n* (%)	12 (12.0)	15 (19.0)	0.20
Cardiac failure *n* (%)	18 (18.0)	12 (15.2)	0.62
Urinary tract infection *n* (%)	10 (10.0)	8 (10.1)	0.98
Surgical complications			
Anaemia *n* (%)	44 (44.0)	34 (43.0)	0.90
Wound infection *n* (%)	3 (3.0)	3 (3.8)	1.00
Other *n* (%)	10 (10.0)	11 (13.9)	0.42
Home *n* (%)	12 (12.0)	3 (3.8)	0.06
Nursery home *n* (%)	45 (45.0)	33 (41.8)	0.67
Rehabilitation *n* (%)	38 (38.0)	41 (51.9)	0.06
In-hospital mortality *n* (%)	5 (5.0)	2 (2.5)	0.47
Mortality			
30-day mortality *n* (%)	11 (11.0)	19 (24.1)	0.02
90-day mortality *n* (%)	21 (21.0)	23 (29.1)	0.21
1-year mortality *n* (%)	37 (37.0)	32 (40.5)	0.63

Numbers are noted in percentages of the total number of patients at the hospital. Cardiac failure: consists of myocardial infarction, congestive heart failure and reanimation. Other: consists of complications with a total incidence ≤ 5 (revision, pulmonary embolism, gastrointestinal bleeding, renal insufficiency, hematoma, decubitus, and cerebrovascular incident), *n* number of patients, *IQR* interquartile range, *HLOS* hospital length of stay.

DISCUSSION

The PHP protocol was designed to optimize hemodynamic stability and ensure adequate perfusion and oxygenation in a subpopulation of patients with a hip fracture who were classified as high risk for complications and mortality. In this study, the PHP group showed a significantly lower short-term mortality, and a reduction in mortality was seen up to 1 year after surgery. Furthermore, the PHP group showed a reduction in the number of patients with complicated courses, and a decrease in the number of complications per patient was noted, as well. A recent systematic review stated that despite widespread focus on care for this population in the first world, preoperative resuscitation in older patients with hip fractures has been overlooked (18). No articles were found regarding this sort of preoperative treatment (18). Therefore, to our knowledge, this is the first study that investigated the effects of the implementation of a preoperative fluid resuscitation strategy in geriatric hip fracture patients. The PHP group did not show a shorter HLOS. Most likely because the HLOS in this hospital was mostly dependent of discharge planning and free beds at discharge locations. Nonetheless, Grigoryan et al. compared orthogeriatric care models for patients with hip fractures, and the HLOS found in our study was shorter than the majority of the participating studies in their review (19). Furthermore, the PHP patients had to meet several criteria before they were scheduled for surgery. The results showed that the PHP protocol did not prolong the time to surgery and can be carried out during the current waiting times for surgery.

There are several limitations to this study. This study had a retrospective design with its known and unknown forms of bias. Because of the design, pPOSSUM scores were missing for 215 patients. However, we are certain that none of these patients received PHP. Furthermore, the patient population was relatively small.

No data were available that defined the level of dehydration in this patient population. Nevertheless, the PHP protocol was strictly based on correcting possible volume deficits, and fluid challenges were performed in order to test patients' responsiveness.

As previously mentioned, patients in both groups were scored with pPOSSUM, and, according to the scoring system, all patients were considered eligible for PHP (pPOSSUM score ≥ 5%). However, the final decision to start the PHP protocol was made by the on-call anesthesiologist. Since the PHP group showed fewer complications and a significant reduction in short-term mortality, the assessment and expertise of an anesthesiologist was of great importance. This may have caused selection bias. The observation that there was no difference in the pPOSSUM scores of the two groups indicates that outcome of the risk prediction score did not influence the anesthesiologists in their decision-making. Furthermore, 79 out of 179 eligible patients were not selected for the PHP group, which implies that the on-call anesthesiologist disagreed with the pPOSSUM score in 44% of the cases. It is known that the pPOSSUM score underestimates mortality in the lower risk bands and overestimated mortality in the higher risk bands in hip fracture patients (20). Therefore, it can be argued that this risk prediction model by itself is not enough to decide whether to start the PHP protocol or, perhaps, it may not be the most reliable way to determine PHP eligibility, especially when the scoring system is used by various clinicians instead of a single trained researcher. In this study, patients with a pPOSSUM score < 5% were not considered eligible for the PHP protocol, and they were not assessed by an anesthesiologist. If the pPOSSUM scoring system is not reliable as an initial sorting system for this patient population, patients who would otherwise benefit from PHP were possibly missed.

This study supports preoperative fluid resuscitation according to the PHP protocol for high-risk surgical patients with THFs. This protocol could possibly reduce morbidity, mortality, and potentially lead to a reduction of costs. A randomized-controlled trial is necessary to confirm the effectiveness of preoperative fluid resuscitation strategies on postoperative outcome in hip fracture patients.

In this study, fewer complications, and a reduction in mortality of high-risk surgical patients with THFs were seen in the group of patients who received preoperative hemodynamic preconditioning. PHP was demonstrated to be a strictly regulated and non-invasive fluid resuscitation protocol for geriatric patients with THFs that required minimal effort and provides positive results. Future research is needed to confirm these finding.

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Inter-rater agreement in pPOSSUM scores of geriatric trauma patients: a prospective evaluation

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ABSTRACT

Purpose: Risk prediction models are widely used in the perioperative setting to identify high-risk patients who may benefit from additional care and to aid clinical decision-making. pPOSSUM is such a prediction model, however, little is known about the inter-rater agreement when scoring subjective parameters. This study assessed the inter-rater agreement between clinicians of different specialties and work-level when scoring 30 clinical case reports of geriatric hip fracture patients with pPOSSUM.

Methods: Eighteen clinicians of the department of Surgery (three specialists, four residents), Anesthesiology (four specialists, two residents) and Emergency Medicine (three specialists, two residents) who were familiar with the pPOSSUM scoring system were asked to calculate the scores. The kappa statistic and the statistical method of Fleiss were used to analyze inter-rater agreement.

Results: The response rate was 100%. Among surgeons, Anesthesiologists and Emergency department doctors (ED) the overall mean kappa values were 0.42, 0.08 and 0.20, respectively. Among surgery-, anesthesiology- and ED residents the overall mean kappa values were 0.21, 0.33 and 0.37, respectively. Within the department of Surgery, Anesthesiology and Emergency Medicine the overall mean kappa values were 0.23, 0.12 and 0.22, respectively. An overall mean kappa value of 0.19 was seen among all specialists. All residents had an overall mean kappa value of 0.21 and all clinicians had an overall mean kappa value of 0.21.

Conclusion: The overall inter-rater agreement of clinicians and interdisciplinary agreement when scoring geriatric hip fracture patients with pPOSSUM was low and prone to subjectivity in our study. A higher work-experience level did not lead to better agreement. When pPOSSUM is calculated without clinical assessment by the same clinician, caution is advised to prevent over-reliance on the pPOSSUM risk prediction model.

