A CULTURE CHANGE IN GERIATRIC TRAUMATOLOGY

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A Culture Change in Geriatric Traumatology

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A Culture Change in Geriatric Traumatology

Een cultuuromslag in de geriatrische traumatologie

(met een samenvatting in het Nederlands)

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Voor Pa,
Voor Charl

Ik zal m'n vrienden niet vergeten
Want wie me lief is blijft me lief
En waar ze wonen moest ik weten
Maar ‘k verloor hun laatste brief

Ik zal ook wel eens een keertje sterven
Daar kom ik echt niet onderuit
Ik laat m'n liedjes dan maar zwerven
En verder zoek je ‘t maar uit

Ramses Shaffy, (Laat me, 1978)

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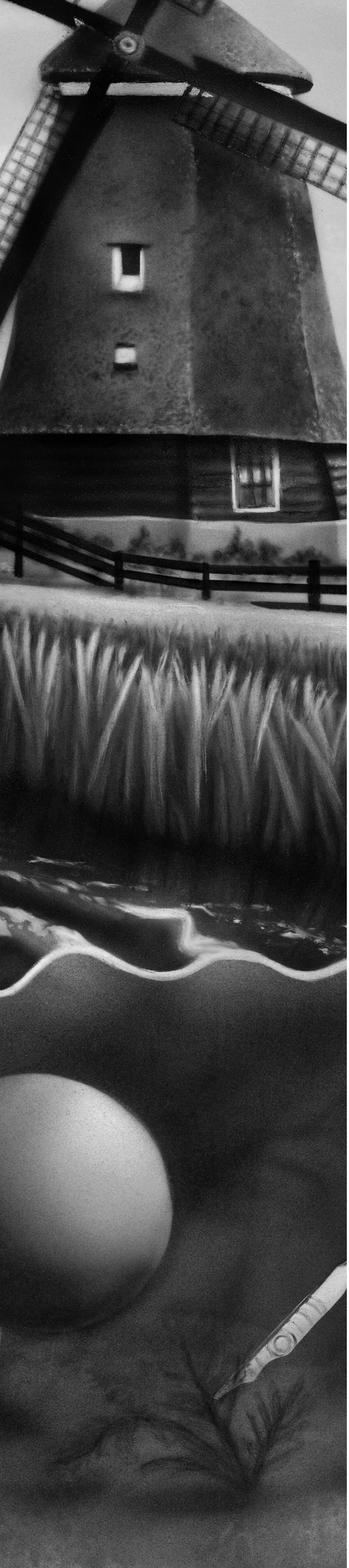

CHAPTER 1

General introduction
and outline of the thesis

A brief history of osteoporosis and fracture management

Since the dawn of our species, osteoporosis and related fractures have plagued mankind. Archeological skeletal remains with osteoporotic fractures originating from Europe, Africa, Asia and Northern-America have been found dating back to 2500 B.C. These findings have shown that osteoporotic rib and vertebral fractures were common in ancient times, as were hip fractures. Healed fractures with callus have been well-documented for most anatomical sites, with the exception of hip fractures, which rarely healed and almost inevitably led to death.[1,2] The management of many fractures types have been well-documented throughout history. The Ancient Egyptians, Romans and Greeks were able to successfully diagnose, reduce and successfully bandage humerus fractures, even documenting complications resulting from too much traction or tight bandaging.[3] Early accounts of Spanish conquistadores report Mayan physicians using wooden sticks as intramedullary fixators.[4] The use of "Plaster of Paris" marked a turning point in traumatology in the first half of the 19th century. This plaster, mined in the Montmartre district of Paris, could be soaked into bandages and revolutionized the nonoperative management of many fractures, a method that essentially changed very little since then.[5,6] The operative treatment of fractures before the 20th century was primarily characterized by pain and lethal infections. The invention of anesthesia (1846), antisepsis (1865), and X-ray imaging (1895), mark the beginning of the modern era of trauma surgery.[7]

Geriatric trauma

In the 20th and 21st century, better healthcare and economic welfare have increased the average lifespan in most developed countries, which has led to an increase in the number of geriatric patients who sustain an osteoporotic fracture.[8] This has resulted in a shift in focus of many medical specialties, including trauma surgery and orthopaedic surgery, toward the older patient.

Unless otherwise specified, the term "geriatric trauma" is used in this thesis to indicate fractures of the appendicular skeleton or pelvis in patients aged 65 years or above. These fractures are typically the result of a low-energy blunt force trauma mechanism such as a ground level fall. The author recognizes that geriatric trauma in a different context may also include blunt force high-energy trauma and visceral trauma, and that this is a significant cause of mortality and morbidity in geriatric patients.[9–12] This is, however, beyond the scope of this thesis.

Fractures in the geriatric age group represent a significant global health concern and often result in morbidity, mortality, disability, and decreased quality of life and are associated with a substantial financial burden on the healthcare system.[13–15] The adverse outcomes for these patients can and should not be solely contributed to increasing age. Instead, they should be contributed to increasing frailty.[16–18]

Frailty is defined as a dynamic syndrome that is often associated with ageing and is characterized by decreased reserves and decreased resistance to stressors.[19] As our understanding of older fracture patients has evolved, it has become clear that frailty is a useful tool in understanding the overall clinical picture and physiologic reserve of geriatric patients. Geriatric fractures can be seen as the common pathway of increased frailty, with slow gait, decreased muscle mass, cognitive issues, visual problems, and an overall low physical function all contributing to an increased risk of falls and fractures.[19,20] It is important to realize that these fractures are a symptom of a larger set of issues, not a diagnosis in isolation.

Medical decision making in geriatric trauma

Even with optimal treatment, outcomes of geriatric patients with a fracture are frequently poor. Currently, surgery is the cornerstone of treatment for many geriatric fractures, including hip fractures. The benefits of surgery include restoration of mobility, reduced pain (once surgical pain subsides), improved mobilization, easier nursing care, and a decreased risk of medical complications resulting from immobilization such as pneumonia, pulmonary embolism, and pressure ulcers.[21] However, surgery is invasive, painful, and is associated with significant risks (such as mortality, pneumonia, and delirium) in the frail patient population.[22,23]

Fractures in frail older patients are a harbinger of death. While surgery may be the primary decision point, de-escalation of care like “do not resuscitate” orders, pain management, less invasive testing and potentially hospice care, are all options even when fracture surgery seems appropriate. These decisions are complex in geriatric trauma patients. The prevalence of cognitive impairment in this population and the sudden nature of trauma make decisions even harder and make it more difficult for patients and their families to fully explore their wishes.

Because of the complexity of decision making and the non-elective nature of trauma surgery, one needs a competent interdisciplinary team that can act fast. Geriatric co-management creates established working relationships which can help find the appropriate fit for each patient with their own unique needs and requirements. Additionally, traumageriatric co-management yields superior patient outcomes in comparison to non-co-managed care, particularly for hip fracture patients.[24,25]

A culture change in geriatric trauma

Coming up with a patient-tailored treatment plan for geriatric fracture patients will require a thorough revision of the current care model for this population and the way we think about geriatric trauma patients. This will require a culture change in geriatric traumatology. First, to improve medical decision making, it is imperative to identify high risk patients in an early stage, preferably at the emergency department. Second, trauma surgeons will need to have a thorough understanding of geriatric (co-)management and a basic understanding of nonoperative or palliative management. Third, there is need for an open multidisciplinary discussion regarding patient-tailored and holistic care, more inclusive clinical research, and ethical aspects of decision making in this field.

Outline of this thesis

First, a nationwide implemented safety screener was evaluated for predictive accuracy for adverse outcome in older adults at the emergency department in **Chapter 2.** Next, in **Chapter 3**, risk factors for 30-day mortality for geriatric trauma patients aged 85 years or above were investigated. In **Chapter 4,** risk factors were incorporated into a multivariable prediction model for in-hospital mortality. This model was externally validated in a large international cohort in **Chapter 5**. The Parker Mobility Score was investigated as a predictor for discharge disposition after surgery In **Chapter 6**. A decision-tree model was constructed that can be used to identify patients who need geriatric rehabilitation after surgery for proximal femur fractures. Another predictor for discharge disposition is the Frailty Index, which is discussed in **Chapter 7**. The relation between the severity of liver cirrhosis and the prognosis of hip fracture patients was investigated In **Chapter 8**. The effect of implementation of an orthogeriatric trauma unit was explored in **Chapter 9**. A scoping review of all geriatric orthopedic trauma papers published in the last 3 years in selected journals was performed in **Chapter 10**. In **Chapter 11**, aspects of end-of-life decision making are reviewed, such as frailty, cognitive impairment, quality of life assessment, goals of care discussions, and palliative care. Additionally, recommendations are made for navigating these complex issues when making a patient-tailored treatment plan. Finally, **in Chapter 12**, the dilemmas of decision making at the end of life of geriatric patients in the acute surgical setting are discussed, and a revised model to improve patient participation in decision making in acute surgical settings is presented.

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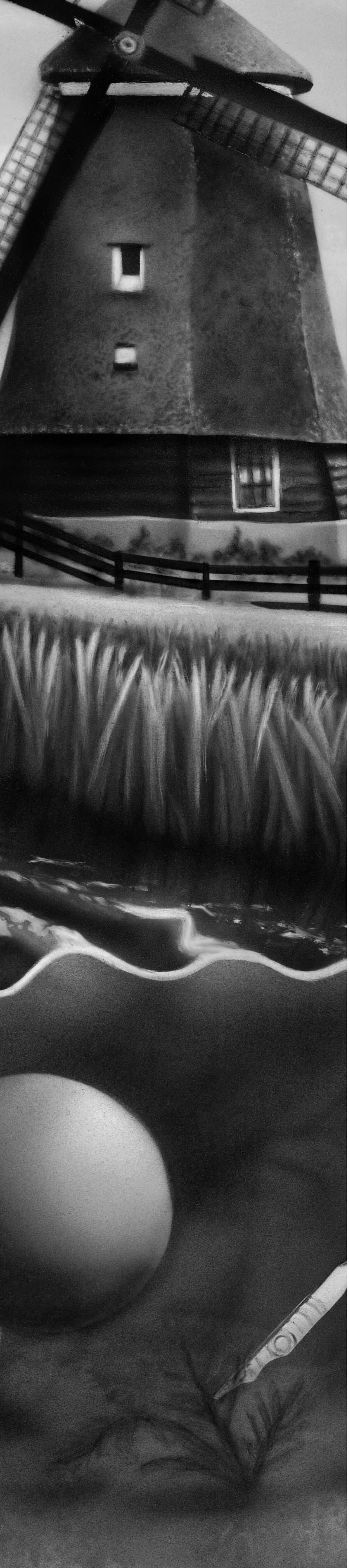

CHAPTER 2

Does the Dutch Safety Management Program predict adverse outcomes for older patients in the emergency department?

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ABSTRACT

Purpose: Frailty screening in the emergency department may identify patients at risk for adverse outcomes. The objective was to investigate if the Dutch Safety Management Program (VMS) screener predicts outcomes in older patients in the emergency department.

Methods: In this prospective cohort study, patients aged 70 years or older presenting to the emergency department were recruited from May until August 2017. Patients were screened in four domains: ADL-dependency, malnutrition, risk of delirium and risk of falling. After 90 days follow up, mortality, functional decline, living situation, falls, readmission to the emergency department and readmission to the hospital were recorded. Two approaches were studied; using total VMS score as a predictor with ROC curve analysis, and using a cut-off point to divide patients into frail and non-frail groups to calculate positive predictive value (PPV) and negative predictive value (NPV).

Results: A total of 249 patients were included. Higher VMS score was associated with 90-day mortality (AUC 0.65, 95% CI 0.54-0.76) and falling (AUC 0.67, 95% CI 0.56-0.78). VMS frailty predicted mortality (PPV 0.15, NPV 0.94, p=0.05) and falling (PPV 0.22, NPV 0.92, p=0.02), but none of the other outcomes.

Conclusion: Higher VMS score is associated with 90-day mortality and falls. The low positive predictive value shows that the VMS screener is unsuitable to identify high risk patients at the ED. The high negative predictive value indicates that the screener can identify patients not at risk for adverse medical outcomes. This could be useful to determine which patients should undergo additional screening.

INTRODUCTION

Life expectance in the Netherlands at the age of 65 is rapidly increasing[1], as is the prevalence of frailty[2]. Up to 25% of emergency department (ED) presentations are older patients [3,4]. These older patients are at risk of adverse outcomes after discharge, such as readmission, functional decline and mortality [4]. This risk of adverse healthcare outcomes is high: after discharge from the ED, 24% of patients are readmitted in the first three months and 44% in the first six months [5]. Functional decline and death occur frequently, with an average 90-day mortality of about ten percent [5–7]. It is important to identify patients who are at high risk of adverse outcomes, so that preventive geriatric interventions can take place. Frailty has been shown to be a predictor of adverse medical outcomes in older patients. Frailty is defined as a dynamic syndrome characterized by decreased reserves and resistance to stressors, resulting from decline in multiple physiological systems [8]. However, a comprehensive assessment of frailty is exceedingly difficult to measure in the ED[9]. The increasing number of older patients at the ED, the increasing prevalence of frailty and the high risk of negative medical outcomes require the development of frailty screening instruments at the ED. Screening for frailty at the ED is feasible and can improve patient outcomes [10,11].

To identify frail patients many screening instruments are available both worldwide and in the Netherlands[9,12,13]. Many studies have been done investigating diagnostic accuracy of older adult vulnerability screening instruments, but there is a lack of pragmatic, accurate and reliable tools [9]. An instrument that might be used to identify frail older patients, determine frailty and assess potentially avoidable risk factors for readmission and mortality in older patients presenting to the ED is the Veiligheids Management system (Dutch Safety Management Program/VMS) for frail older patients[14]. This instrument is part of a national program to prevent avoidable injury or death. The screening aims to identify frail patients (aged 70 years or older) at risk for delirium, falls, malnutrition and functional impairment in order to take adequate preventive measures[14,15]. In the Netherlands all hospitalized patients aged 70 years or above are screened but the screening is not routinely performed at the ED. The VMS instrument has been shown to be a good predictor for adverse outcomes in older hospital patients[16,17].

No previous studies have been done to test the predictive value of the VMS screener in the ED. The objective of this study was to investigate if the VMS screener can be used to identify patients aged 70 years or above at risk for adverse outcomes (i.e. mortality, functional decline, falls, readmission to the hospital or ED or a change in living situation) in the ED.

MATERIALS AND METHODS

This prospective cohort study was approved by the medical ethical committee of the Amsterdam Medical Centre, The Netherlands and the institutional review board at Gelre Hospitals Apeldoorn & Zutphen, The Netherlands. It was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from all eligible patients before inclusion in the study. The inclusion period ran from May 2017 until August 2017. It was estimated that around 200 patients were to be included in the study. Patients aged 70 years or older presenting for the following specialties; internal medicine, geriatric medicine, general surgery (including trauma), orthopaedic surgery, gastroenterology, pulmonary medicine and urology were recruited at the ED of Gelre Hospital Apeldoorn. Gelre Apeldoorn is a level 2 trauma center in an urban setting. Inclusion hours were between 10 AM and 7 PM during week days. Exclusion criteria were: logistical impossibility to include patient (i.e. patient missed for inclusion, unstable medical condition), language barrier (patient not proficient in Dutch or English), patients with severe cognitive impairment (diagnosed by physician at ED or as mentioned in patient records) with no proxy present, no permission to approach the patient by their attending nurse or physician. Age, sex and specialty for which the patient had been referred was documented for all excluded patients.

All measurements were performed within approximately 30 minutes of presentation at the ED. The following baseline data were collected: age, sex, specialty for which the patient had been referred, living situation (at home, in a residential care facility, in a nursing home), whether the patient had been diagnosed with dementia, number of different medications, use of a walking device, and whether the reason for the ED visit had been a fall.