INTRODUCTION

Risk prediction models can be useful in the process of preoperative triage, clinical decision making and perioperative planning. Stratification of patients based on preoperative risk prediction could help to allocate resources and care to those who are most in need. Therefore, many perioperative risk assessment tools to predict morbidity and mortality in surgical patients have been validated(1).

The Physiological and Operative Severity Score for the enumeration of Mortality and morbidity (POSSUM) is such a validated risk prediction model. It was initially described by Copeland et al (2). The Portsmouth-POSSUM (pPOSSUM) score was a modification of POSSUM that corrected for an overestimation in mortality which occurred particularly in low-risk patients (3,4). pPOSSUM is a widely used validated tool for audit and perioperative planning in emergency surgical practice (3,5–7).

In 2015, at the emergency department of a multidisciplinary geriatric trauma center in Switzerland, the pPOSSUM scoring system was used as a preoperative triaging aid to stratify high-risk surgical hip fracture patients (8). Patients with a high mortality risk prediction (>5%) would receive additional preoperative hemodynamic optimization according to a local fluid resuscitation protocol (9). The reliability of pPOSSUM as an aid in preoperative triage and decision-making makes it important that inter-rater variability is low. Moreover, if the clinician who calculates the score is not the same clinician making clinical decisions, unintentional malpractice may be the result. The involvement of multiple disciplines in the decision-making process may even complicate this issue. Moreover, concerns were raised after differences in calculated pPOSSUM scores were observed at the geriatric trauma center.

pPOSSUM scores 12 physiological and 6 operative parameters which are divided into 4 grades with exponentially increasing score (1, 2, 4, and 8) to calculate the risk of mortality (Appendix A.) (3). Some of these parameters may be susceptible to subjective interpretation.

This study aimed to investigate the inter-rater agreement in the scoring of 3 physiological (cardiac, respiratory and electrocardiograph) and 3 operative parameters (operation type, operative blood loss and the confidential enquiry into perioperative deaths [CEPOD]) of pPOSSUM that may be prone to subjectivity. The research questions were as follows: 1. Is the inter-rater agreement of the calculation of the pPOSSUM score in a controlled setting moderate (kappa-value > 0.41) (10)? 2. Do experience and/or medical specialty affect the level of consensus? We hypothesized that the inter-rater agreement in the scoring of these parameters would be low.

METHODS

Ethical approval was given by the responsible ethical commission (Ethikkommission Nordwest-und Zentralschweiz (EKNZ), 2014-343.

Participants

Specialists and residents of the department of orthopedic and trauma surgery, department of anesthesiology and the emergency department (ED) were asked to participate in this study. Clinicians of these three disciplines were selected because they worked together in a multidisciplinary team to provide optimal care for geriatric patients with a traumatic proximal femur fracture (PFF) admitted to the geriatric fracture center of the hospital (11). A condition for participation was that the participant had at least one year of clinical experience with the pPOSSUM scoring system as a tool for preoperative screening of traumatic PFF patients at the ED.

Clinical case reports

Thirty patients with a traumatic PFF were randomly extracted from a database using the RAND function in excel. The database contained all patients with a traumatic PFF who were admitted to the emergency department of a level 1 trauma center in Switzerland between January 2015 and October 2017. The electronic patient documentation of the selected patients was reviewed by an independent author (JK) and the following data were extracted: diagnosis, medical history, anamnesis, and physical examination results upon admission to the ED, admission report, electrocardiography conclusion (assessed by a cardiologist), radiology imaging (assessed by a radiologist), pre-admission medication. Furthermore, all lab values required to calculate the pPOSSUM score (urea, potassium, sodium, and leukocytes) were presented in a table at the bottom of each case report. The content of the clinical case reports was literally copied from the EPD, and no alterations were made with exception of the deletion of patient-identifying factors. The information in the case report reflected the information that was usually available at the time of calculating the pPOSSUM score.

Survey

The survey consisted of 30 identical anonymized clinical case reports of traumatic PFF patients. The reports were printed and presented to each participant in a presentation binder. The first page contained a brief study introduction and the participant was asked to write down their profession (specialist/resident and name of department). At the end of each clinical case report, a pPOSSUM scoring form was added that contained only the variables that were thought to be prone to subjectivity (Appendix B). All other parameters were available in each report. The participants were asked to leave no questions unanswered and they were provided as much time as needed for the accurate assessment of the clinical case reports.

Statistical analysis

Statistical analysis was performed by calculating the multi-rater kappa for the inter-rater agreement using the statistical method of Fleiss (12). The kappa statistic was used to analyze inter-rater agreement between two raters (10). R statistical software for Mac (R Foundation for Statistical Computing, Vienna, Austria) was used to calculate the kappa values. Inter-rater variation of six variables (cardiac, respiratory and electrocardiograph, operation type, operative blood loss and the confidential enquiry into perioperative deaths [CEPOD]), that were possibly prone to subjectivity, were calculated for different groups: agreement among all raters (specialists and residents of all departments), agreement within the same department (specialists and residents), agreement among specialists of a single department (specialists only), agreement among residents of a single department (residents only). Overall mean kappa values were calculated for different groups: surgeons, anesthesiologists, ED doctors, surgery residents, anesthesiology residents, ED residents, department of surgery, department of anesthesiology, emergency medicine, specialists, residents, all clinicians. Kappa values range from -1.0 to 1.0. The kappa value coefficient was interpreted according to the guidelines proposed by Landis and Koch: less than 0.00 poor agreement, 0.00 to 0.20 slight agreement, 0.21 to 0.40 fair agreement, 0.41 to 0.60 moderate agreement, 0.61 to 0.80 substantial agreement and 0.81 to 1.00 almost perfect agreement (10). pPOSSUM scores and median pPOSSUM scores were calculated using Microsoft Excel (Microsoft® Office Excel 2019, Microsoft® Corporation, Redmond, USA). A dot-plot was created using the graph function in Microsoft Word (Microsoft® Office Word 2019, Microsoft® Corporation, Redmond, USA)

RESULTS

Participants and response rate

18 clinicians participated in this study and a total of 540 clinical case reports were scored (table 1.). All pPOSSUM scoring forms were returned without missing data (100% response rate).

Figure 1 demonstrates the results of the Fleiss kappa statistical analysis of the inter-rater-agreement for the pPOSSUM scoring system.

Table 1 Participant inclusion

	Specialists	Residents	Total
Department of Surgery	3	4	7
Department of Anaesthesiology	4	2	6
Department of Emergency Medicine	3	2	5
Total included	10	8	18

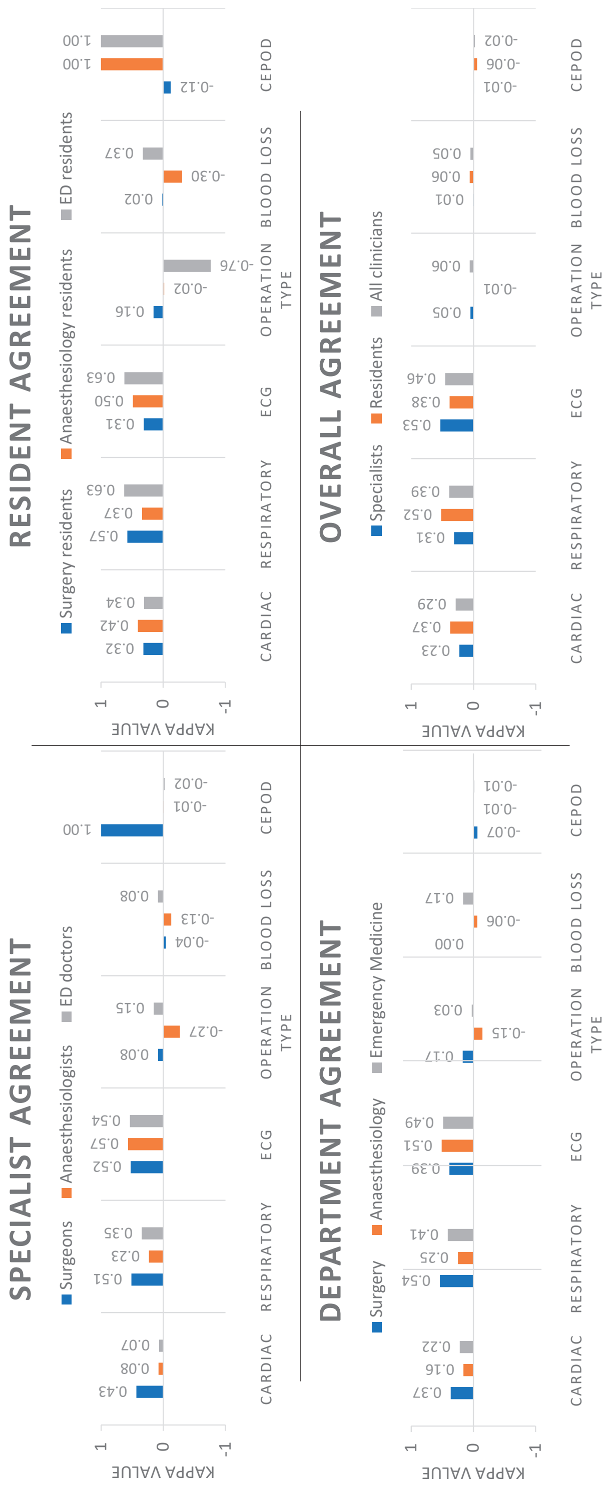

Figure 1 Clustered column charts of agreement among raters

Specialist agreement

An overall mean kappa value of 0.42 was seen among surgeons. Anesthesiologists had an overall mean kappa value of 0.08 and ED doctors had an overall mean kappa value of 0.20.

Resident agreement

An overall mean kappa value of 0.21 was seen among surgery residents. Anesthesiology residents had an overall mean kappa value of 0.33 and ED residents had an overall mean kappa value of 0.37.

Department agreement

An overall mean kappa value of 0.23 was seen within de department of Surgery. The department of Anesthesiology had an overall mean kappa value of 0.12 and the Emergency department had an overall mean kappa value of 0.22

Specialist, resident, and overall agreement

An overall mean kappa value of 0.19 was seen among all specialists. All residents had an overall mean kappa value of 0.21 and all clinicians had an overall mean kappa value of 0.21.

Figure 2 shows the calculated pPOSSUM scores of each participant per clinical case report and the median of all pPOSSUM scores per clinical case report.

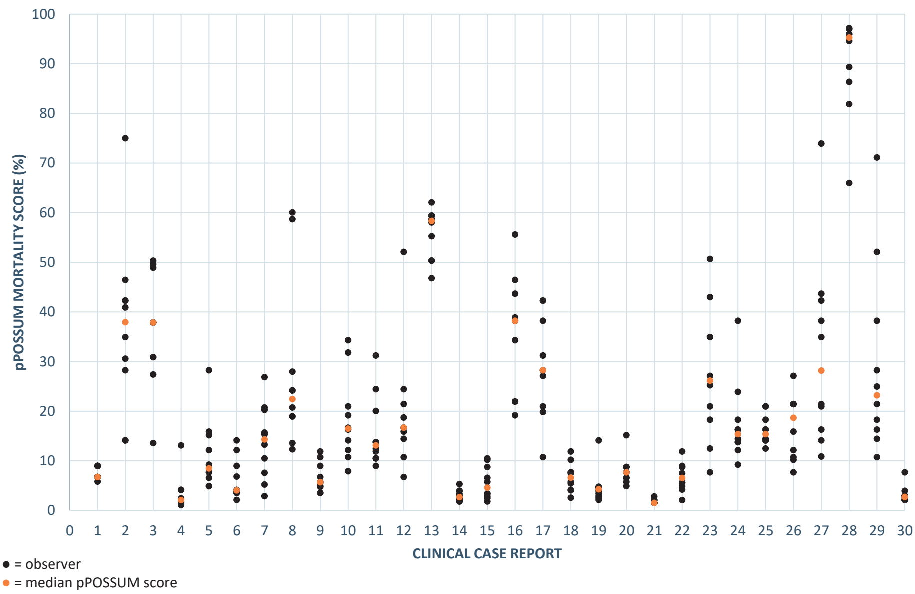

Figure 2 Calculated pPOSSUM scores of each participant per clinical case report
pPOSSUM: Portsmouth Physiological and Operative Severity Score for the enumeration of Mortality.

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DISCUSSION

This study was conducted to determine the inter-rater agreement when scoring certain physiological and operative parameters of the pPOSSUM assessment tool in a controlled setting. The exact same 30 clinical case reports were presented to 18 raters from different departments and of different work-experience levels. Except for the agreement among surgeons, which was moderate, the overall mean kappa values showed slight to fair agreement when scoring the parameters (cardiac, respiratory, ECG, operation type, blood loss and CEPOD). In general, agreement was lower when scoring operative parameters as opposed to the physiological parameters. This was observed in all categories (specialists, residents, departments, and overall agreement). In terms of work-experience level, the overall mean kappa value showed slight agreement among specialists and fair agreement among residents. Furthermore, the range of the calculated pPOSSUM scores was wide in many clinical case reports.