VMS screening was done for all included patients by author HS who had received training by a professional geriatrician. The VMS screener consists of four domains: risk of functional decline, risk of falling, risk of delirium and risk of malnourishment[15]. The complete screener is presented in Figure 1. Functional decline was measured using the KATZ activities of daily living (KATZ-ADL) score [18]. The SNAQ score is a validated screening instrument for detecting malnutrition [19]. Delirium was assessed by asking if the patient had cognitive problems, needed help with self-care in the previous 24 hours or had experienced a previous episode of delirium. In case of a positive answer to either of these questions, the risk of delirium was considered present. The risk of falling was assessed by asking if the patient had experienced a fall in the previous six months. Risk of falling was considered present in case of a positive answer.

Figure 1. The VMS screener.

Risk for delirium

1. Do you have cognitive problems?
2. Did you need help with self-care in the past 24 hours?
3. Have you experienced an episode of confusion or delirium before?

≥1 point: increased risk for delirium

Falls

1. Did you fall at least once in the last six months?

Yes: increased risk for further functional decline

Risk for undernutrition

SNAQ

1. Did you lose weight unintentionally?
   - ≥6kg in the past six months(3)
   - ≥3kg in the last month (2)
2. Did you have a reduced appetite last month? (1)
3. Did you take nutritional drinks or did you use a feeding pump last month? (1)

2 points: medium risk : observe intake
≥3 points: high risk: consult dietician

MUST

1. Calculate Body Mass Index
   a. >20(0)
   b. 18.5-20 (1)
   c. <18.5 (2)
2. Weight loss score in past 3-6 months
   a. 5%(0)
   b. 5-10% (1)
   c. >10% (2)
3. Acute illness and likely to be no nutritional intake for >5 days (2)

1 point: observe intake
≥2 points high risk: consult dietician

Katz-ADL 6

1. Do you need help with bathing?
2. Do you need help with dressing?
3. Do you need help with using the toilet?
4. Do you need help with eating?
5. Do you need help with a transfer from bed to chair?
6. Do you use incontinence materials?

Patients with incomplete VMS data were excluded from further analysis. VMS score was calculated by adding up all positive domains, resulting in a score ranging from zero to four. All domains were given equal weight. Additionally, in order to divide patients into "frail" and "non-frail" groups, VMS scores were dichotomized using a cut-off point of two or more positive domains, based on previous studies[17,21,22]. Treating physicians at the ED were blinded for VMS scores.

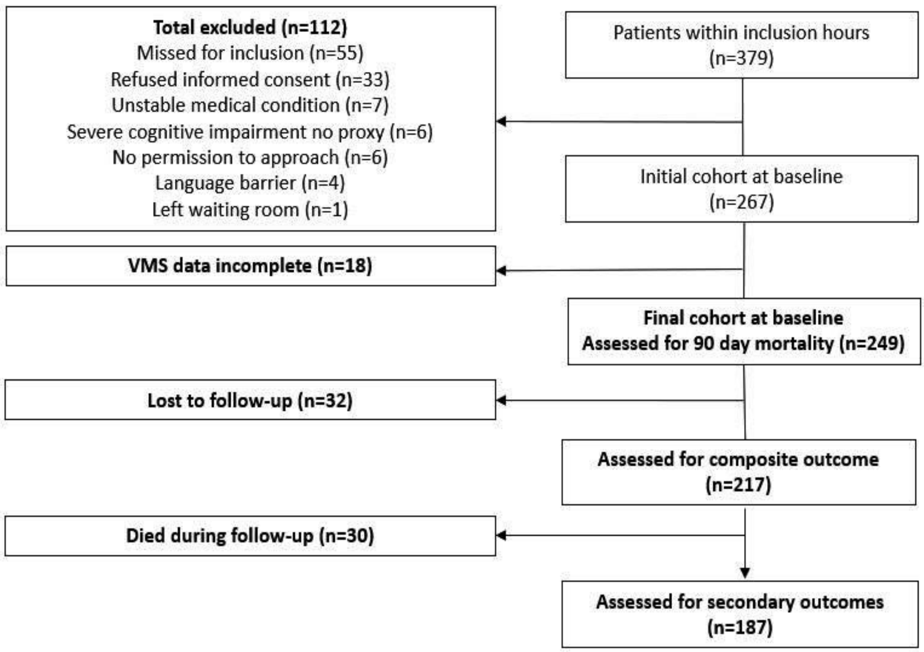
The primary outcome of this study was 90-day mortality, which was determined by consulting the municipal civil registry. After a follow up period of 90 days after presentation at the ED, all surviving patients were contacted by telephone to determine secondary outcomes. Three attempts on three different dates at different times were made to contact the patient. If the patient could not be reached after the third attempt, the patient was considered lost to follow up. Secondary outcomes were functional decline, defined as one or more points loss of KATZ-ADL; having experienced a fall during follow up; change in living situation; or a hospital or ED readmission during follow up. A change in living situation was defined as moving to a facility in which more care was given at follow up than before presentation at the ED (e.g. from living on their own to a residential care facility). A composite outcome was created defined as either death or functional decline (loss of points on KATZ-ADL) at follow up, assuming that patients who had died inherently had also experienced functional decline. This decline could of course not be quantified by the KATZ-ADL, because the patient must be alive at follow up to determine this score.

Differences between frail and non-frail patients were analyzed with the chi squared test for categorical data, and the student's t test for normally distributed continuous data; for non-normally distributed continuous data and ordinal data the Mann-Whitney u test was performed. Positive predictive value (PPV) and negative predictive value (NPV) was calculated for VMS frailty and each outcome. VMS scores were analyzed as a continuous variable using ROC curve analysis for each outcome. All statistical analyses were done using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., 2017, Armonk, NY). The level of statistical significance was set at 0.05 for all analyses. No funding was received for this study. This paper was written in accordance with the STROBE guidelines[23].

RESULTS

During the inclusion period, 379 eligible patients presented at the ED. A total of 112 patients were excluded, mainly because they were missed for inclusion or refused to participate. Another 18 subjects had to be excluded because their VMS data were incomplete due to a software error in data registration. After 90 days, 30 patients had died. Of the surviving patients, 32 individuals could not be reached by telephone. Cohort selection is summarized in Figure 2.

Figure 2: Patient flow chart



Baseline characteristics are shown in Table 1. The median VMS score was 2 (IQR 1-3), and 168 (68%) of patients were classified as frail. The median age was 80 years (IQR 75-86) and there were 153 (61%) female patients. Patients were mainly referred to the ED for general surgery, internal medicine and geriatric medicine. Median KATZ-ADL score was 1 (IQR 0-2), indicating that most patients were (almost) completely ADL independent two weeks prior to the visit to the ED. Frail patients were older: median 83, IQR (77-87) vs. non frail median 78 (74-83), p<0.01 and used more different medications; median 6, IQR 4-8 vs. non-frail: median 4, IQR (2-7), p<0.01. They more often had dementia (frail (n=18;

11% vs. non-frail n=1; 1%, *p*=0.01) and more often lived in an institutional care facility (frail n=31; 19% vs. non frail n=4; 5%, *p*<0.01). In the excluded cohort, there were more presentations to the department of internal medicine; 67 (27%) vs. 23 (18%), *p*= 0.05, and the department of geriatrics; 30 (25%) vs. 32 (12%), *p*= 0.01. There were no other significant differences between included and excluded patients.

Table 1: Baseline characteristics, frail (2 or more VMS domains positive) vs. non frail patients

	Overall n=249	**Frail n=168 (67%)**	**Non frail n=81 (33%)**	***p*-value**
Age, median (IQR)	80 (75-86)	83 (77-87)	78 (74-83)	**0.01**
Female, n (%)	153 (61%)	107 (64%)	46 (57%)	0.30
KATZ-ADL score, median (IQR)	1 (0-2)	1 (0-3)	0 (0-0)	**0.01**
SNAQ score, median (IQR)	1 (0-3)	2 (0-3)	0 (0-1)	**0.01**
ED visit because of fall, n (%)	96 (39%)	70 (42%)	26 (31%)	0.15
Number of different medications, median (IQR)	5.5 (3-8)	6 (4-8)	4 (2-7)	**0.01**
Diagnosed with dementia, n (%)	19 (8%)	18 (11%)	1 (1%)	**0.01**
Living in an institutional care facility, n (%)	35 (14%)	31 (19%)	4 (5%)	**0.01**
Specialty for which patient had been referred, n (%)				
General surgery	120 (48%)	79 (47%)	41 (51%)	0.60
Internal medicine	67 (27%)	45 (27%)	22 (27%)	0.95
Geriatric medicine	30 (12%)	23 (14%)	7 (9%)	0.25
Pulmonary medicine	16 (6%)	11 (7%)	5 (6%)	0.91
Gastroenterology	10 (4%)	6 (4%)	4 (5%)	0.61
Orthopaedic surgery	5 (2%)	3 (2%)	2 (3%)	0.72
Urology	1 (0%)	1 (1%)	0 (0%)	0.49

VMS: Dutch Safety Management Program; IQR: interquartile range; KATZ-ADL: Katz activities of daily living; SNAQ: short nutritional assessment questionnaire; ED: emergency department

The ROC curve analysis for VMS score in relation to 90-day mortality is shown in Table 2. The area under the curve (AUC) was 0.65, with a 95% CI of (0.54-0.76) and a *p*-value of < 0.01. A higher VMS score was also associated with a fall during follow-up, with an AUC of 0.67 and a 95% CI of (0.56-0.78), *p*=<0.01. There was no association between a higher VMS score and the composite outcome (functional decline and death), functional decline (KATZ-ADL), readmission to the ED, readmission to the hospital or change in living situation during follow up. Results of all ROC curve analyses are summarized in Table 2.

Table 2: Summary of ROC curve analysis for VMS scores and outcomes

Outcome	AUC	95% CI	*p*-value
Mortality	0.65	0.54-0.76	**0.01**
Fall during follow up	0.67	0.56-0.78	**0.01**
Composite outcome	0.54	0.46-0.62	0.29
Functional decline	0.49	0.40-0.58	0.85
Readmission to ED	0.58	0.48-0.67	0.12
Readmission to the hospital	0.52	0.43-0.62	0.63
Change in living situation	0.56	0.44-0.67	0.31

ROC: radio operator characteristic; VMS: Dutch Safety Management Program ; AUC: area under the curve; CI: confidence interval; ED: emergency department

The associations between VMS frailty and different outcomes is presented in Table 3. Patients classified as frail were more likely to die during follow up in this study; frail n=25 (15%) vs. non-frail n=5 (6%), *p*= 0.05 with a PPV 0.15 and a NPV 0.94. They were also more likely to experience a fall after their visit to the ED; frail n=27 (22%) vs. non-frail n=5 (8%), *p*= 0.02, with a PPV 0.22 and a NPV 0.92. There was no association between VMS frailty and KATZ-ADL functional decline (*p*=0.83), the composite outcome of functional decline and death (p=0.13), readmission to the ED (*p*=0.18) or the hospital (*p*=0.81) or a change in living situation (p=0.94).

Table 3: Outcomes of VMS frailty vs. non-frail

Outcome	Overall	Frail	Non Frail	*p*-value
90 days mortality, n (%)	30 (12%)	25 (15%)	5 (6%)	**0.05**
Functional decline*, n (%) (composite outcome)	84 (39%)	62 (41%)	22 (33%)	0.13
Functional decline**, n (%) (KATZ-ADL)	54 (29%)	37 (29%)	17 (28%)	0.83
Readmission to ED**, n (%)	45 (24%)	34 (27%)	11 (18%)	0.18
Readmission to the hospital**, n (%)	48 (26%)	33 (26%)	15 (25%)	0.81
Change in living situation**, n (%)	24 (13%)	16 (13%)	8 (13%)	0.94
Fall during follow up***, n (%)	32 (17%)	27 (22%)	5 (8%)	**0.02**

** Total N= 217, Frail N=151, Non-Frail N=66 **Total N= 187, Frail N=126, Non-Frail N=61 *** Total N= 186, Frail N=125, Non-Frail N=61*

VMS: Dutch Safety Management Program; KATZ-ADL: Katz activities of daily living; ED: emergency department

DISCUSSION

In this study, frail patients as identified by the VMS were more likely to die during 90-day follow up or experience a fall, compared to non-frail patients. ROC curve analysis showed that a higher VMS score was also predictive of mortality and of a fall during follow up.

No previous studies have investigated VMS score in the ED in relation to adverse medical outcomes in the general population. Previous studies investigating VMS score in relation to adverse outcomes target patients who are already hospitalized or target specific patient populations such as cancer patients or orthogeriatric patients[17,20,21,24]. These cohorts are not comparable to the cohort presented in this study. The 12% mortality in this study corresponds with previous studies, in which 90-day mortality was between 9% and 12% in older patients presenting to the ED [5].

The ED may provide physicians with an opportunity to screen patients in an early stage and implement geriatric interventions if necessary. There is currently no gold standard to identify frail patients at the ED[25]. The VMS screener can provide physicians with useful information regarding deficits in the four different domains, but predictive performance as a screener for adverse medical outcomes seems limited. Total VMS score ROC curve had an AUC <0.7, which represents poor test performance in predicting outcomes[26]. The low positive predictive value of the VMS frailty score means that in practice some patients would be classified as frail, while not at higher risk for adverse outcomes. The high negative predictive value indicates that the screener can be used to identify patients not at risk for adverse medical outcomes. This could be a useful first step to determine which patients should undergo additional screening (e.g. comprehensive geriatric assessment). However, the VMS screener identified 68% of all patients as frail, and it is unlikely that recourses are available to provide all these patients with a thorough geriatric follow-up. This problem could be solved by a two-step approach using the VMS screening with a high negative predictive value as a first step, and a second step were patients are screened using a frailty tool with a high positive predictive value.

This study has a few limitations. First, due to limited logistical resources, inclusion hours were between 10 AM and 7 PM on workdays. This resulted in a smaller sample size and the possibility of selection bias. Second, 18 patients had incomplete VMS score data because of a software malfunction and 32 patients were lost to follow up for secondary outcomes, which may introduce selection bias. However, there was almost no difference in baseline characteristics between included and excluded patients, suggesting that selection bias was limited. Third, it is possible that patients with a higher VMS score received different treatment than patients with a lower VMS score. Although treating physicians were blinded for VMS score, factors such as comorbidity and older age may have guided decision making, which may introduce bias. Fourth, external validity of this study may be limited as it was a single center study and patients presenting for the department of cardiology and neurology were excluded.

This is the first study to investigate the use of the VMS screener in relation to adverse medical outcomes in the ED. Also, no previous studies have investigated VMS score as a continuous outcome in relation to outcomes in the ED. An important strength of this study was the use of many different important patient outcomes during follow up, such as functional decline and change of living situation. Another important strength was that functional decline was determined in two different ways to reduce survival bias. KATZ-ADL is frequently used in follow-up studies to measure a degree of functional decline or functional outcomes[25,27]. The authors advise caution regarding this approach for two reasons. First, KATZ-ADL follow-up can only be done in patients who are alive after the follow-up period. This holds true for any functional outcome measure and is especially challenging when investigating functional decline in older patients. Second, patients who are not ADL dependent can more easily lose points in KATZ-ADL than patients who are fully dependent on others at baseline. This means that one point loss of KATZ-ADL does not represent an equal loss of function among patients.