To our knowledge, only one other study investigated pPOSSUM variability among clinicians. Van Boxel et al. concluded that the inter operator variability of pPOSSUM, based on the same clinical information was wide (13). Furthermore, they warned for subjectiveness of primarily the operative components. Van Boxel et al. found subjectivity in the physiological parameters "cardiac" and "respiratory" as well. These results are in line with the results described in the present study. Moreover, van Boxel et al. proposed that, in the context of perioperative decision-making individual operative components should be discussed with the clinician in charge to decide what the most appropriate predictive score would be. The present study however, showed that inter-rater agreement among specialists of the same department was low as well. This suggests that review by a senior staff member could still lead to variability in the calculation of pPOSSUM. In addition, a recent paper showed that 44% of the anesthesiologists even overruled the pPOSSUM score as a screening tool for traumatic PPF patients because they disagreed with the calculated score (9).

This study showed that variability was present in both the physiological and operative parameters of pPOSSUM. The physiological score of pPOSSUM consists of 12 parameters, each with the same weight (3). A subjective component in the cardiac, respiratory or ECG parameter has therefore less influence on the final height of the pPOSSUM score. On the other hand, the operative score of pPOSSUM consists of only 6 parameters. This means that subjectivity in operation type, operative blood loss and CEPOD has a higher impact on the calculated operative score and ultimately, the final pPOSSUM score. This underscores the importance of consensus in scoring operative parameters.

In Switzerland, no formal training program that helps to understand and use the pPOSSUM scoring system exists. We found no literature regarding training programs for the improvement of agreement of pPOSSUM or other mortality risk assessment tools in the field of surgery. In psychiatry and neurology however, clinical outcome assessments, who are subjective to varying degrees, are frequently part of assessment tools. A literature review showed that there was significant improvement in the accuracy and agreement of clinical outcome assessments across diverse indications with training (14). Given the subjectivity of certain parameters of pPOSSUM, a training program may help to increase inter-rater agreement of this scoring system as well.

Because of the low inter-rater agreement in this study, it is possible that the pPOSSUM scoring system is too complex and more objective and less complex tools, such as the Nottingham hip fracture score (NHFS) which uses routinely available preoperative data, may prove to be more suitable as risk scoring models for the stratification of hip fracture patients (15). However, Boddaert et al. compared specific, geriatric, and general scores (American Society of Anesthesiologists physical classification (ASA), PreOperative Score to Predict Postoperative Mortality [POSPOM], Cumulated Illness Rating Score [CIRS], Charlson Comorbidity Index [CCI], and NHFS) for postoperative mortality in geriatric hip fracture patients that use only data available at the preoperative stage and concluded that all of these tools performed poorly (ROCAUC [0.6-0.7]) (16). They theorized that preoperative characteristics may not be crucial in identifying mortality risks in this population admitted in emergency conditions. Perhaps this suggests that the right preoperative risk prediction model for postoperative mortality in geriatric hip fracture patients has yet to be developed.

Limitations

Given the imponderability of daily clinical practice, it was not possible to organize bedside observations of a patient cohort for multiple raters. Therefore, each rater was provided with the exact same 30 paper clinical case reports. Because pPOSSUM can be used as an audit tool as well it was thought that this would not pose a problem when answering the research questions. The advantage was that each rater was presented with the exact same data to minimize imponderability in data acquisition and interpretation. Besides that, calculation of the pPOSSUM score was often based on an admission report and resident-staff consultation without direct patient contact in our hospital.

In the study hospital, the ECG parameter was based on the written conclusion of a cardiologist and the cardiologists were not aware of the options provided for the ECG parameter (Appendix A). We hypothesized that these conclusions would leave room for speculation. The kappa values of the ECG parameter showed that these conclusions were indeed prone to subjectivity. If the full ECG would have been provided, this could have led to either more or less subjectivity depending on the participants' abilities to accurately interpret an ECG. To minimize subjectivity, cardiologists should be made aware of the options of the ECG parameter so that they can provide the user with an advisory opinion.

Another limitation was that pPOSSUM was validated in many surgical specialties but only few studies were performed to ascertain validity in hip fracture surgery (17–19). We emphasize that this study does not question, nor does it present any evidence for or against the validity of the pPOSSUM risk assessment tool. This study showed that there was variability when scoring the parameters which we believed to be subject to subjective interpretation. Of course, the final pPOSSUM scores may vary less depending on the difference in scores that were acknowledged to each parameter (appendix A). For example, a score difference of 1 and 2 has less impact on the final difference in pPOSSUM score than a score difference of 1 and 8.

To conclude, it is important to keep in mind that risk assessment tools can be helpful during the decision-making process, but they should never replace clinical judgment based on experience. Although pPOSSUM has shown to outperform surgeons in their estimation of mortality, not all variables affecting outcome are taken into account (20,21). Therefore, it may be difficult to use pPOSSUM in a day-to-day clinical setting. Future studies should focus on inter rater agreement of clinicians when scoring pPOSSUM in a clinical setting and the effect of training on the agreement of preoperative risk prediction models such as pPOSSUM.

CONCLUSION

The overall inter-rater agreement of clinicians when scoring geriatric hip fracture patients with the pPOSSUM scoring system was low and prone to subjectivity in our study. Interdisciplinary inter-rater agreement was low. A higher work-experience level did not lead to better agreement. Therefore, when pPOSSUM is calculated without clinical assessment by the same clinician, caution is advised to prevent over-reliance on the pPOSSUM risk prediction model for preoperative triage, clinical decision-making, and perioperative planning in geriatric hip fracture surgery.

		Score			
		1	2	4	8
Physiological parameters	Age	≤60	61-70	≥71	
	Cardiac function	No failure	Diuretic. digoxin. anti-angina or hypertensive therapy	Peripheral oedema or warfarin therapy	Raised central venous pressure or cardiomegaly
	Respiratory function	No dyspnoea	Dyspnoea on exertion. mild obstructive airway disease	Limiting dyspnoea or moderate obstructive airway disease	Dyspnoea at rest (rate ≥30/min) fibrosis or consolidation on x-ray
	Electrocardiogram	normal		Atrial fibrillation (rate 60-90)	Any abnormal rhythm or ≥5 ectopics/minute or Q waves or ST/T changes
	Systolic blood pressure (mmHg)	110-130	131-170. 100-109	≥171. 90-99	≤89
	Pulse rate (rate/minute)	50-80	81-100. 40-49	101-120	≥121. ≤39
	Haemoglobin (g/dl)	13-16	11.5-12.9. 16.1-17.0	10.0-11.4	≤9.9. ≥18.1
	White blood cells (10^9 cells/L)	4-10	10.1-20. 3.1-4.0	≥2.0. ≤3.0	
	Urea (mmol/L)	≤7.5	7.6-10	10.1-15.0	≥15.1
	Sodium (mmol/L)	≥136	131-135	126-130	≤125
	Potassium (mmol/L)	3.5-5.5	3.2-3.4. 5.1-5.3	2.9-3.1. 5.4-5.9	≥2.8. ≥6.0
	Glasgow coma scale	15	12-14	9-11	≤8
Operative parameters	Operation type	Minor	Moderate	Major	Complex major
	Number of procedures	1		2	>2
	Operative blood loss (ml)	≤100	101-500	501-999	≥1000
	Peritoneal contamination	None	Minor (serous fluid)	Local pus	Free bowel content
	Malignancy status	None	Minor (serous fluid)	Nodal metastasis	Distant metastasis
	Mode of surgery	elective		urgent	Emergency (within 2 hours)