In conclusion, two different statistical approaches to VMS screening in the ED were studied. Adding up all positive domains into a sum score has poor predictive performance when predicting outcomes at the ED. Using a cut-off point of two or more positive domains predicts 90-day mortality (PPV 0.15, NPV 0.94) and falls (PPV 0.22, NPV 0.92), but none of the other outcomes. The low PPV shows that many patients classified as frail do not experience adverse outcomes, making the screener less suitable to identify high risk patients. The screener can still be used to get a quick impression of the functional, nutritional and cognitive status of a patient, which can help guide decision making. The high negative predictive value indicates that the screener can identify patients not at risk for adverse medical outcomes, which could be a useful first step to determine which patients should undergo additional screening by comprehensive geriatric assessment.

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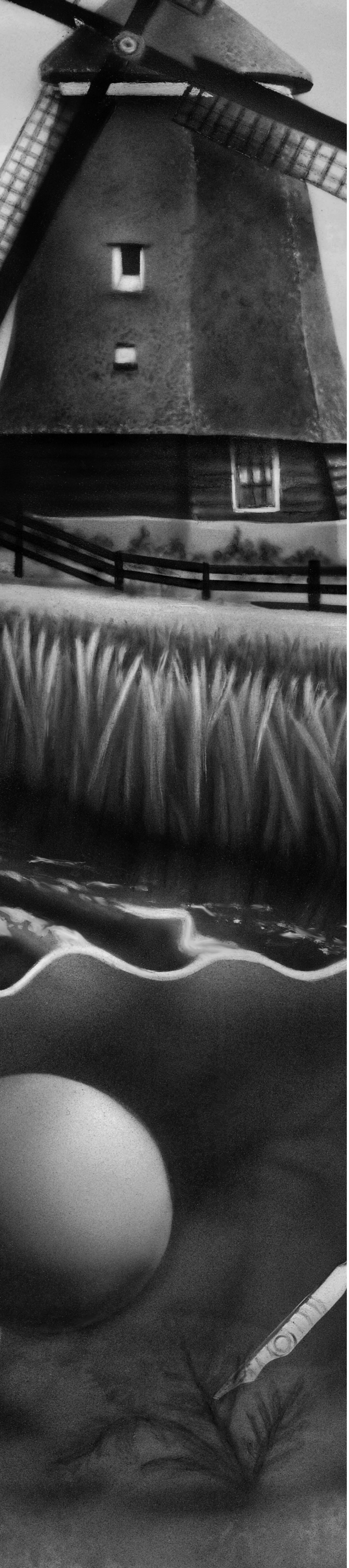

CHAPTER 3

Predictors of 30-day mortality in orthogeriatric fracture patients aged 85 years or above admitted from the emergency department

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ABSTRACT

Purpose: Orthogeriatric trauma patients are at risk for functional decline and mortality. It is important to identify high risk patients in an early stage, in order to improve outcomes and make better informed treatment decisions. The aim of this study was to identify independent risk factors for 30-day mortality in patients aged 85 years or above admitted from the emergency department with a fracture.

Methods: All orthopaedic trauma patients 85 years or above admitted from the emergency department were included. After a 30-day follow-up, mortality was determined by consulting the patient records. Multivariable logistics regression analysis was done to get the adjusted odd ratio's for risk factors for mortality. A subgroup analysis was performed for patients undergoing hip fracture surgery.

Results: The 30-day mortality in geriatric fracture patients admitted to the hospital is 12%. Risk factors for 30-day mortality were: increased age, male sex, decreased hemoglobin levels, living in an institutional care facility and a decreased BMI. For geriatric patients undergoing hip fracture surgery 30-day mortality was 11%. Independent risk factors for this group were: increased age, male sex, and a decreased BMI.

Conclusion: Orthopaedic trauma patients aged 85 years or above who are admitted to the hospital with a fracture are at high risk for mortality. This study identified older age, male sex, and decreased BMI as predictors of 30-day mortality in admitted geriatric trauma patients and in geriatric hip fracture patients undergoing surgery.

INTRODUCTION

Life expectancy is rising, and older trauma patients presenting to the emergency department (ED) are becoming a bigger part of the workload for orthopaedic surgeons. The number of geriatric hip fracture patients is expected to increase up to 250% over the coming years[1]. Older patients often present with complex multidisciplinary medical problems, cognitive impairment and a higher level urgency, which complicates their evaluation and management[2]. Older orthogeriatric patients are also at risk for negative medical outcomes, such as functional decline and mortality[3]. It is important to identify high risk patients in an early stage, in order to improve outcomes with geriatric interventions [4]. Identification of high-risk patients may also provide information for better informed treatment decisions and surgical management.

Patients aged 85 years or above constitute the fastest growing age group, and are at even higher risk for postoperative complications and death than the general geriatric population[5–7]. These geriatric trauma patients are a distinct age group with considerable risk of negative medical outcomes. Many studies have been done that include these older patients, especially hip fracture patients. These studies have shown that age, male gender and comorbidity are important predictors of mortality, but few have specifically targeted the age group of patients aged 85 or above[7,8]. Most studies focus on hip fractures and not the general population of geriatric trauma patients[8]. There is need for more research targeting this age group, in order to identify risk factors for negative medical outcomes, which is why this study will exclusively target patients 85 years or above. Additionally, this study will target the general geriatric population of trauma patients (i.e. any fracture regardless of treatment) as well as hip fracture patients undergoing surgery.

The primary aim of this study was to identify independent risk factors for 30-day mortality in patients 85 years or above admitted from the emergency department with any fracture. The secondary aim of this study was to identify independent risk factors for 30-day mortality in hip fracture patients aged 85 years or above undergoing surgery.

3

METHODS

Study design and patient selection

The study period for this retrospective cohort study was 1-1-2012 until 31-12-2016. All patients 85 years or older presenting with a fracture at the ED who were admitted to the hospital were eligible for inclusion. Patients who were treated at the ED but who were not admitted were not included in this study because there were no registration data for these patients. Data collection was done by consulting the electronic patient files. This retrospective cohort study was conducted in a level 2 trauma center at St. Antonius Hospital, Utrecht, The Netherlands. The study was approved by the local institutional review board of St. Antonius Hospital and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. The Dutch Medical Research Involving Human Subjects act (WMO) did not apply to this study.

Identification of eligible patients was done using the diagnostic codes (DBC) for the most common fractures: wrist, fore arm, upper arm, shoulder, neck, vertebrate, pelvis, hip (proximal femur), distal femur, knee, lower leg and ankle. Patients were excluded if 1; primary survey was not performed at St Antonius hospital 2; if patients were discharged to another hospital or 3; if patients were admitted directly to ICU. If a patient was admitted multiple times in the study period, only the first admittance was used.

Measurements

A number of variables were collected based on literature and availability[7–9]. The following pre-operative baseline variables were collected upon admission to the ED: age, sex, BMI (Quetelet index), living situation prior to admission (at home, at home with home care, institutional care facility, other), whether or not the patient was living with a partner, number of different comorbidities (as mentioned in admission form), number of different medications, whether patients had experienced a previous episode of delirium, cognitive impairment (as mentioned in the admittance form, either normal or declined), use of oral anticoagulants (yes/no), hemoglobin- (mmol/L), creatinine- (µmol/L), C-reactive protein (mg/L) levels. For patients undergoing surgery (regardless of fracture type) the following variables were collected: type of surgery (if any), type of anesthesia (general or regional, only applicable for patients undergoing surgery) and ASA classification (1 to 4).

Outcome

The 30-day mortality was determined by consulting electronic patient files. For patients with an unknown date of death the last professional caregiver was contacted to ascertain the exact date of death.

Statistical analysis

All statistical analyses were done using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., 2017, Armonk, NY). The level of significance was set at 0.05. Differences between deceased and surviving patients were analyzed at baseline. Normally distributed continuous data were tested with an unpaired t-test, not normally distributed continuous data were tested with a Mann-Whitney U test. All categorical and dichotomous data were tested with a chi square test.

Multivariable analysis

To reduce the number of possible predictors, candidate predictors to be included in the multivariable model were selected based on clinical relevance, availability, expert opinion and literature[10]. No univariable predictor selection was done which is in line with current recommendations by expert in the field of prediction modelling as it introduces data driven predictor selection bias[10,11]. The most relevant variables were included in multivariable logistic regression analysis. A full model approach was used, with at least 10 events per variable[12]. Missing data in the initial cohort were analyzed for patterns using Little's MCAR test except for ASA classification and type of anesthesia, which were missing for all patients who did not undergo surgery. Data missing completely at random (MCAR) were imputed using multiple imputation techniques (5 imputations).

Subgroup analysis

Because hip fractures are the most common indication for surgery in orthogeriatric trauma patients, a subgroup analysis was performed for all hip fracture patients undergoing surgery. Missing data for all variables including ASA classification and type of anesthesia were analyzed for patterns using Little's MCAR test. An additional multivariable logistic regression analysis was performed to calculate the adjusted OR for the selected candidate predictors in this subgroup.

RESULTS

Baseline characteristics

In total, 810 eligible cases were identified, 83 of which met the exclusion criteria and 35 patients were admitted two times during the study period. This resulted in an included cohort of 692 patients. After 30 days a total of 86 patients (12%) had deceased. Baseline characteristics of survivors and deceased patients are summarized in Table 1.

Table 1. Baseline characteristics of 30-day mortality vs. survivors. All percentages are calculated for valid data (i.e. excluding missing data)

Characteristics	**Total (n=692)**	*Missing*	**30-day mortality (n=86)**	**Survivors (n=606)**	*p-value*
Age, median (IQR)	89 (87 - 92)	0	90.5 (87-94)	89 (87-92)	**<0.01**
Male sex, n (%)	149 (22%)	0	29 (34%)	120 (20%)	**<0.01**
BMI (kg/m^2), median (IQR)	24 (21-26)	180	21 (19-24)	24 (22-26)	**<0.01**
Living situation, n (%)		27			**<0.01**
At home / at home with care	350 (53%)	36	29 (35%)	321 (56%)	**<0.01**
Living in institutional care facility	306 (47%)	36	54 (64%)	252 (44%)	**<0.01**
Living with partner, n (%)	107 (16%)	17	16 (19%)	91 (15%)	0.39
Comorbidity					
Number of comorbidities, median (IQR)	3 (2-5)	62	4 (2-5)	3 (2-5)	**<0.01**
Number of different medications, median (IQR)	6 (4-8)	69	7 (5-10)	6 (4-8)	**<0.01**
Prior delirium, n (%)	199 (31%)	40	35 (44%)	164 (29%)	**<0.01**
Impaired cognitive functioning, n (%)	278 (42%)	29	47 (57%)	231 (40%)	**<0.01**
Use of oral anticoagulants, n (%)	392 (62%)	63	61 (78%)	331 (60%)	**<0.01**
Biomarkers					
Hemoglobin (mmol/L), mean (SD)	7,5 (1,0)	88	7,2 (1,1)	7,6 (1,0)	**<0.01**
Creatinine (µmol/L), median (IQR)	79 (64-100)	195	95 (74-109)	78 (63-98)	**<0.01**

Table 1. (Continued)

Characteristics	**Total (n=692)**	*Missing*	**30-day mortality (n=86)**	**Survivors (n=606)**	*p-value*
C-reactive protein (mg/L), median (IQR)	5 (1-18)	153	6 (1-31)	5 (1-18)	0.56
Type of surgery, n (%)		5			0.15
Spinal column	2 (0%)		1 (1%)	1 (0%)	
Proximal humerus	11 (2%)		3 (4%)	8 (1%)	
Distal humerus	2 (0%)		0 (0%)	2 (0%)	
Hip fracture (proximal femur or collum)	492 (72%)		55 (65%)	437 (73%)	
Distal femur	18 (3%)		3 (4%)	15 (3%)	
Ankle	19 (3%)		0 (0%)	19 (3%)	
Other trauma surgical procedure	1 (0%)		0 (0%)	1 (0%)	
Conservative treatment	142 (21%)		23 (27%)	119 (20%)	
****Type of anesthesia, n (%)***		13			0.57
General	452 (84%)		52 (12%)	400 (89%)	
Regional	85 (16%)		8 (9%)	77 (91%)	
****ASA classification, n (%)***		81			**<0.01**
1	14 (3%)		0 (0%)	14 (3%)	
2	217 (46%)		17 (30%)	200 (48%)	
3	230 (49%)		34 (62%)	196 (47%)	
4	8 (2%)		4 (7%)	4 (1%)	

* percentages and missing data calculated for patients undergoing surgery

Patients who died during follow-up were older at baseline (median 89; IQR 87-92) than survivors (median 89; IQR 87-92). Deceased patients were more often male (n= 29; 34%) vs. survivors (n=120; 20%) and they had a lower BMI (median 21; IQR 19-24) vs. survivors (median 24; IQR 22-26). Patients living in an institutional care facility were more likely to die during follow-up (n=54; 64%) vs. survivors (n=252; 44%). They had more comorbidities (median 4; IQR 2-5) than survivors (median 3; IQR 2-5) and used more medications (median 7; IQR 5-10) vs. survivors (median 6; 4-8). A previous episode of delirium was associated with 30-day mortality (n=35; 44%) vs. survivors (n=164; 29%), as was impaired cognitive function (n=47; 57%) vs. survivors (n=231; 40%). The use of oral anticoagulants was higher in the deceased group (n=61; 78%) vs. survivors (n=331; 60%). Hemoglobin levels (mmol/L) were lower in the 30-day mortality group (mean 7,2; SD 1,1) vs. survivors (mean 7,6 SD 1,0) whereas were creatinine levels were higher (median 95 (IQR74-109) vs. survivors (median 78; IQR 63-98). There was no significant difference between the surviving and deceased groups in terms of the type of anesthesia in patients who were operated. A higher ASA classification was associated with 30-day mortality in these patients.

Missing data & multivariable analysis

In the initial cohort, missing data were missing completely at random (Little's MCAR test p=0.702). In the subgroup, all missing data, including ASA classification and type of anesthesia, were also missing completely at random (p=0.625). The results of the multivariable analysis are shown in Table 2.

Table 2: Multivariable analysis for all admitted patients and subgroup analysis for all hip fracture patients

Initial cohort (n=692)	***Adjusted OR***	***95% CI***	***p-value***
Age (per year above 85)	1.10	1.03 – 1.18	**<0.01**
Male sex	3.04	1.72 – 5.39	**<0.01**
Living in an institutional care facility	2.39	1.38 – 4.13	**<0.01**
Previous episode of delirium	1.37	0.79 – 2.37	0.26
Hemoglobin (each 1 mmol/L decrease)	1.31	1.03 – 1.66	**0.03**
BMI (each point decrease)	1.16	1.03 -1.30	**0.02**
Use of oral anticoagulants	2.25	0.90 - 5.64	0.08
Surgery for hip fracture	0.56	0.33 – 0.95	**0.03**
Hip fracture patients (n=492)			
Age (per year above85)	1.14	1.05 - 1.25	**<0.01**
Male sex	3.09	1.56 - 6.10	**<0.01**
Living in an institutional care facility	1.94	0.99 - 3.79	0.05
Hemoglobin (each 1 mmol/L decrease)	1.25	0.93 – 1.70	0.14
BMI (each point decrease)	1.22	1.02 - 1.46	**0.03**
ASA classification (per class increase)	1.93	0.97 - 3.83	0.06

It showed that age was an independent risk factor for 30-day mortality (adjusted OR 1.10 for each year above 85 years), as was male sex (adjusted OR 3.04) and living in an institutional care facility (adjusted OR 2.39). Each 1 mmol/L decrease in hemoglobin increased the chance of mortality (adjusted OR 1.31), as did each 1 point decrease in

BMI (adjusted OR 1.16). Previous episodes of delirium or the use of oral anticoagulants were not independent predictors of mortality in this study. Surgery for hip fracture was an independent protective factor in this sample (adjusted OR 0.56).

The subgroup analysis for patients with hip fractures undergoing surgery consisted of 492 patients, 55 of whom died during follow-up (11%). The multivariable analysis for this group showed similar results for age (adjusted OR 1.14 for each year above 85 years) male sex (adjusted OR 3.09) and BMI (adjusted OR 1.22) as independent predictors of mortality. ASA classification, living in an institutional care facility and hemoglobin levels at presentation at the ED were not a statistically significant independent predictors of mortality in this subgroup.

DISCUSSION

Red line and take-home message

This study shows that 30-day mortality in geriatric patients admitted to the hospital with a fracture is high (12%). There are several independent risk factors for 30-day mortality in this population: increased age, male sex, decreased hemoglobin levels, living in an institutional care facility and a decreased BMI. For geriatric patients undergoing hip fracture surgery, 30-day mortality was 11%. Independent risk factors for this group were: increased age, male sex and decreased BMI.

Comparison with previous studies

Previous studies investigating risk factors for mortality in geriatric trauma patients have targeted patients aged 65 or above. In one such study, age was found to be a risk factor for mortality, which corresponds with our results. Higher injury severity and low systolic blood pressure were also found to be predictors of mortality in younger cohorts, but these variables were unavailable in our cohort[13].

Predictors of mortality in older hip fracture patients have been extensively studied but not in the patient group aged 85 years or above[8,14]. Age was found to be an independent predictor of mortality in both studies but was dichotomized in age groups below 85 years or 85 years and above. Hemoglobin level and ASA classification were also independent predictors, but were analyzed as dichotomous outcomes[9,15]. Dichotomization results in loss of information and predictive power[16]. In this study, age, hemoglobin and ASA classification were analyzed as a continuous outcomes to address this problem.

Male sex was found by previous studies to be a risk factor for 30-day mortality in hip fracture patients with an adjusted OR of 1.66 (95% CI 1.15-2.39)[15]. In this study, an adjusted OR of 3.09 (95% CI 1.56-6.10) was found, suggesting that male trauma patients aged 85 years or above are at even higher risk of mortality. This would confirm that risk factors in geriatric fracture patients aged 85 years or above are distinctly different from their younger counterparts.

Strengths and limitations

This was the first study to investigate risk factors for 30-day mortality in general geriatric trauma patients and hip fracture patients aged 85 years or above. The cohort was very large and there was no loss to follow-up. Another strength is the analysis of continuous outcomes without dichotomization, unlike previous studies[9,15]. In this study, predictor selection bias was reduced because there was no data-driven predictor selection. Because the cohort consisted mainly of hip fracture patients (71%), a subgroup analysis was performed to correct for this.

This study has a few limitations. Only patients admitted to the hospital from the ED were included. This means that patients who were treated and discharged from the ED were not included, which leads to possible selection bias. Very few studies include these patients, because follow-up data of these patients are often unavailable. This selective follow-up is a challenge in trauma research, but can be addressed by searching death registries or telephone follow-up[17]. The authors of this study recommend that these patients are included in future investigations, in order to get a more accurate representation of the ED population. Another limitation is the amount of data missing at baseline. This is inevitable in retrospective cohort studies, but it also reflects that different caregivers collect and record different patient characteristics. This illustrates the need for more standardized management of these patients, and the relevance of this study.

Interpretation of results

Almost all hip fracture patients are admitted directly from the ED, while patients with other fracture types are not always admitted. This means that patients with a fracture other than a hip fracture are likely to have a worse prognosis at baseline due to overrepresentation of relatively healthy hip fracture patients. Geriatric hip fracture patients are indeed notorious for adverse medical outcomes[18]. It is important to realize that hip fracture patients who received conservative treatment were not included in the subgroup analysis. Not all patients who received conservative treatment were hip fractures, but mortality in the conservative treatment group was high (16%). These two factors may explain why hip fracture patients undergoing surgery in this study were at lower risk of death than the general population of geriatric fracture patients (adjusted OR 0.56, 95% CI 0.33-0.95).

A decreased BMI was found to be a risk factor in both the total cohort and hip fracture surgery subgroup. These results should be interpreted with some caution, as there was a lot of missing data for this variable (n=180). Previous high quality studies in hip fracture patients have not found a relation between BMI and mortality, although these studies did not specifically target patients aged 85 or older[7,14].

It is important to realize that the BMI might not be the best parameter for nutritional status. Patients with a high BMI may still be malnourished. In future research, scoring systems, such as the short nutritional assessment questionnaire (SNAQ) or malnutrition universal screening tool (MUST), should be investigated as screening methods for 30-day mortality in geriatric trauma patients[19,20].

Living in an institutional care facility (*p*=0.05*)* and ASA classification (*p*=0.06*)* were not independent predictors of 30-day mortality in hip fracture patients undergoing surgery. ASA classification has been shown to be a predictor of 30-day mortality in non-geriatric hip fracture patients in previous studies[21]. Living in an institutional care facility has also been shown to be a risk factor for both patients aged 70 years or above admitted from the ED in several studies, and in hip fracture patients presenting at the ED[9,15,22,23]. The number of events per variable in the hip fracture subgroup analysis was 9.2 which is slightly lower than the commonly used 10 events per variable in this type of analysis[10]. There is no scientific evidence that the number of events per variable should be at least 10, and a simulation studies have shown that an event per variable rate between

5 and 10 can be acceptable in most cases[11,24]. Nevertheless, it may still indicate that the sample may have been too small to detect a significant difference between deceased patients and survivors in this sample. Therefore, both these variables cannot be ruled out as predictors of 30-day mortality and merit further investigation.

During the study period, there was no integrated orthogeriatric care unit in St. Antonius hospital. Orthogeriatric care units have been shown to improve patient outcomes[25,26]. By identifying patients at risk for negative medical outcomes, geriatric interventions can be targeted at those patients that would benefit from them. However, there was a geriatric awareness program which increased awareness for the most common complications during admission for these patients.

Clinical relevance

This is one of the first studies to investigate geriatric trauma patients in the age group of 85 years and above. Very little is known about this rapidly growing group of patients who are at much higher risk of negative medical outcomes than younger patients[5,6]. There is urgent need for more research into screening methods and medical outcomes in very old geriatric trauma patients.

Conclusion

This study shows that older geriatric trauma patients who are admitted to the hospital with a fracture have a high risk (12%) of 30-day mortality. Several routinely collected predictors of 30-day mortality in admitted geriatric trauma patients were identified. In the population of geriatric fracture patients, independent risk factors for mortality were: increased age, male sex, living in an institutional care facility, decreased hemoglobin levels or decreased BMI. For geriatric hip fracture patients, independent risk factors were: increased age, male sex and decreased BMI.

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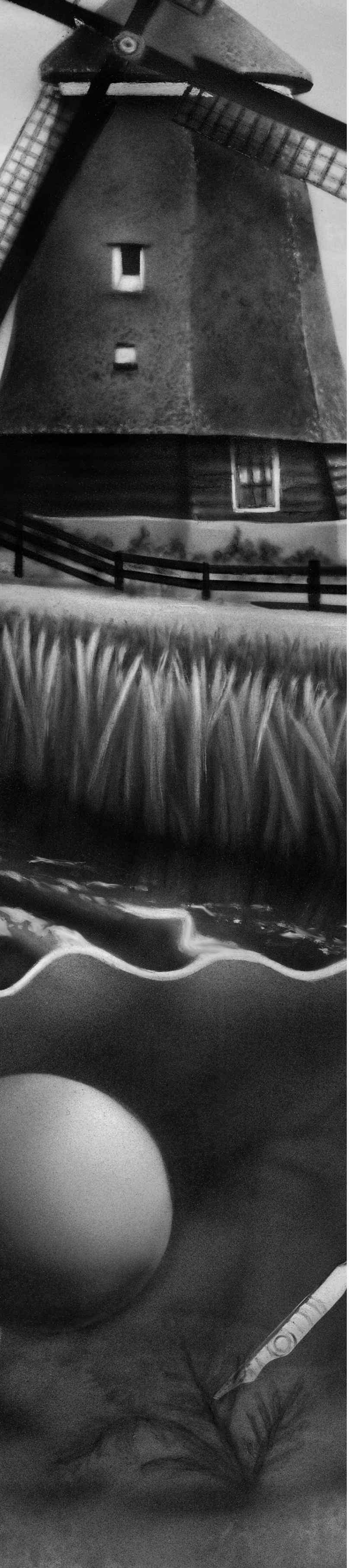

CHAPTER 4

Development and internal validation of a prediction model for in-hospital mortality in geriatric hip fracture patients

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ABSTRACT

Objective: The increase in the number of geriatric hip fracture patients is a global health concern. Patients aged 85 or above are at high risk of adverse outcomes, making them the most clinically relevant patient group. Identification of high-risk patients is vital for guiding surgical management. There are currently no validated tools to predict in-hospital mortality in hip fracture patients aged 85 or above. The goal of this study was to develop and validate a prediction model for in-hospital mortality in hip fracture patients aged 85 or older undergoing surgery.

Design: multicenter prospective cohort study

Setting: six Dutch trauma centers, level two and three

Participants: hip fracture patients aged 85 or older undergoing surgery

Intervention: hip fracture surgery

Main Outcome Measurements: in-hospital mortality

Results: The development cohort consisted of 1014 patients. In-hospital mortality was 4%. Age, male sex, ASA classification and hemoglobin levels at presentation were independent predictors of in-hospital mortality. The bootstrap adjusted performance showed good discrimination with a c-statistic of 0.77.

Conclusion: Age, male sex, higher ASA classification and lower hemoglobin levels at presentation are robust independent predictors of in-hospital mortality in geriatric hip fracture patients and were incorporated in a simple prediction model with good accuracy and no lack of fit.

INTRODUCTION

Better healthcare and economic welfare have increased the average lifespan in most developed countries. This has resulted in a shift in focus of many medical specialties, such as trauma surgery and orthopaedic surgery, toward the elderly patient. Osteoporotic hip fractures in elderly patients are now regarded as a worldwide epidemic with 1.6 million new cases every year[1].

Hip fractures in the elderly often lead to a reduction of quality of life or death and are a major public health concern[1,2]. Surgical intervention is standard treatment for hip fractures. Without surgery, the patient is likely to die from pulmonary, cardiovascular or infectious complications that result from immobilization. However, even with surgery and rehabilitation therapy, functional decline, diminished quality of life, and death are common in these patients[3]. In-hospital mortality is between 2%[4] and 8%[5,6], and 30-day mortality rates have been reported between 6%[7] and 11%[8]. The number of complications and mortality can be reduced in older patients when proper care is provided early on[9,10]. Surgeons should keep in mind that the one-year mortality of these patients is 20-35%, even with optimal treatment[10]. For patients with a grave prognosis, conservative treatment should be considered. A recent review has shown that a nonoperative approach can improve patient quality of life and superior management for patients at the end of their lives[11]. To this end, early detection of high-risk patients is of vital importance to help make better-informed treatment decisions and guide surgical management. A prediction model could help guide decision making for patients that may benefit from nonoperative or palliative management.

Some studies have investigated the relationship between hip fracture patient characteristics and mortality[4,5,8,12–15], and attempts have been made to make prediction models for both short and long term mortality[4,8,12–15]. These models do not have a good predictive value and rely on risk stratification rather than exact risk prediction. There is a need for a validated prediction model with good predictive value for the chance of short-term mortality in the elderly patient with a hip fracture. Patients aged 85 years or above are 10-15 times more likely to sustain a hip fracture[2]. Hence, the group of patients aged 85 years or above is clinically the most relevant, which is why this study will specifically target this population[7,15–17].

The goal of this study was to develop and validate a prediction model for in-hospital mortality in hip fracture patients aged 85 or older undergoing surgery.

MATERIALS AND METHODS

This prospective cohort study was registered with the institutional review board of St. Antonius hospital. Data was collected from 01-01-2018 to 08-06-2019 by the Dutch Hip Fracture Audit Taskforce study group (DHFA TF). The DHFA TF collects data from six Dutch hospitals in different regions: St. Antonius hospital Utrecht, Bernhoven hospital Oss, Admiraal de Ruyter hospital Goes, Diakonessen hospital Utrecht, Ziekenhuisgroep Twente Almelo, Haaglanden medical center The Hague. These hospitals are all level two or level three trauma centers in an urban setting. This article was written in accordance with the transparent reporting of a multivariable prediction model for individual prognosis or diagnosis (TRIPOD) guidelines[18] in addition to the STROBE[19] guidelines. The study was approved by the local institutional review board of St. Antonius Hospital (registration number W17.034) and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. The Dutch Medical Research Involving Human Subjects act (WMO) did not apply to this study.

The inclusion criteria for this study were: 1) patients aged 85 years or older presenting to the emergency department with a hip fracture (OTA classification[20]: 31-A or 31-B) and; 2) undergoing hip fracture surgery for non-periprosthetic and non-pathological hip fractures. Exclusion criteria were: 1) treatment and follow-up in different hospitals; 2) missing in-hospital mortality data. The outcome of this study was in-hospital mortality, which was recorded for all patients at discharge.

The following baseline data were collected at presentation: surgical treatment (i.e. hemiarthroplasty, total hip arthroplasty, cannulated hip screw, dynamic hip screw, intramedullary nailing or girdle stone procedure) and polypharmacy (i.e. use of five or more different medications). The following routinely collected predictors were selected using logical predictor selection based on literature[2,4,7,8,12–15,21]. These predictors were: age, gender, short nutritional assessment questionnaire (SNAQ) score[22], ASA classification (1 to 4), living situation defined as; at home (with or without help with activities of daily living) or in an institutional care facility (i.e. assisted care facility, nursing home, rehabilitation center), diagnosis of dementia (either diagnosis known in the hospital or known by the general practitioner) , and hemoglobin (mmol/L) at presentation at the ED.

Given that the events per variable should be at least five[23], and a maximum of six variables was to be included in the model, 30 patients who experienced the outcome were to be included in the development cohort. Assuming an in-hospital mortality of 4%[6], the sample size of the development cohort should be at least 750 patients.

Baseline data were described using descriptive statistics. Distribution of non-normal distributed data was presented with the median and interquartile range (IQR) and for normally distributed data the mean and standard deviation (SD) was presented. A comparison was made between the development and validation cohort using a Student's t-test for normally distributed continuous data, Mann Whitney U test for non-normally distributed continuous data, and the chi-square test for dichotomous and categorical data. Continuous predictor variables were tested for linearity by testing the correlation of these variables in relation to the outcome with a two-tailed Pearson correlation test. Significant correlations were considered linear. If variables were non-linear, a transformation of the predictor variable was used in the model.

If 20% or more of a predictor variable was missing it was excluded from further analysis and imputation. Large numbers of missing data are not likely missing at random and these variables are also likely unavailable in the general population which makes them useless in the prediction model[24]. Missing data were analyzed for patterns (not at random, at random, completely at random) with Little's MCAR test. Data missing at random were imputed ten times using multiple imputation[24].

To reduce overfitting and reduce predictor selection bias the full-model approach was used instead of data-driven predictor selection. Multivariable analysis was done using logistic regression analysis to calculate the adjusted odds ratios (adjusted OR) and regression coefficients (unstandardized Beta weights or B) for all predictors and the intercept of the y-axis. Goodness-of-fit was tested with a Hosmer-Lemeshow test. A prediction model was built using the following formula:

Linear predictor = intercept + (B1*variable1 + B2*variable2 + B3*variable3, etc.)

Predicted probability = $1/ (1+e^{(\text{-linear predictor})})$

The c-statistic for predicted probability versus in-hospital mortality was calculated using ROC curve analysis.