Appendix A pPOSSUM assessment tool
pPOSSUM: Portsmouth Physiological and Operative Severity Score for the enumeration of Mortality.

pPossum scoring form

Cardiac	
☐	No cardiac failure
☐	Diuretic, digoxin, Rx for angina or hypertension
☐	Peripheral oedema, warfarin, borderline cardiomyopathy
☐	Raised JVP, cardiomegaly

Respiratory	
☐	No dyspnoea
☐	Dyspnoea on exertion, mild COAD
☐	Limiting dyspnoea, moderate COAD
☐	Dyspnoea at rest, pulmonary fibrosis/consolidation on x-ray

ECG	
☐	ECG normal
☐	AF, rate 60-90
☐	Any other abnormal rhythm,>4/min. ectopics,Q-waves, ST/T changes

Operation type	
☐	Minor operation
☐	Moderate operation
☐	Major operation
☐	Complex major operation

Operative blood loss	
☐	<100mls
☐	101-500mls
☐	501-999mls
☐	>1000mls

CEPOD	
☐	Elective
☐	Urgent/'emergency'
☐	Emergency (within 2 hours)

Appendix B pPOSSUM scoring form.

pPOSSUM: Portsmouth Physiological and Operative Severity Score for the enumeration of Mortality. Rx: prescription. JVP: jugular venous pressure. COAD: chronic obstructive airway disease. AF: atrial fibrillation. CEPOD: confidential enquiry into perioperative deaths.

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PART III

General discussion and summary

10

General discussion

Because of the ageing society and the present-day shortage of healthcare workers we are forced to look critically at the management of patient flow in our hospitals (1,2) If we don't address this unfolding crisis, the accessibility of our healthcare services will be severely challenged in the next decades (3). This thesis focused on implementations and optimizations of traumageriatric care pathways to address these growing challenges.

PART I. THE EFFECT OF TRAUMAGERIATRIC CARE PATHWAYS FOR HIP FRACTURE PATIENTS IN THE NETHERLANDS AND SWITZERLAND.

The multidisciplinary approach

Traumatic hip fractures in geriatric patients are often symptoms of underlying morbidity rather than isolated fractures and comanaged care has proven to improve outcome for this population (**Chapter 2**) (4). A surgeon is not trained to recognize frailty, no more than a geriatrician is trained to manage the treatment of traumatic hip fractures (5). There is profound evidence that the complexity of care for geriatric patients with traumatic fractures requires a multidisciplinary approach and it should become standard care for this population (6–9).

Lean care pathways

In the beginning of the new millennium the lean approach, which originates from the automotive industry, became increasingly popular in healthcare (10–13). Since 2005, organizations in the United Kingdom and the United States started advocating the use of lean, as it had proven useful in other sectors and began to show promising results in the healthcare system as well (14). The traumageriatric care pathways in this thesis (**chapter 3-8)** are based on lean principles (15–20). Lean is a set of operating philosophies and methods that help create maximum value for patients by reducing waste including the waste of time waiting for service. It is often referred to as a learning and management system. An adaptation of the lean principles as defined by Womack and Jones can be found in fig.1 (21).

1. **Define value** Lean traumageriatric care pathways are designed with the patient in mind. If an action doesn't add value to the patient experience it must be seen as non-value added waste.
2. **Map value stream** Describe the order of activities in the patient journey of a geriatric hip fracture patient.
3. **Create flow** Delete all non-value added activities from the value stream to create optimal flow.
4. **Establish pull** Only provide a service when the patient indicates the need.

5. **Strive for perfection** Always strive for perfection in all value streams. Perfection should always be considered from the perspective of the healthcare consumer.

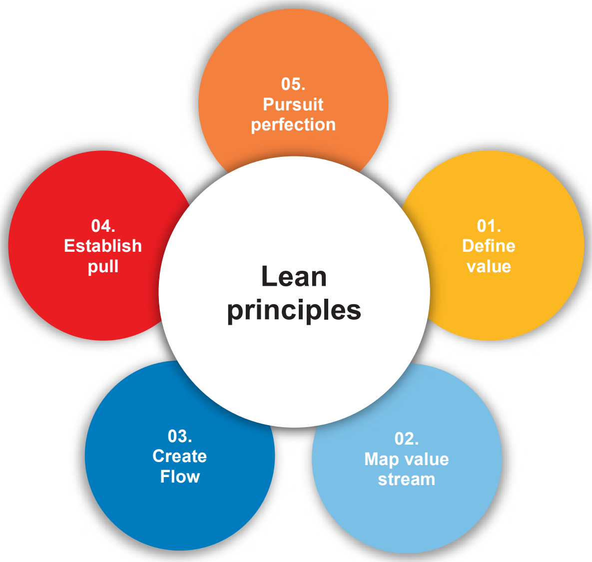


Figure. 1 The five lean principles

Chapter 3 and **4** showed that the implementation of traumageriatric care pathways for geriatric hip fracture patients, based on these lean principles, could improve flow through better cooperation with post-acute settings, faster turnaround times at the ED and OR, and a reduction of HLOS (15,16). It also resulted in a decrease in mortality and postoperative complications in this population. An improvement in the quality of data registration was found as well.

Chapter 5 showed a comparison of a traumageriatric care pathway versus extensive standard care with a focus on geriatric hip fracture patients to assess if a multidisciplinary geriatric care pathway leads to lower mortality and morbidity (17). This study showed no outcome that favors one specific geriatric care model over another. Although there is still debate regarding the best model for comanaged care, there is an important advantage to the lean multidisciplinary care pathway (4). Because all activities from the value stream are mapped, it is known how processes take place, who are involved, and which information streams exist, we can start improving clinical care pathways gradually.

Chapter 6 showed that, despite different cultural clinical practices specific to each hospital, the traumageriatric care pathways for hip fracture patients in the Netherlands and Switzerland performed similarly in terms of mortality. A longer HLOS in Switzerland was seen because of scarcity of beds in the hospitals' affiliated rehabilitation clinic. External factors like these could potentially delay the optimization of traumageriatric care pathways in the future. Collaboration with external parties is therefore crucial, both during the design of a care pathway and afterwards, to ensure that we can continue to meet the increasing healthcare demand.

PART II. MODIFICATIONS TO EXISTING GERIATRIC CARE PATHWAYS WITH A PURPOSE TO IMPROVE PATIENT FLOW AND PATIENT OUTCOME.