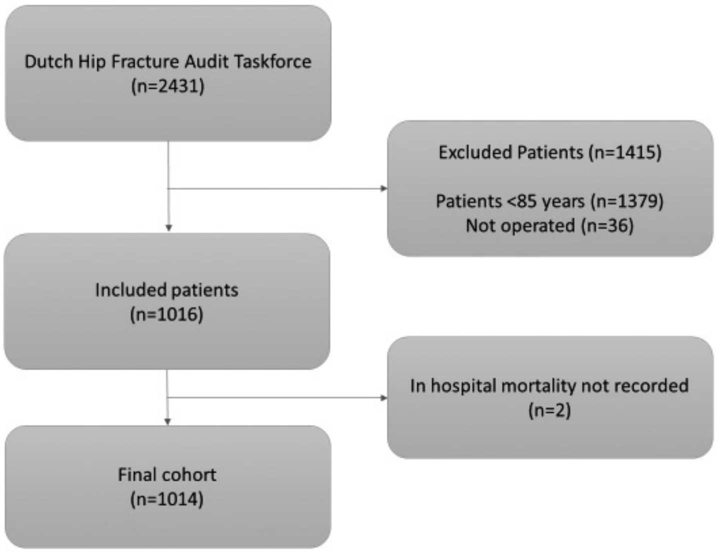
For internal validation, the bootstrap adjusted performance was calculated by a professional statistician. The development cohort was bootstrapped 10 times with a sample size equal to the development cohort. The difference in c-statistic was calculated for each bootstrap sample vs. the development cohort. The mean difference in c-statistic was subtracted from the original c-statistic to obtain the bootstrap adjusted performance[24].

All statistical analyses were done using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., 2017, Armonk, NY), except the bootstrap analysis, which was done using R statistical package for Windows, version 3.6 (R foundation, 2019, Vienna, Austria). The level of significance was set at 0.05.

RESULTS

The patient flow chart is shown in Figure 1. A total of 2431 patients were included by the DHFA during the study period. After excluding patients younger than 85 years (n=1379) and patients who did not undergo surgery (n=36), the initial cohort consisted of 1016 patients. For two patients in-hospital mortality was not recorded, resulting in a final cohort of 1014 patients.

Figure 1: patient flow chart



Baseline characteristics of all patients are shown in Table 1. A total of 38 patients (4%) died in-hospital. Patients who died in-hospital were older (median 92, IQR 88-94) than survivors (median 89, IQR 87-93) and were more often males (n= 15, 40%) than survivors (n=228, 23%). In both groups 32% of all patients were diagnosed with dementia prior to the fracture. ASA classification was significantly higher in deceased patients (median 3 IQR 3-4) than in the survivor group (median 2, IQR 2-3). There was no significant difference in the number of patients living in an institutional care facility between groups. Hemoglobin levels at presentation were lower in patients who died in-hospital (mean 7.2 SD 1.1) compared to survivors (mean 7.6 SD 1.0). The boxplot for hemoglobin versus mortality is shown in Supplementary Figure 1. Polypharmacy was common in both deceased patients (n=22, 71%) and survivors (n=604, 66%), but there was no significant difference. There were no significant differences in surgical treatment between groups.

Table 1: Baseline characteristics.

Variable	Total (n=1014)	Missing	Survivors (n=976)	Deceased (n=38)	*p*-value
Age (median, IQR)	90 (87-93)	0 (0%)	89 (87-93)	92 (88-94)	**0.02**
Male sex; n (%)	243 (24%)	2 (0%)	228 (23%)	15 (40%)	**0.02**
Comorbidity					
Dementia; n (%)	247 (32%)	234 (23%)	238 (32%)	9 (32%)	0.956
ASA classification (median, IQR)	3 (2-3)	38 (4%)	3 (2-3)	3 (3-4)	**<0.01**
Living situation					
Living in an institutional care facility; n (%)	253 (34%)	276 (27%)	247 (35%)	6 (26%)	0.40
Biomarkers					
Serum hemoglobin (mmol/L) at presentation (mean, SD)	7,6 (1,0)	40 (4%)	7,6 (1,0)	7,2 (1,1)	**0.02**
Malnutrition					
SNAQ score (median, IQR)	0 (0-1)	202 (20%)	0 (0-1)	1 (0-1)	**0.02**
Polypharmacy					
Use of five or more different medications; n (%)	626 (66%)	62 (6%)	604 (66%)	22 (71%)	0.53
Surgical treatment; n (%)	1014 (100%)	0 (0%)			0.94
Hemiarthroplasty	458 (45%)		439 (45%)	19 (50%)	
Cannulated hip screw	5 (1%)		5 (1%)	0 (0%)	
Total hip arthroplasty	4 (0%)		4 (0%)	0 (0%)	
Dynamic hip screw	71 (7%)		69 (7%)	2 (5%)	
Intramedullary nailing	476 (47%)		459 (47%)	17 (44%)	
Girdle stone procedure	0 (0%)		0 (0%)	0 (0%)	

The linear correlation between in-hospital mortality and age ($p < 0.01$, Pearson's r = 0.08), ASA classification ($p < 0.01$, Pearson's r = 0.16) and hemoglobin ($p = 0.02$, Pearson's r = -0.08) was significant. SNAQ score was not linear ($p = 0.387$) but did not have to be transformed as it was excluded from further analysis because there was too much data missing.

Missing data are shown in Table 1. The predictor variables dementia, SNAQ score and living in an institutional care facility all had 20% or more missing data and were therefore excluded from further analysis. Analysis of the remaining data showed 2% of all values to be missing. Little's MCAR test showed all missing data to be missing completely at random (p=0.985).

Results of the multivariable analysis are shown in Table 2. Four predictors were incorporated in the model resulting in 9.5 events per variable in the multivariable prediction model. Age was an independent predictor of in-hospital mortality (adjusted OR 1.09 for each year above 85), which means for every year above 85, the chance of in-hospital mortality is increased by 9%. Male gender had an adjusted OR of 2.20, showing males have a 120% higher chance of in-hospital mortality in comparison to females. ASA classification was also a robust predictor of mortality. For each ASA class increase, the chance of in-hospital mortality is increased by 265% (adjusted OR 3.65 for each class increase). A decrease in hemoglobin was also a robust predictor (adjusted OR 1.41 for each mmol/L decrease), which means for each mmol/L decrease, the chance of in-hospital mortality is increased by 41%. The model showed no lack of fit (Hosmer-Lemeshow p=0.814).

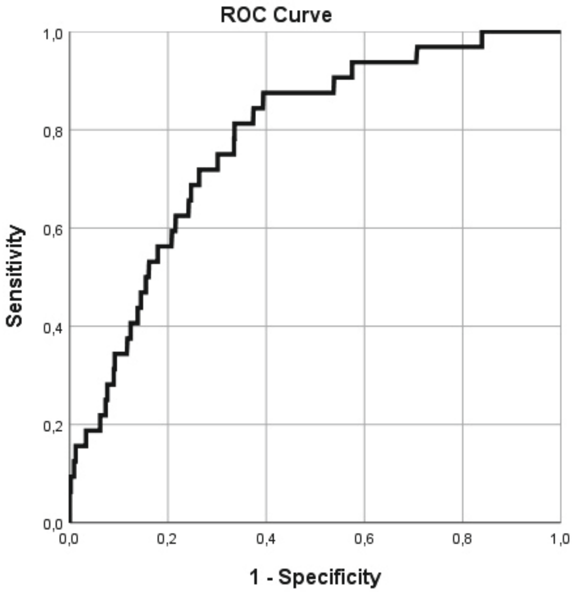
Table 2: Multivariable logistic regression analysis

Predictor	Adjusted OR	95% CI	*p*-value	Clinical interpretation
Age (per year above 85)	1.09	1.01-1.18	**0.02**	For every year above 85, the chance of in-hospital mortality is increased by 9%.
Male sex	2.20	1.10-4.40	**0.03**	Males have a 120% higher chance of in-hospital mortality in comparison to females
ASA classification per class increase	3.65	1.81-7.38	**<0.01**	For each ASA class increase, the chance of in-hospital mortality is increased by 265%
Hemoglobin per mmol/L decrease	1.41	1.05-1.89	**0.02**	For each mmol/L decrease, the chance of in-hospital mortality is increased by 41%

Following the results of the multivariable logistic regression analysis (Table 2), the initial algorithm for the prediction model was:

Linear predictor = (-12.896) + (0.088*age) + (0.789*sex) + (1.296*ASA) + (-0.341*Hb)
Predicted probability = 1/ (1+e$^{(-\text{linear predictor})}$)
Variable "age" is the patients' age in years, "sex" is equal to 0 if patient is female and 1 if patient is male, "ASA" is equal to the patients ASA classification, and Hb is equal to the patient's hemoglobin level in mmol/L upon presentation at the ED. The mathematical constant "e" is Euler's number which is approximately equal to 2.718281828459.
Example 1: A 89-year-old male with an ASA score of 1 and a hemoglobin level of 6.4 has a 1% chance of in-hospital mortality.
Example 2: A 92-year-old male with an ASA score of 4 and a hemoglobin level of 5.7 has a 32% chance of in-hospital mortality
The area under the curve (c-statistic) for the model was 0.78 with a 95% confidence interval of 0.71–0.85. The ROC curve and c-statistic are shown in Figure 2. The bootstrap adjusted c-statistic was 0.77. Including quadratic transformations of continuous predictor variables did not improve the accuracy of the model.

Figure 2: Receiver operating characteristic analysis



c-statistic	95% confidence interval
0.78	0.71–0.85

DISCUSSION

The goal of this study was to develop and validate a prediction model for in-hospital mortality in geriatric hip fracture patients aged 85 or older undergoing surgery. In-hospital mortality in these elderly patients is high (4%), compared to mortality in hip fracture patients in general (2%)[4]. In this study age, male sex, higher ASA classification and lower hemoglobin levels were robust independent predictors of in-hospital mortality. A prediction model was built incorporating these routinely collected predictors with fair discriminative power after correction for overfitting.

Two previous studies have proposed prediction models for in-hospital mortality in hip fracture patients, one study from the United States[4] and one from Canada[13]. In-hospital mortality was 1.8% and 6.3% in these studies, respectively. Both found male gender to be a robust predictor of in-hospital mortality. Age was also an independent predictor, especially in patients aged 85 or above. Hemoglobin levels were not investigated in either study[4,13], but were found to be robust predictors of mortality in our study and in previous studies[14,25]. Neither model tested ASA classification, which was an independent predictor of mortality in our study and in previous studies[14,25,26]. ASA status is always known for all patients undergoing surgery, but there is evidence of a fair amount of interrater variability for this tool[27].

This was a large multicenter prospective cohort study that included patients from six different hospitals in different regions in The Netherlands. It is likely to be a good reflection of the Dutch geriatric hip fracture population. Loss to follow-up was negligible. After exclusion of data that were not routinely collected at the ED, analysis of the remaining data used in the multivariable analysis showed less than 2% of all values to be missing. Continuous data were analyzed as continuous data, and no cut-off values were used, as this would result in loss of information and accuracy. This is the first prediction model for in-hospital mortality in hip fracture patients to use the correct methodology as described in the TRIPOD statement[18].

This study has a few limitations. In-hospital mortality is frequently used as an outcome in this field, but length of stay and discharge policies can be different between centers, which can induce bias[28]. Experts in prediction modelling recommend using a standardized period of time in which an outcome can occur[18]. This is challenging in geriatric trauma patients because they are notorious for selective loss to follow-up which induces survival bias[29]. European Union privacy laws make it difficult for researchers to consult municipal records or death registries. In-hospital mortality does not have this problem and is easy to collect from registration data. Though in-hospital mortality is correlated with 30-day mortality for many conditions, this is not the case for hip fractures[28]. Nevertheless, it can still be used to identify high-risk patients for which refraining from surgery may be the best decision.

The c-statistic for this prediction model is good (0.77) but not excellent (>0.80)[30]. This is likely the result of the limited number of predictors that could be incorporated into the model, and the variability in degree of illness associated with each individual diagnosis. Although this was a multicenter study, there was no external validation cohort. Instead, all available data was used in the development of the model, and a bootstrap procedure was done for internal validation, which is in line with current recommendations[24].

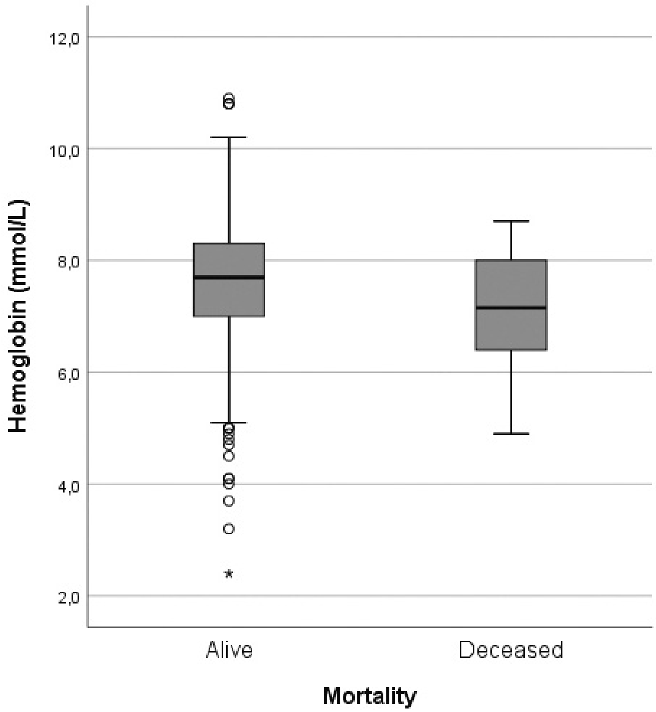
In future investigations, external validation is needed to validate this model in populations other than Dutch geriatric hip fracture patients. The authors of this study are currently working on external validation and further improvement of the model at Brigham and Women's hospital, Boston, USA. If the model is sufficiently validated, it could be programmed into electronic healthcare systems.

The proposed prediction model can predict the chance of in-hospital mortality for geriatric hip fracture patients presenting to the ED. It is composed of four simple predictors that are always known for all patients in which surgical intervention is considered. Geriatric hip fracture patients are a fast-growing group of patients who are notorious for adverse outcomes[3]. The model proposed in this study may be a helpful tool to identify high-risk patients and may be used in two ways. First, increasing awareness of patients who are at risk for adverse medical outcomes and implementing geriatric interventions may improve patient outcomes. Second, conservative treatment could be considered for geriatric hip fracture patients with a very high risk of mortality. This simple prediction model can be used when patients are presented at the ED to guide medical decision making in terms of treatment options and may be of use to manage the patients and family's expectations of the clinical course.

In this study, the authors chose to avoid dichotomization wherever possible, so no cut-off value is given for which patients are at "high risk". The tool can be used to assess the chance of in-hospital mortality. Whether this chance is considered "high" or "low" is up to the user and the patient. For patients with a moderate to high risk of mortality, geriatric consultation and comanagement is indicated. Orthogeriatric comanagement improves in-hospital mortality and other outcomes after hip fracture surgery, by targeted geriatric interventions such as early mobilization, secondary prevention (e.g. falls, osteoporosis management), and measures to reduce adverse events such as delirium[31,32]. Conservative treatment should be considered for patients with a very high risk of mortality. The authors of this paper strongly advocate shared decision making for all geriatric hip fracture patients and recommend that quality and quantity of life is discussed with the patient before making any treatment decisions. A Dutch multicenter study (FRAIL-HIP, registration number Trial NL7040) is currently investigating non-operative treatment versus surgery in relation to quality of life in frail institutionalized elderly hip fracture patients, but results have yet to be published[33].

In conclusion, age, male sex, higher ASA classification and lower hemoglobin levels are robust independent predictors of in-hospital mortality in geriatric hip fracture patients and were incorporated in a simple prediction model with fair accuracy.

Supplemental Figure 1



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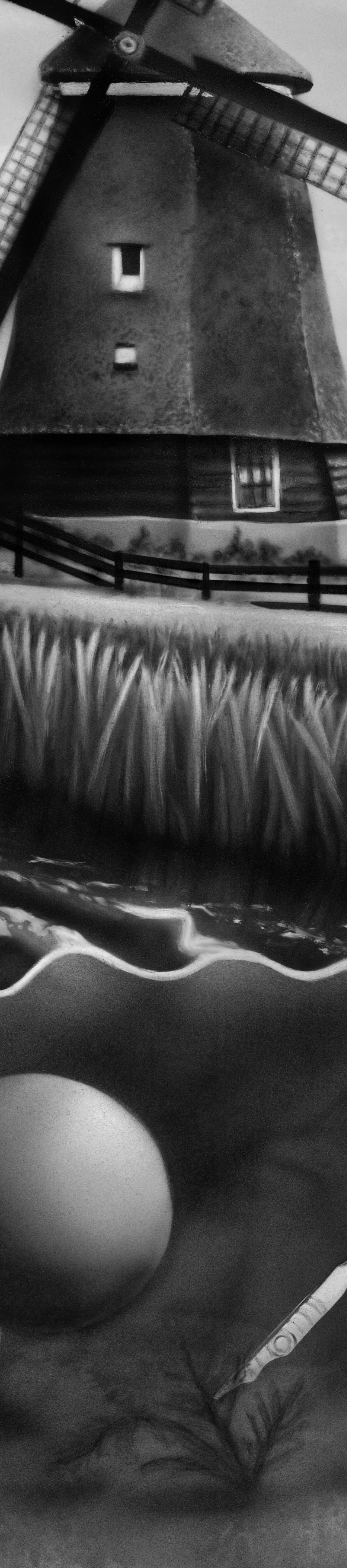

CHAPTER 5

External validation of the U-HIP prediction model for in-hospital mortality in geriatric hip fracture patients

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Submitted

ABSTRACT

Objectives: To perform an external international validation study of the U-HIP prediction model for in-hospital mortality in geriatric patients with a hip fracture undergoing surgery.

Design: Retrospective cohort

Setting: Data were used from The American College of Surgeons National Surgical Quality Improvement Program.

Patients: Patients aged 70 years or above undergoing hip fracture surgery were included. The discrimination (c-statistic) and calibration of the model were investigated.

Intervention: Hip fracture surgery

Main Outcome measurement: In-hospital mortality

Results: A total of 25,502 patients were included, of whom 618 (2.4%) died. The mean predicted probability of in-hospital mortality was 3.9% (range 0%-55%). The c-statistic of the model was 0.74 (95% CI 0.72-0.76), which was comparable to the c-statistic of 0.78 (95% CI 0.71-0.85) that was found in the development cohort. The calibration plot indicated that the model was slightly overfitted, with a calibration-in-the-large of 0.015 and a calibration slope of 0.780. Within the subgroup of patients aged between 70 and 85, however, the c-statistic was 0.78 (95% CI 0.75-0.81), with good calibration (calibration slope 0.934).

Conclusions: The U-HIP model for in-hospital mortality in geriatric hip fractures was externally validated in a large international cohort, and showed a good discrimination and fair calibration. This model is freely available online and can be used to predict the risk of mortality, identify high-risk patients and aid clinical decision making.

INTRODUCTION

The increase in the number of geriatric hip fracture patients is a global health concern. They constitute a fast-growing group of patients who are notorious for adverse outcomes.[1] Identification of high-risk patients in an early stage is vital for guiding surgical management and shared decision making. Prediction models can be used to predict the risk of clinical outcomes and help to identify high-risk patients.[2]

A few prediction models have been developed to predict post-operative mortality among hip fracture patients, including two studies that investigated in-hospital mortality as an outcome.[3–5] However, in many prediction models, predictor values are dichotomized (even though this is strongly discouraged by experts in this field), and have not been sufficiently validated.[2–4,6,7] Additionally, these models showed a lack of fit and poor discrimination in previous studies.[5] Finally, both of these models have incorporated variables that are generally not known at the emergency department at the moment that the prediction is to be made (e.g. time to surgery), which is the most critical flaw of both these prediction models and severely limits their clinical usefulness.[3–5] Hence, there are no externally validated models predicting in-hospital mortality in this patient population that show a good predictive performance.

In a previous study, a prediction model (the U-HIP (Utrecht Hip) algorithm) was developed in 1014 hip fracture patients aged 85 years or older (median 90, IQR 87-93) in the Netherlands, with an in-hospital mortality of 4% (n=38). After correction for optimism, this model showed good discrimination (c-statistic 0.77) at internal validation. Predictors in the model were age, sex, American Society of Anesthesiologists physical status classification system (ASA) and hemoglobin serum levels (mmol/L) upon presentation at the ED.[8] The purpose of the current study was to perform a validation study to externally validate the U-HIP prediction model for in-hospital mortality in a North-American population of hip fracture patients aged 70 or above undergoing surgery.[8,9] The authors hypothesize that the model will show good discrimination (i.e. c-statistic ≥0.70) and calibration (i.e. calibration-in-the-large <0.02 and >-0.02, and calibration slope >0.75).

MATERIALS AND METHODS

This study was approved by the institutional review board and medical ethical committee and reported in accordance with the transparent reporting of a multivariable prediction model for individual prognosis or diagnosis (TRIPOD) guidelines of the enhancing the quality and transparency of health research network (EQUATOR).[10]

For this cohort study, data were collected from January 1st 2016 until December 31st 2018 by The American College of Surgeons National Surgical Quality Improvement Program (NSQIP).[11] The NSQIP collects data on hip fracture surgery from over 150 hospitals across the world, although most of these hospitals are located in North-America. The inclusion criteria for the validation cohort were as follows: 1) patients aged 70 years or above, presenting to the emergency department with a hip fracture (OTA classification: 31-A or 31-B)[12] and; 2) undergoing hip fracture surgery for a nonpathological hip fracture. Patients with American Society of Anesthesiologists physical status classification system (ASA) V were excluded, because the development cohort did not include these patients and because patients with ASA status V are, by definition, moribund and thus accurate risk prediction are irrelevant.[8,13] The primary outcome for this study was in-hospital mortality. In this study, the authors decided to validate the model in patients aged 70 years or above, even though the development cohort consisted of patients 85 year or above.[8] The cut-off of 70 years was chosen because the vast majority of patients who experience in-hospital mortality after a hip fracture are aged 70 years or above. Because of expected heterogeneity in patients younger than 70 and the relatively low mortality risk in that group, a cut-off of 70 years was chosen. Hence, we focus on the patient population in whom the risk prediction is likely to be most relevant, while increasing the age range (compared to the development population) to improve clinical applicability and usefulness.

The following data were collected at baseline (i.e., at hospital admission): fracture type (i.e. femoral neck nondisplaced, femoral neck displaced, intertrochanteric, or subtrochanteric), age, sex, ASA classification[13] (I to IV), a previous diagnosis of dementia in medical history, and hemoglobin levels (mmol/L) at presentation at the emergency department. Since hemoglobin levels are not collected by NSQIP, hemoglobin levels in mmol/L (Hb) were calculated by converting hematocrit (Ht) using the following formula: Hb (mmol/L) = (Ht/2.941) x 0.6206.[14]

It is recommended that a sufficient sample size is used to externally validate existing prediction models, to facilitate possible recalibration of a prediction model.[15] We aimed to have 400 events, and given an expected in-hospital mortality of 4% (based on the study in which the prediction model was developed), the minimum required sample size for this study was estimated to be at least 10,000 hip fracture patients aged 70 years or above.

For all baseline characteristics, nominal variables were described with numbers and percentages and survivors and deceased patients were compared with a Chi-square test. Descriptive statistics were used to report numeric variables. Normality was determined for continuous variables by examining the boxplots and histograms. Normally distributed data were tested using a Students paired t-test and presented as a mean ± standard deviation (SD). Non-normally distributed data were tested with a Mann-Whitney U-test and presented as a median with an interquartile range (IQR).

Missing data were analyzed. A total of 142 cases had one or more missing values in predictor variables needed for the algorithm (<0.1% of all data points) and were not included for the validation of the model (<0.1% of all patients). The authors chose not to impute missing data but instead do a complete case analysis for validation of the model. This resulted in a minimal loss of data.

Discrimination of the model was measured with the area under the curve (AUC) of the receiver operating characteristic (ROC) curve, a measure commonly referred to as the c-statistic, including a 95% confidence interval (CI). Calibration of the model was examined by means of a calibration plot, which plots the predicted probabilities (based on the model) versus the observed risk of the outcome.[16–18] Calibration was quantified by determining the calibration slope of the calibration curve and determining calibration-in-the-large defined as the difference of the mean predicted probability and observed risk of the outcome, which is a measure for predictions being systematically too low or too high. For a perfect model, calibration-in-the large equals 0 and the calibration slope equals 1.[17,18]

If a low predictive accuracy was found during this validation study (i.e. c-statistic <0.70, calibration-in-the-large >0.02 or <-0.02, and/or calibration slope <0.75), the model was to be updated or recalibrated by either; 1) intercept recalibration, 2) recalibrating all predictors simultaneously, or 3) adding a new predictor variable (i.e. the presence of dementia at baseline).[19] However, predictive accuracy was not found to be low and hence the model was not updated nor recalibrated.

The authors performed a subgroup analysis for the performance of the model in the group of patients aged 70-85 years (domain validation) and the group of patient aged 85 or older (original domain). The threshold for significance was set at 0.05. All analyses were conducted using SPSS Statistics (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.), except for the calibration curve analysis, which was conducted using R statistical package for Windows version 3.6 (R foundation, 2019, Vienna, Austria).

RESULTS

Baseline characteristics

A total of 31,751 geriatric hip fracture patients were considered for this study. After exclusion of 6,249 patients, 25,502 patients were included in this study (Figure 1).

Figure 1: Selection of patients in external validation study of the U-HIP model.

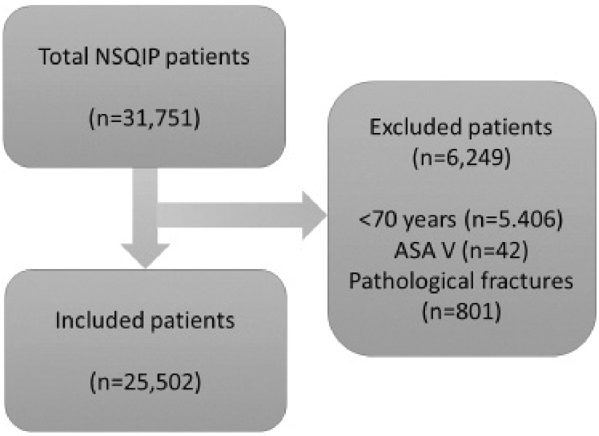


Table 1: Characteristics of geriatric hip fracture patients included in the external validation study of the U-HIP model

Variable	In-hospital mortality				
	Total (n=25,502)	**Missing**	**Survivors (n=24,884)**	**Deceased (n=618)**	***p*-value**
Age; median, IQR)	85 (80-90)	0	85 (79-90)	88 (83-90)	<0.01
Female sex; n (%)	18,248 (72)	0	17,894 (72)	354 (57)	<0.01
Dementia; n (%)	8,567 (34)	0	8,288 (33)	279 (45)	<0.01
ASA classification; n (%)		41 (0)			<0.01
ASA I	70 (0)		70 (0)	0 (0)	
ASA II	3,458 (14)		3,440 (14)	18 (3)	
ASA III	16,052 (63)		15,796 (64)	256 (42)	
ASA IV	5,881 (23)		5,539 (22)	342 (56)	
Serum hemoglobin (mmol/L) at presentation; mean (SD)	7.3 (1.1)	101 (0)	7.3 (1.1)	6.9 (1.2)	<0.01
Type of hip fracture; n (%)		433 (2)			0.25
Femoral neck, nondisplaced	2,115 (9)		2,108 (9)	47 (8)	
Femoral neck, displaced	7,512 (30)		7,349 (30)	163 (27)	
Intertrochanteric	13,987 (56)		13,631 (56)	356 (59)	
Subtrochanteric	1,415 (6)		1,376 (6)	39 (6)	

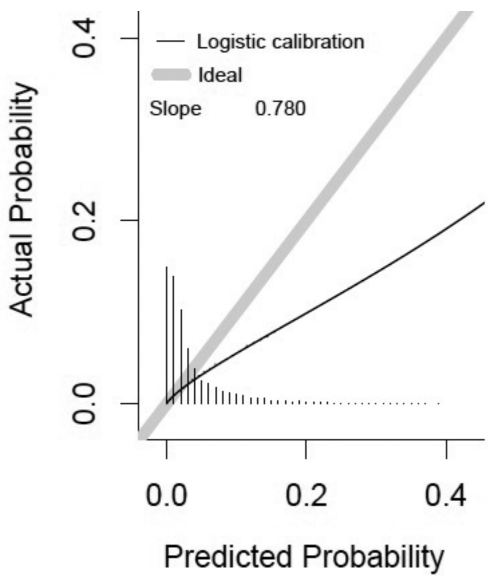
Percentages calculated for complete data and rounded to nearest integer.

The overall in-hospital mortality was 2.4% (Table 1). Patients who experienced in-hospital mortality were older at baseline (median 88, IQR 83-90) than survivors (median 85, IQR 79-90, *p*<0.01). Survivors were more often female (72%) than deceased patients (57%, *p*<0.01). Patients who experienced in-hospital mortality more often had a diagnosis of dementia (45%) than survivors (33%, *p*<0.01), and a higher ASA status (median 4, IQR 3-4) than survivors (median 3, IQR 3-3, *p*<0.01). Patients who died in-hospital also had lower levels of serum hemoglobin at presentation (*p*<0.01).

Performance of the model: discrimination and calibration

The mean predicted probability of in-hospital mortality was 3.9% (range 0%-55%) and the observed risk of in-hospital mortality was 2.4%. Calibration-in-the-large was 0.015. Graphical evaluation of the calibration plot showed that the model is fairly well-calibrated in the validation cohort, with a calibration slope of 0.780 (Figure 2). The c-statistic of the model was 0.74 (95% CI 0.72-0.76).

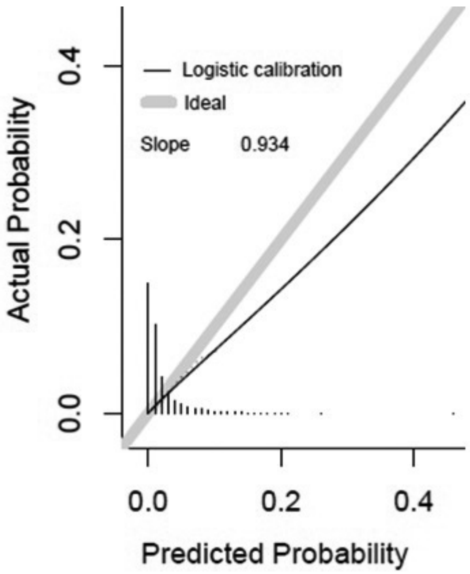
Figure 2: Calibration plot of observed mortality risk versus predicted risk based on the U-HIP model.



Calibration of the model is presented for the entire study population of geriatric hip fracture patients, aged >70 years. The distribution of subjects is indicated with spikes at the bottom of the figure. Calibration-in-the-large is 0.015 and the calibration slope is 0.780. The c-statistic for this population is 0.74 (95% CI 0.72-0.76).

A subgroup analysis was done for 11,617 patients who were aged between 70 and 85 years to investigate the discrimination and calibration of the model for this group specifically, because patients in this age category were not included in the development cohort. In this age subgroup, 197 patients died (1.7%), while the mean predicted probability of mortality was 2.2%. Calibration-in-the-large was 0.005. The calibration was good, with a calibration slope of 0.934. (Figure 3). The c-statistics was 0.78 (95% CI 0.75-0.81).