Once all processes are mapped, it becomes easier to target the possible bottlenecks and decrease or eliminate waste within care pathways. As beforementioned, waste is anything that creates no value for the healthcare consumer. Waste is defined in terms of value; therefore, we can only know the waste by first knowing the value first. Waste, therefore, is relative to the patients' needs. Table 1. shows the seven original wastes of the lean philosophy (22).

Table 1. Definitions of waste

Waste	Definition
Transporting	Required relocation/delivery of patient, materials or supplies to complete a task
Inventory	More materials on hand than are required to do the work
Motion	Movement of people that does not add value
Waiting	Idle time created when people, information, equipment or materials are not at hand
Overproduction	Redundant work
Overprocessing	Activities that do not add value from the perspective of the patient
Defects (rework)	Work that contains errors or lacks something of value

A known form of waste is non-value added time for placement in a rehabilitation facility after hip fracture treatment which increases length of stay. **Chapter** 7 showed that the prediction of discharge disposition with the Parker Mobility Score as a modification on an existing traumageriatric care pathway could potentially reduce HLOS by starting discharge planning at an earlier stage.

Chapter 8 showed that a non-invasive fluid resuscitation protocol could improve patient outcome in a subpopulation of patients with a hip fracture who were classified as high risk for complications and mortality (18,20). Furthermore, the PHP protocol added value for this subpopulation without obstructing the patient flow within the traumageriatric care pathway.

Chapter 9 showed that a risk prediction tool to estimate mortality was unreliable for the identification of high-risk patients and it did not add value to the traumageriatric care pathway (23). These findings provide the evidence that, in order to optimize the traumageriatric care pathway, additional training for this risk prediction model is needed or perhaps it should be replaced by another tool for risk prediction.

These studies have shown that the efficiency of traumageriatric care pathways can be improved while maintaining or improving the quality of care for hip fracture patients. Young et al. stated that in the context of health care, we should not expect to invent lean systems that work perfectly immediately but rather that a process of gradual improvement should be designed into them, with all stakeholders participating in the improvement process (11).

FUTURE PERSPECTIVES

How do we keep traumageriatric care pathways cost-effective

Traumageriatric care pathways have proven to reduce costs (24,25). However, it is important that in lean care pathways, money should not be the driving force. The process of continuously and gradually optimizing traumageriatric care pathways by reducing waste will ultimately lead to cost reduction by itself. Fig. 3 shows the traditional way of cost reduction versus lean cost reduction. Lean is based on reducing costs rather than raising prices or reducing services.

In the Netherlands, healthcare is financed with DBC (Diagnosis Treatment Combination) care products (26). DBC healthcare products form the basis of Dutch hospital care finance. The costs of a treatment, or a DBC care product, are based on the average costs for the respective treatment rather than the total costs of all provided forms of treatment. This means that it makes no difference whether a patient receives more or less care than the average, the price will always be the same. Based on this system, a cost saving care pathway could lead to extra profit or a chance to reinvest surplus profit in improving the care pathway as proposed in figure 4.

The price of a DBC is recalculated periodically, which means that when the price for hip fracture treatment decreases, the average DBC price will decrease as well. Through continuous gradual reduction of waste in the long term, surplus profit could continuously be reinvested in care pathways in the future while reducing overall costs for hip fracture care nation-wide.

Fig. 3 Traditional vs. Lean cost reduction

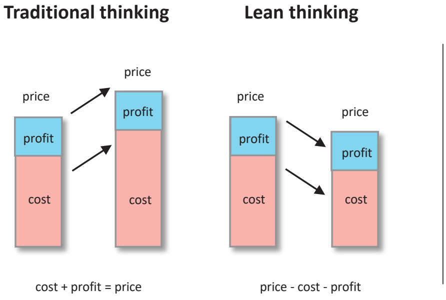
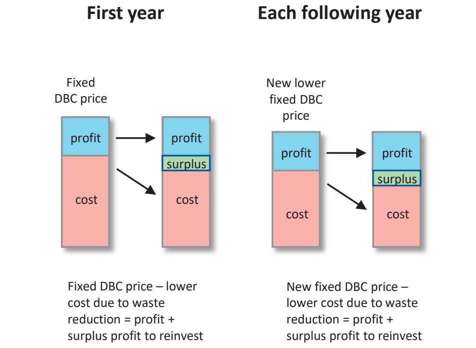


Fig. 4 Investing in care pathways through waste reduction



Access to data and data sharing

A quick response to a (potential) stagnation in patient flow could help to improve the overall performance of care pathways. Constant monitoring of care pathway performance may be the solution. So called *dashboards* could improve data analysis and subsequently improve quality control, planning, and cross-sectorial strategies. On a national scale, registries like the Dutch hip fracture audit provide a benchmark for the quality of hip fracture care and make it possible to study geriatric care pathways on a larger scale to improve overall quality of hip fracture care in the future (27).

How do we keep traumageriatric hip fracture care accessible

This thesis proved that traumageriatric care pathways make it possible to treat more patients with traumatic hip fractures per year while maintaining or increasing patient outcome. However, the increasing strain on our healthcare system due to an ageing society, requires us to invest in better prevention strategies as well. Secondary fracture prevention programs have already proven to reduce the risk of sustaining a subsequent fracture (28). A problem, however, is that these initiatives are often project-based and scattered (29,30). Therefore, future research should focus on the effects of population-based interventions to increase the level of evidence in support of a population-based approach. In the Netherlands, the government actively promotes older adults to live at home as a solution to the growing shortage of healthcare workers due to the ageing society (31). Periodic screening for the risk of falling in older adults before initial fracture and addressing potential dangers in their living environment upfront should be considered to reduce the incidence of osteoporotic hip fractures (32).

Non-utilized talent

Important potential barriers when implementing a clinical care pathway are lack of feedback, lack of staff involvement and lack of support from all levels (33). These barriers are associated with the eighth waste in lean management: non-utilized talent.

The authors' opinion is that this is perhaps the most important type of waste, especially in healthcare. This type of waste could potentially minimize the effect of a clinical care pathway before it is even implemented. Only by engaging employees from all the levels of an organization and involving them in the development of process improvements that are in line with the reality they experience and their skill set, we gain their support to successfully implement a care pathway. Hierarchy in medicine is an important disruptive factor for the success of care pathways. If the involved medical personnel do not feel safe to speak up or they don't feel heard, care pathways could never reach their full potential (34).

High employee turnover is another disruptive factor in the success of care pathways. High employee turnover can negatively affect workflow, quality of care and increase costs (35–37). Unfortunately, in teaching-hospitals, high turnover will always be a problem. However, adequate periodic training of staff and freelance medical personnel could help to sustain the quality of care and to preserve support for a clinical care pathway.

Lastly, besides getting health professionals on board, the patient should be at the center of the clinical care pathway (38). The involvement of patients is a paramount factor for the success or failure in clinical pathway interventions when it comes to quality of care provided and clinical efficiency (39). Therefore, it is important to keep the patient at the center of care by including patients in clinical pathway development, implementation, and evaluation (40). If patients are not involved, they may feel treated as objects rather than persons (41). During admission, it is important to provide patients with information about clinical care pathways they can comprehend, and shared decision making is an essential element in increasing compliance, satisfaction, and safety.

To conclude, the future of traumageriatric hip fracture management should be a patient-centered and multidisciplinary never-ending journey to continuous optimalization.

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11

Summary

The socioeconomic burden of hip fracture patients will become a serious challenge in the next decades. The overall aim of this thesis was to evaluate the effect of geriatric care pathways for hip fracture patients in the Netherlands and Switzerland (Part I) and to evaluate modifications of existing traumageriatric care pathways with a purpose to improve patient flow and patient outcome (Part II).

PART I. THE EFFECT OF TRAUMAGERIATRIC CARE PATHWAYS FOR HIP FRACTURE PATIENTS IN THE NETHERLANDS AND SWITZERLAND.

Chapter 2 presented a clinical lesson on the importance of a multidisciplinary approach and concentration of care. It emphasized that hip fractures in geriatric patients are a major public health problem, with high morbidity, mortality, and health and social care costs. Recent literature showed that a multidisciplinary approach and concentration of care result in better outcome of geriatric trauma patients.

In **chapter 3**, the implementation of a traumageriatric treatment model (GFC) for hip fracture patients in Switzerland was evaluated. The implementation of the GFC led to improved processes and outcomes for geriatric patients with THFs with a mortality reduction and reduced HLOS. Increased awareness and recognition led to an increase in the diagnosis of complications that would otherwise remain untreated. Expanding these efforts could lead to a significant reduction of morbidity and mortality in the future.

In **chapter 4**, the implementation of an orthogeriatric trauma unit for hip fracture patients in the Netherlands was evaluated. After implementation, there was a significant decrease in postoperative complications and turnaround time at the emergency department was reduced by 38 minutes. Additionally, there was significantly fewer 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 and a lower chance of 1-year mortality.

In **chapter 5**, two geriatric treatment models (geriatric care pathway vs. extensive standard care) for hip fracture patients in the Netherlands were compared. This study found no differences in postoperative complications, 30-day mortality, hospital length of stay (HLOS) and the amount of secondary surgical interventions. This inter-hospital comparison of two types of geriatric care models showed no outcome that favors one specific geriatric care model over another.

In **chapter 6**, two traumageriatric care models, one Swiss (CH) and one Dutch (NL) were compared, to assess whether these models would perform similarly despite the possible differences in local clinical practices. This study showed that quality of care in terms of mortality was equal. The difference in complicated course was mainly caused by a difference in delirium diagnosis. Differences were seen in surgical techniques, operation duration and timing. The local clinical practices did not result in a difference in patient outcomes between the two care pathways.

These studies suggest that geriatric care models improve patient outcome and could perform similarly, despite of a different approach, location, or clinical practices.

PART II. MODIFICATIONS TO EXISTING TRAUMAGERIATRIC CARE PATHWAYS WITH A PURPOSE TO IMPROVE PATIENT FLOW AND PATIENT OUTCOME.

In **chapter 7** we evaluated if the Parker Mobility Score (PMS) was associated with discharge disposition and HLOS of geriatric traumatic hip fracture patients and whether it could be incorporated in a decision tree for the prediction of discharge disposition upon admittance. The PMS was strongly associated with discharge disposition and HLOS. The decision tree for the discharge disposition of geriatric traumatic hip fracture patients offers a practical solution to start discharge planning upon admittance which could potentially reduce HLOS.

In **chapter 8**, the effect of a preoperative hemodynamic preconditioning (PHP) protocol using only clinical parameters to assess cardiovascular performance was examined. Patients who had been treated according to the PHP protocol showed a significant reduction in mortality at 30 days and a reduced mortality at 90 days and at 1 year, respectively. The PHP protocol is a safe, strictly regulated, non-invasive fluid resuscitation protocol for the optimization of geriatric patients with a THF that requires minimal effort.

Chapter 9 showed the inter-rater agreement in pPOSSUM scores of geriatric trauma patients in a prospective evaluation. The overall inter-rater agreement of clinicians and interdisciplinary agreement when scoring geriatric hip fracture patients with pPOSSUM was low and prone to subjectivity in our study. A higher work-experience level did not lead to better agreement. When pPOSSUM is calculated without clinical assessment by the same clinician, caution is advised to prevent over-reliance on the pPOSSUM risk prediction model.

These studies showed that alterations to existing traumageriatric care models as well as a thorough examination of tools in existing traumageriatric care models could lead to new additions to a pathway or reconsideration of a tool that was already in use.

12

Nederlandse samenvatting

De sociaaleconomisch last van patiënten met een heupfractuur zal een serieuze uitdaging gaan vormen in de aankomende decennia. Het doel van dit proefschrift was om het effect van traumageriatrische zorgpaden voor patiënten met een heupfractuur in Nederland en Zwitserland te evalueren (Deel I) en om modificaties van bestaande traumageriatrische zorgpaden te evalueren die als doel hebben om de patiënt flow en de patiënt uitkomsten te verbeteren (Deel II).

DEEL I. HET EFFECT VAN GERIATRISCHE TRAUMAZORGPADEN VOOR PATIËNTEN MET EEN HEUPFRACTUUR IN NEDERLAND EN ZWITSERLAND.

Hoofdstuk 2 toonde een klinische les over het belang van multidisciplinaire zorg en de concentratie van zorg. Er werd benadrukt dat geriatrische patiënten met een heupfractuur een groot probleem zijn voor de volksgezondheid, met hoge morbiditeit, mortaliteit en hoge zorg- en maatschappelijke kosten. Verwijzingen, operaties en postoperatieve zorg dienen nauwkeurig te worden afgestemd tussen verschillende specialismen en eerste en tweede lijn. Elke stap in de keten is cruciaal om te komen tot de beste behandeluitkomsten. Recente literatuur liet zien dat een multidisciplinaire benadering en concentratie van zorg leidt tot betere uitkomsten voor traumageriatrische patiënten.

In **hoofdstuk 3** werd de implementatie van een traumageriatrisch zorgpad (GFC) voor patiënten met een heupfractuur in Zwitserland geëvalueerd. We vonden een reductie van de mortaliteit. Er werd een significante toename van delieren gezien. De mediane HLOS was significant afgenomen met 2 dagen. Het aantal patiënten die postoperatief naar een revalidatieplek gingen steeg, evenals het aantal operaties binnen werktijd. De implementatie van het GFC leidde tot verbeterde processen en uitkomsten voor geriatrische patiënten met een traumatische heupfractuur. Een toename in bewustwording en herkenning van complicaties door medisch personeel heeft geleid tot een toename van het aantal gediagnosticeerde complicaties die anders mogelijk zouden zijn gemist. Intensivering van huidige inspanningen leidt mogelijk tot een significante reductie van morbiditeit en mortaliteit in de toekomst.