Figure 3: Calibration plot of observed mortality risk versus predicted risk based on the U-HIP model in the subgroup of patients aged 70-84



The figure shows the calibration plot for the subgroup of the domain validation cohort of patients aged 70-84. The distribution of subjects is indicated with spikes at the bottom of the figure. Calibration-in-the-large is 0.005 and the calibration slope is 0.934. The c-statistic for this population is 0.78 (95% CI 0.75-0.81).

There were 13,885 patients in the age group of patients aged 85 years or above. In this subgroup, 421 (3.1%) patients died in-hospital, while the mean predicted probability was 5.4%. Calibration-in-the-large was 0.022. The calibration was moderate in this group, with a calibration slope of 0.743 (Supplemental Figure 1). The c-statistic was 0.70 (95% CI 0.68-0.73).

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DISCUSSION

The aim of this study was to validate a previously developed prediction model (U-HIP) for in-hospital mortality in geriatric hip fracture patients.[8] In this large retrospective cohort study using NSQIP data, the model showed a fairly good predictive performance.

Development cohort versus validation cohort

The baseline characteristics of this external validation cohort were comparable to the development cohort in terms of sex, ASA classification, diagnosis of dementia and hemoglobin levels.[8] There were several differences between the development cohort and this external validation cohort. First, in the development cohort, no truncation for age was used for nonagenarians and centennials, whereas in the development cohort, no truncation was used. Second, this validation cohort included patients who received total hip arthroplasty as a treatment for their hip fracture, while the development cohort did not. It was not possible to conduct a subgroup analysis for this group. It is possible that there are differences in in-hospital mortality and model performance for total hip arthroplasty patients, considering that patients who are eligible for total hip arthroplasty are often in a better medical condition. Third, in this validation cohort, periprosthetic fractures were included. It was not possible to conduct a subgroup analysis for periprosthetic fractures because they do not have an identifier variable in the NSQIP dataset. Fourth, in this study, the model was validated for patients aged 70 years or above, not just 85 years or above as was the case in the development cohort. Fifth, this external geographical validation study was conducted in a large international cohort of patients recruited from over 150 hospitals (most of them in Northern-America), whereas the development cohort included geriatric hip fracture patients from six Dutch hospitals.

Performance of the model: discrimination and calibration

The model presented here has a good discrimination and fair calibration. Both metrics are important in prediction modelling. The discrimination of the model was good, with a c-statistic of 0.74, which is comparable to the c-statistic of 0.78 that was found in the development cohort.[8] However, a good discrimination (i.e. separating people who experience a certain outcome from people who do not) alone does not make a good prognostic prediction model. For example, a model may show an excellent discrimination between patients who experience an outcome and patients who do not, but if predicted risk is substantially under- or overestimates of the actual risk of the outcome, the model is usually not suitable for supporting clinical decisions.

Calibration in prediction modelling is defined as the agreement between the observed risk and the predicted risk. There are currently no prediction models for geriatric hip fractures that are well calibrated.[3,4,7,20,21] Calibration is important in prognostic settings, because the magnitude of the predicted risk (or, in the absence of a formal prediction model, the estimated risk) is what drives medical management of our patients.[17] As can be seen in the calibration plots, the calibration is fairly good for the total population and very good for patients aged between 70 and 85 years, and somewhat lower for patients aged 85 years or above. The model tends to slightly overestimate the risk of in-hospital mortality, especially for patients with a higher risk of dying (Figure 2, Figure 3). Extremes are always hardest to predict, and it is not uncommon for prediction models to overestimate the higher deciles of the calibration plot.[9] This need not be a problem, given that there are very few patients that fall into these extreme categories, as can be seen in the spikes in Figure 2 and 3, that show patient distribution according to their predicted probabilities. More importantly, it is unlikely that these overestimations will lead to incorrect medical decision making and thus are of no clinical consequence.

Strengths and limitations

The model presented here is well-calibrated and shows a good discrimination. The advantage of this model in comparison to other models is its predictive accuracy, that it is both internally and externally (even internationally) validated in large cohorts, that it offers exact risk prediction instead of risk stratification, and that it only uses predictor variables that are known at the time the prediction is to be made.

This study has a few limitations. First and foremost, in the NSQIP data, age was truncated at 90 years, which means that patients who are older than 90 years (e.g. 99 years) are entered into the database as being 90 years old. The reason behind this is that a very old age is regarded by the NSQIP as a possible patient identifier, and it is likely that this had led to an underestimation of the discrimination for patients aged 91 years or above. It is likely that many subjects who experienced the outcome were in the age category of 90 years or above, which explains the difference in calibration found between the total population and subgroup analysis of the population aged 75-84 years in this study. The performance of the model in patients aged 90 years or above would probably have been much better if their exact age had been used to develop the model.

Second, in-hospital mortality is frequently used as an outcome in geriatric traumatology, but length of stay and discharge policies can be different between centers, which may impact the performance of a model predicting in-hospital mortality, notably when moribund patients are discharged to other facilities such as hospice care. In our external validation setting, where data of 150 different centers was combined, the impact of this appears to be small.

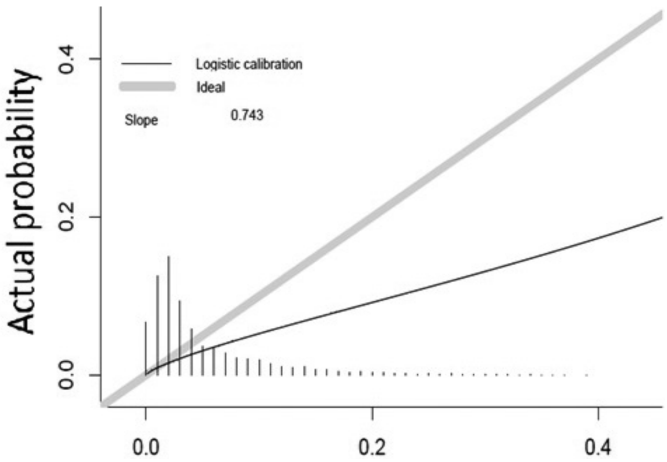
Clinical application and future perspectives

The U-HIP model is available online for free as a web-based calculator at (https://www.evidencio.com/models/show/2268). Physicians can enter the patient characteristics, and the patients' individual risk of in-hospital mortality is automatically calculated and returned on screen. Alternatively, the model could be programmed into electronic medical records to calculate the mortality risk for each individual patient. Prediction models are useful tools that can be used to complement medical decision making, but not substitute it. The authors recommend a holistic approach for every geriatric hip fracture patient, preferably with geriatric co-management. This model can help guide clinical decision making for these patients, and palliative care should regularly be considered for patients with a very high risk of in-hospital mortality. Additionally, the authors encourage colleagues around the world to perform validation studies for this model in different settings and populations to further investigate model performance.

Conclusion

In this study, a previously developed model for in-hospital mortality in geriatric hip fracture patients was externally validated in a large North-American cohort. The model showed a good discrimination and fair calibration, with good calibration in the subgroup of patients aged 70-85 years. This model is available online as a web-based calculator, and can be used to predict the risk of mortality, identify high-risk patients and thus help guide clinical decision making.

Supplemental Content 1: Calibration plot of observed mortality risk versus predicted risk based on the U-HIP model in the subgroup of patients aged 85 years or above



The figure shows the calibration plot for the subgroup of the cohort of patients aged 85 or above. The distribution of subjects is indicated with spikes at the bottom of the figure. Calibration-in-the-large is 0.022 and the calibration slope is 0.743. The c-statistic for this population is 0.70 (95% CI 0.68-0.73).

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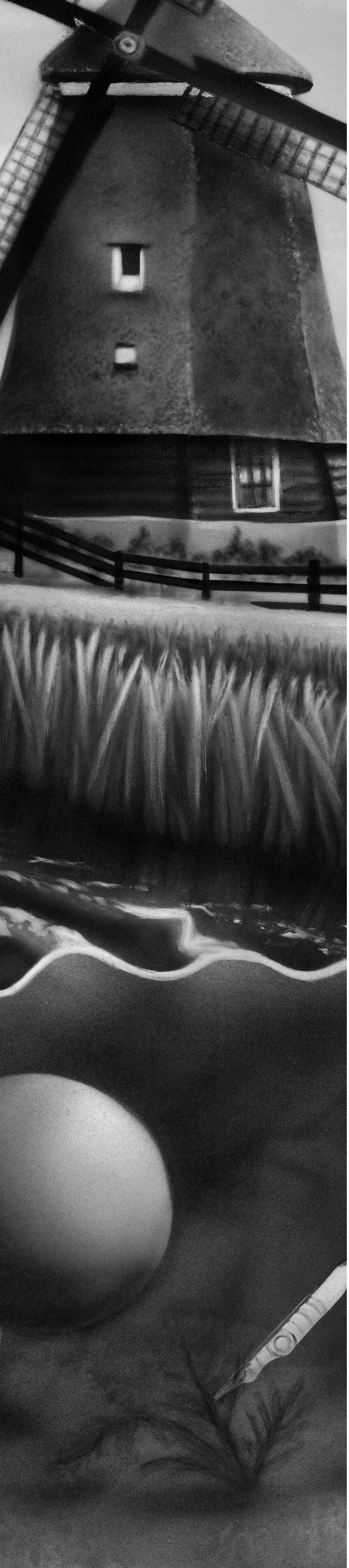

CHAPTER 6

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 chi-square 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 (c^2=22.409, p<0.001) after age (c^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 ageing 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. Additionally, 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.

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

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 St. Antonius Hospital, Nieuwgein, The Netherlands between 2018 and 2019 and Diakonessen Hospital, Utrecht, The Netherlands 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 St. Antonius Hospital, 2 researchers in Diakonessen Hospital). 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), pre-fracture 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 pre-fracture mobility on a scale of 0 to 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, pre-fracture PMS were scored and documented by physiotherapists who visited the patients at the ward after surgery.

Statistical analysis

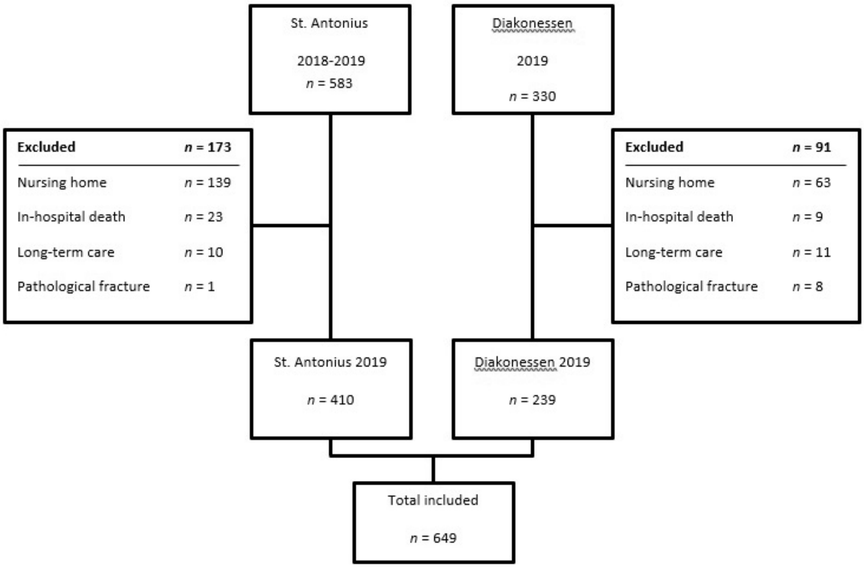
Descriptive statistics were used to report quantitative variables. Normality was determined for continuous variables by examining the boxplots and histograms. Normally distributed data were tested using a Students independent t test, while non-normally distributed data were tested with a Mann-Whitney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

A chi-square automatic interaction detection (CHAID) analysis was performed to construct two tree models, using 10-fold 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).

RESULTS

A total of 649 patients who met the inclusion criteria were consecutively included in this analysis (Figure 1).

Figure 1. Flowchart of patient inclusion



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).

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

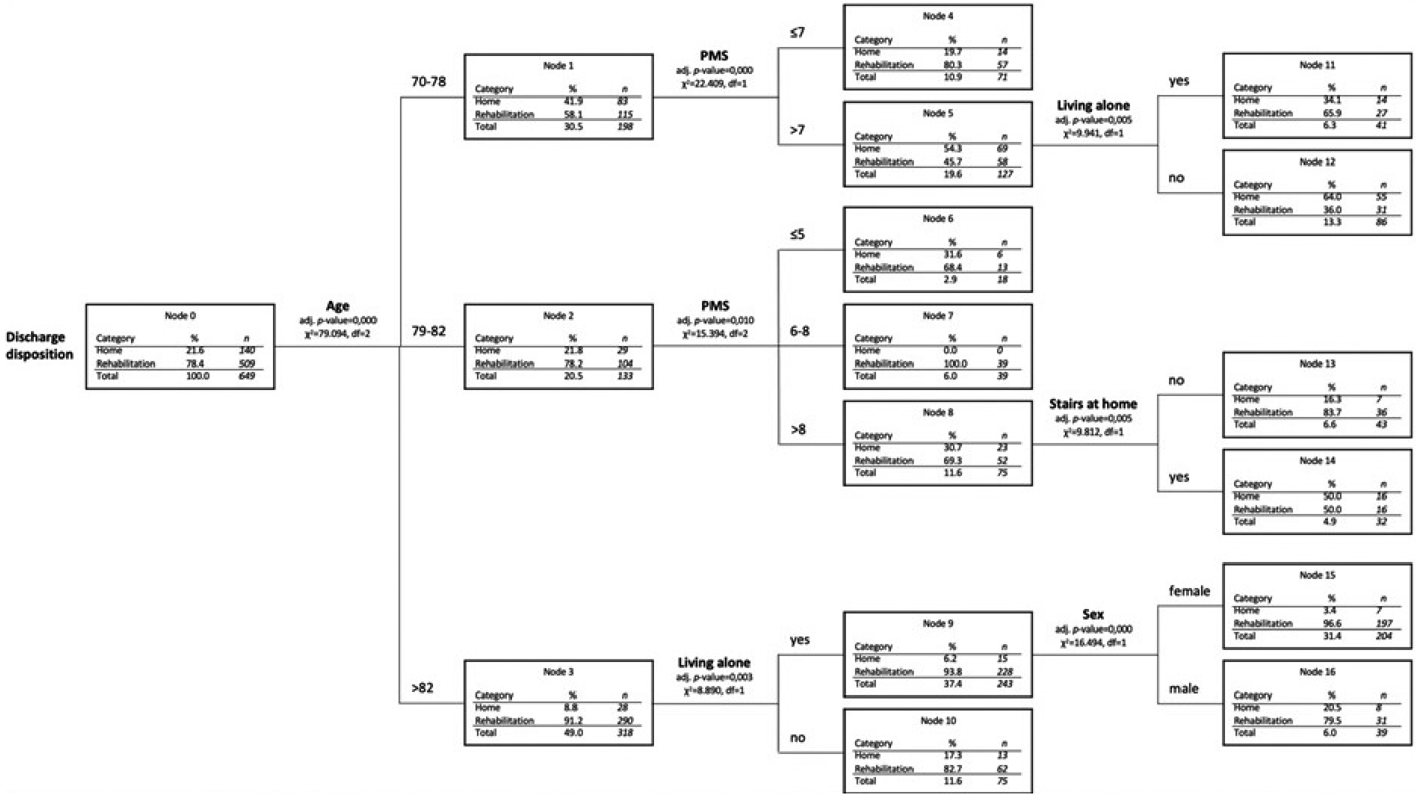
	Missing *n* (%)	Home (*n* = 140)	Rehabilitation (*n* = *509*)	*p*-value
age (years) *median* (IQR)	0(0.0)	77(73-81.75)	84(79-89)	<0.01
BMI *median* (IQR)	51(7.9)	23.80(21.84-26.42)	23.90(21.23-26.36)	0.66
Sex	0(0.0)			<0.01
male *n (%)*		58(41.4)	134(26.3)	
female *n (%)*		82(58.6)	375(73.7)	
ASA classification	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.