In **hoofdstuk 4** werd de implementatie van een traumageriatrisch zorgpad voor geriatrische patiënten met een heupfractuur in Nederland geëvalueerd. Na implementatie was er een significante afname in postoperatieve complicaties en een reductie van de doorlooptijd op de SEH van 38 minuten. Daarnaast was er een significante afname van *missing data* na implementatie van het traumageriatrische zorgpad. Na correctie voor covariabelen, hadden patiënten een lagere kans op complicaties en een lagere kans om te overlijden na 1 jaar.

In **hoofdstuk 5** vergeleken we twee traumageriatrische modellen (traumageriatrisch zorgpad versus uitgebreide standaardzorg) voor geriatrische patiënten met een heupfractuur in Nederland. Deze studie vond geen verschillen in postoperatieve complicaties, 30 dagen mortaliteit, HLOS en het aantal secundaire chirurgische interventies. De modellen hadden vergelijkbaar gepresteerd. Dit biedt de mogelijkheid voor toekomstige studies om te onderzoeken welke specifieke factoren van traumageriatrische modellen het meeste bijdragen aan de verbetering van de behandeling van deze populatie om zo tot de meest kosteneffectieve behandeling te komen.

In **hoofdstuk 6** vergeleken we twee traumageriatrische zorgpaden uit Zwitserland (CH) en Nederland (NL) om te beoordelen of deze twee zorgpaden vergelijkbaar zouden presteren ondanks de verschillen in lokale klinische werkwijzen en gebruiken. Deze studie toonde dat de kwaliteit van zorg vergelijkbaar was, gekeken naar de mortaliteit. Het verschil in gecompliceerd beloop bestond voornamelijk uit het verschil in het aantal gediagnosticeerde delieren. Er werden verschillen gevonden in chirurgische techniek, operatieduur en tijdstip. De lokale klinische werkwijzen en gebruiken hebben niet geleid tot een verschil in patiëntuitkomsten tussen de twee zorgpaden.

Deze studies suggereren dat traumageriatrische modellen patiëntuitkomsten verbeteren en dat ze vergelijkbaar kunnen presteren ondanks een andere aanpak, locatie of klinische praktijken.

DEEL II. MODIFICATIES AAN BESTAANDE TRAUMAGERIATRISCHE ZORGPADEN VOOR PATIËNTEN MET EEN HEUPFRACTUUR MET ALS DOEL DE FLOW EN PATIËNTEN UITKOMSTEN TE VERBETEREN.

In **hoofdstuk 7** hebben we geëvalueerd of de Parker Mobility Score (PMS) was geassocieerd met de ontslaglocatie en ligduur van geriatrische patiënten met een traumatische heupfractuur en of hier een beslisboom uit kan ontstaan die de ontslaglocatie bij opname op de spoedeisende hulp kan voorspellen. De beslisboom voor de ontslaglocatie classificeerde patiënten met een nauwkeurigheid van 82.1% en een positief voorspellende waarde van 91% voor ontslag naar een revalidatiekliniek. De PMS was sterk geassocieerd met de ontslaglocatie en ligduur. De beslisboom voor de ontslaglocatie van geriatrische patiënten met een traumatische heupfractuur biedt een praktische oplossing om ontslagplanning bij opname te starten waardoor mogelijk de ligduur kan worden verkort.

In **hoofdstuk 8** hebben we het effect van een preoperatief hemodynamisch preconditioneringsprotocol (PHP) onderzocht dat alleen gebruik maakt van klinische parameters om de cardiovasculaire status te beoordelen. Patiënten die waren behandeld volgens het PHP-protocol lieten een significante afname in mortaliteit na 30 dagen zien en een reductie na 90 dagen en 1 jaar zien. De PHP-groep liet een significante afname in het aantal patiënten met een gecompliceerd beloop zijn. Er werden geen significante verschillen gezien in ligduur en ontslaglocatie. Het PHP-protocol is een veilig, strikt gereguleerde, niet invasief resuscitatieprotocol voor de optimalisatie van geriatrische patiënten met een traumatische heupfractuur die minimale inspanning vereist.

In **hoofdstuk 9** onderzochten we de interbeoordelaarsbetrouwbaarheid bij pPOSSUM scores van geriatrische traumapatiënten in een prospectieve evaluatie. Achttien artsen van de afdeling chirurgie, anesthesie en de spoedeisende hulp die bekend waren met de pPOSSUM score werden gevraagd om de scores te berekenen. De algehele interbeoordelaarsbetrouwbaarheid van artsen en de interdisciplinaire beoordelaarsbetrouwbaarheid bij het scoren van pPOSSUM bij geriatrische patiënten met een traumatische heupfractuur was laag en gevoelig voor subjectiviteit. Meer werkervaring heeft niet geleid tot hogere beoordelaarsbetrouwbaarheid. Als pPOSSUM wordt berekend zonder klinische beoordeling door dezelfde arts is voorzichtigheid geboden om te veel te vertrouwen op het pPOSSUM risico predictie model.

Deze studies lieten zien dat aanpassingen aan bestaande traumageriatrische zorgpaden evenals een grondige inspectie van tools in bestaande traumageriatrische zorgpaden kunnen leiden tot zowel nieuwe toevoegingen aan zorgpaden als het heroverwegen van tools die al in gebruik zijn.

PART IV

Appendices

DANKWOORD

Allereerst wil ik mijn geweldige promotieteam hartelijk bedanken, zonder hen had ik niet gestaan waar ik nu sta. Een promotietraject doorloop je namelijk niet alleen, dat is onmogelijk.

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CURRICULUM VITAE

Jip Kusen was born on March 28, 1991 in Heerlen, the Netherlands. In 2010 he graduated from secondary school at Porta Mosana College, Maastricht. In the same year he started medical school at the Erasmus Medical Center in Rotterdam. In 2013, he became a member of "het snijzaalteam" and participated as a tutor in a peer-to-peer surgical anatomy masterclass (Erasmus Anatomy Research Project). During these years he established an anatomical training program for nurses in training and he co-founded Anapptomy, an online web application that enables students and healthcare professionals to study surgical approaches. In addition, he enjoyed participating in running races and contributing to charitable projects. In 2017-2018, he worked as a researcher at the Luzerner Kantonsspital, conducting research on the geriatric trauma center. In 2021 he started his medical career in Antonius hospital Nieuwegein. In 2022, he opted for a different approach to healthcare by transitioning to work as a healthcare consultant at KINASE Consulting.

He lives with his girlfriend, Kimberly, in Amsterdam, and in his spare time, he enjoys being creatively engaged in various projects related to aesthetic design with a functional aspect. He looks forward to what the future has in store for him.