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 (Figure 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 (c^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 (c^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 (c^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 (c^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 (c^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 (c^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 by sex (c^2=16.494, p<0.001). 96.6% of females and 79.5% of males were transferred to a rehabilitation facility.

Figure 2. Tree diagram discharge disposition

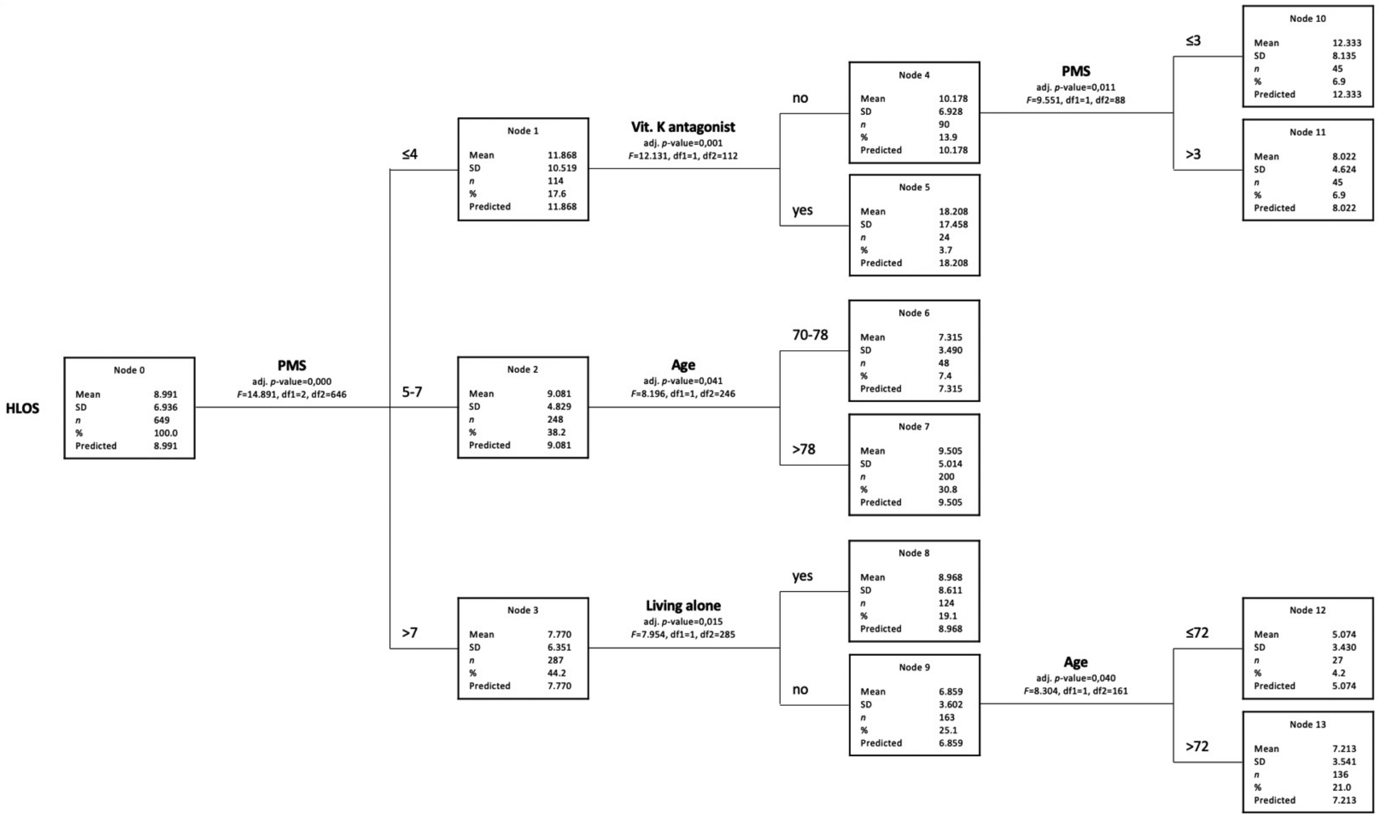


SD: standard deviation. PMS: Parker Mobility Score

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 the most significant association with HLOS (*F*=14.891, *p*<0.001) (Figure 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).

Figure 3. Tree diagram hospital length of stay



HLOS: hospital length of stay. SD: standard deviation. PMS: Parker Mobility Score

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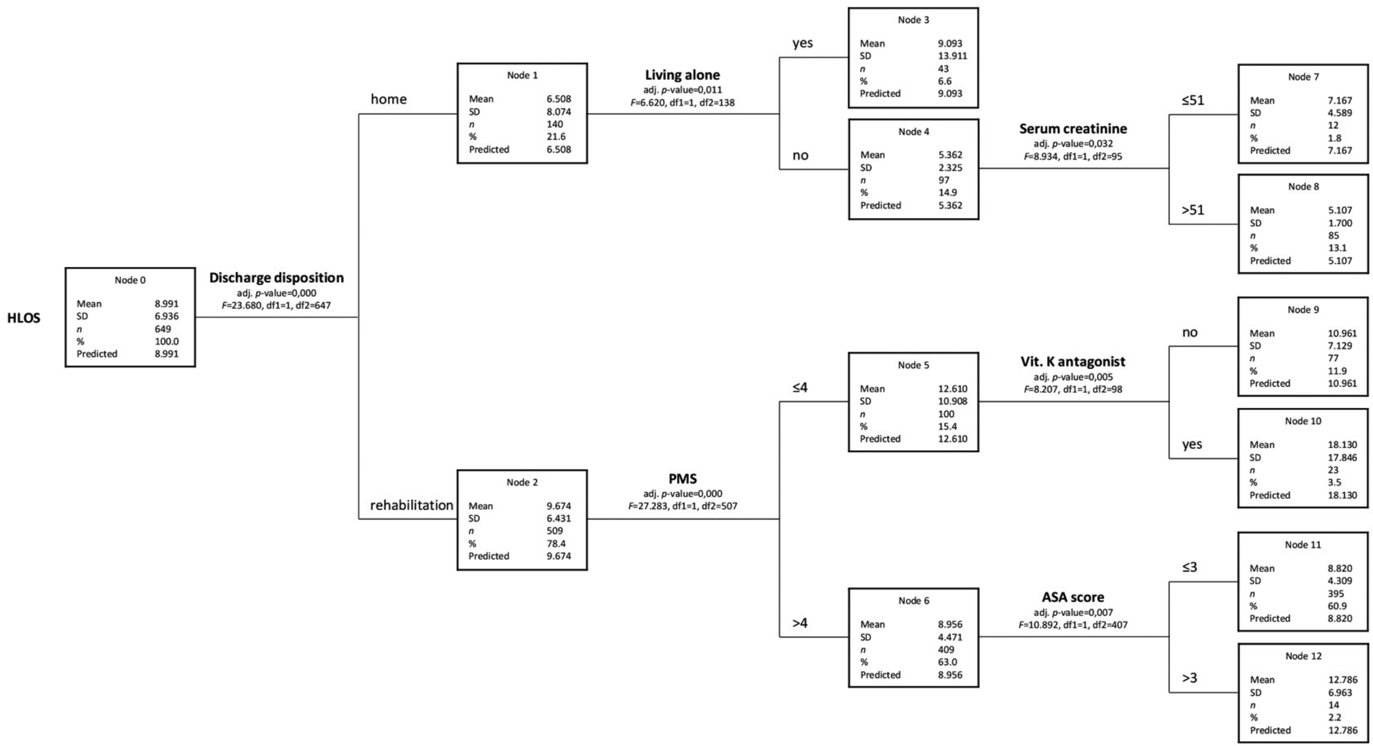
Figure 4. Tree diagram hospital length of stay (discharge disposition included)



HLOS: hospital length of stay. SD: standard deviation. PMS: Parker Mobility Score. 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.

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) (Figure 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 by 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 (Figure 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 pre-fracture 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. Because 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 pre-fracture 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 months 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

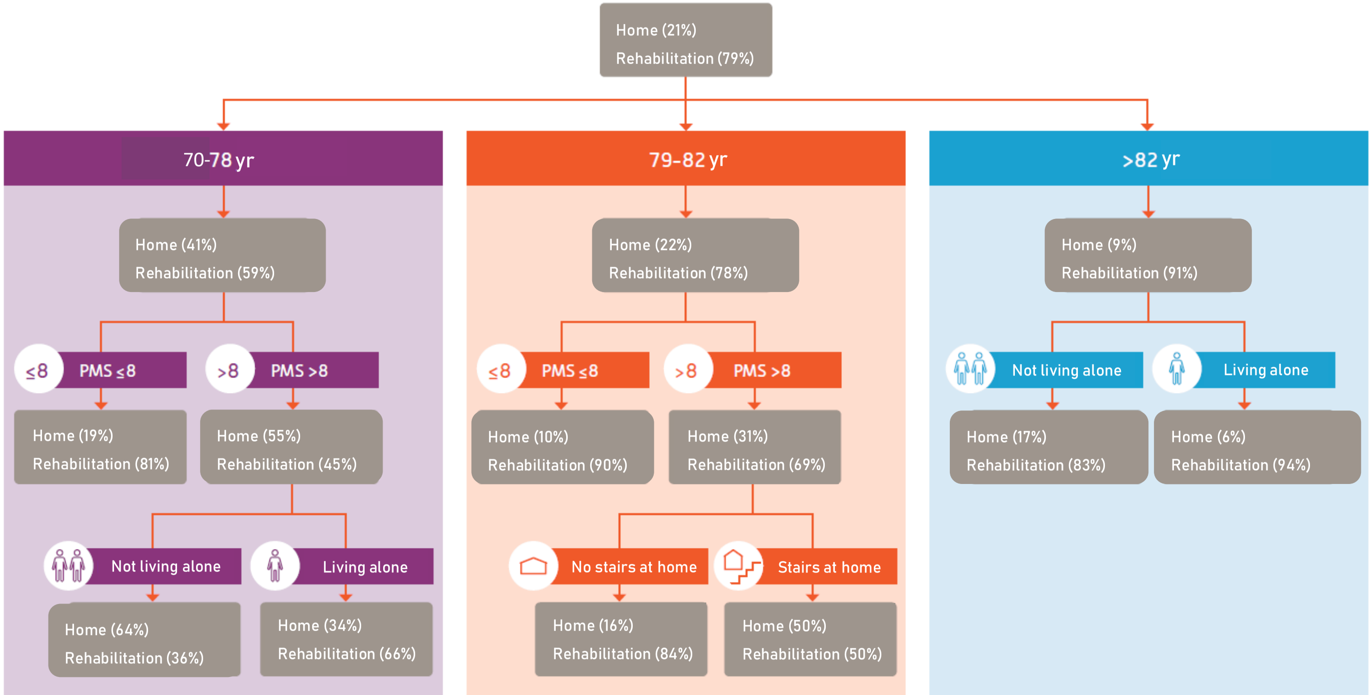
This study is one of the first studies to classify discharge disposition and HLOS specifically for geriatric traumatic hip fracture patients using the PMS. A strength of this study is that it provides a practical solution to an important operational problem. The decision tree for the prediction of discharge 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 the 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 at the Diakonessen Hospital at the start of 2019. Therefore, only patients presenting in 2019 were included from this hospital. 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.

Appendix A. Decision model for the emergency department



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

ST ANTONIUS een santeon ziekenhuis

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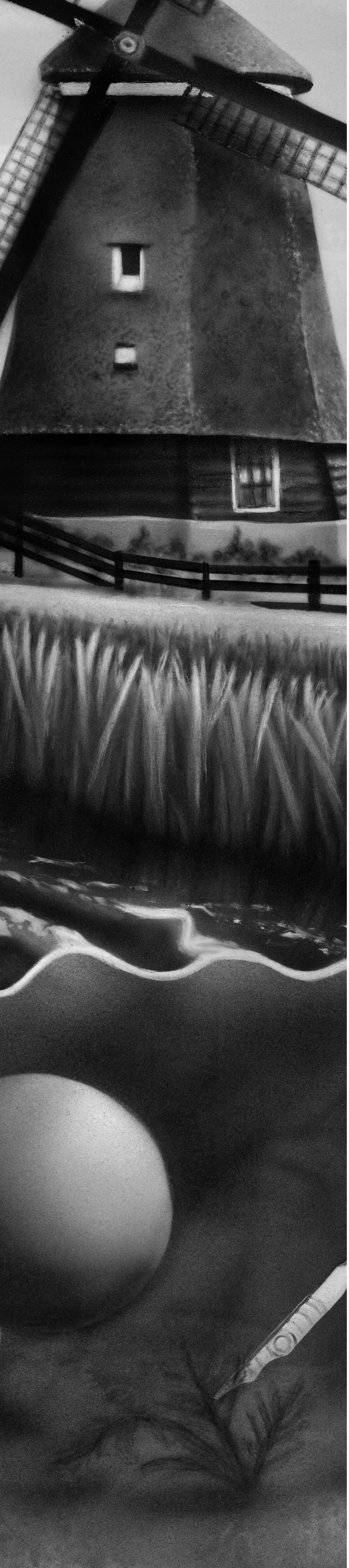

CHAPTER 7

Does the Frailty Index predict discharge disposition and length of stay at the hospital and rehabilitation facilities?

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Injury, 2021

ABSTRACT

Introduction: Many geriatric hip fracture patients utilize significant healthcare resources and require an extensive recovery period after surgery. There is an increasing awareness that measuring frailty in geriatric patients may be useful in predicting mortality and perioperative complications and may be useful in helping guide treatment decisions. The primary purpose of the study is to investigate whether the frailty index predicts discharge disposition from the hospital and discharge facility and length of stay.

Methods: In this retrospective cohort study, patients aged 65 years and older presenting to a level 1 trauma center with a hip fracture and a calculated frailty index were eligible for inclusion. The primary outcome was discharge disposition. Secondary outcomes were hospital and discharge facility length of stay, 90-day hospital mortality and readmissions, and return to home.

Results: A total of 313 patients were included. The frailty index was a robust predictor of discharge to a skilled nursing facility (OR 1.440 per 0.1 point increase). Patients with a higher frailty index were at higher risk of 90-day mortality and less likely to return to home at the end of follow-up. There was a very weak correlation between the frailty index and hospital length of stay (ρ=0.30) and rehab length of stay (ρ=0.26).

Conclusion: The frailty index can be used to predict discharge destination from both the hospital and rehabilitation facility, 90-day mortality, and return to home after rehabilitation. In this study, the frailty index had a very weak correlation with length of stay in the hospital and in discharge destination. The frailty index can be used to help guide medical decision making and to determine which patients benefit from intensive rehabilitation.

INTRODUCTION

Hip fractures in the elderly present a significant strain on the patient and the healthcare system.[1–3] Many geriatric hip fracture patients are frail and require an extensive recovery period after surgery.[3–8] Frailty is defined as a dynamic syndrome that is often associated with ageing and is characterized by decreased reserves and decreased resistance to stressors.[9] Given the high cost associated with long term care it would be helpful for clinicians and health systems to have a tool that can quantify frailty in an early stage, and which is also predictive of the discharge destination and length of stay (LOS).

One example of a tool that can be used to assess frailty is the Rockwood Frailty Index (FI).[10,11] An advantage of the FI is that it offers insight into multiple systems and is a quantitative measure of frailty, meaning that it can capture the dynamic change of frailty in patients. It is also a robust predictor of mortality, which can be used to assess surgical risk.[12,13] While some studies have investigated the relationship between the FI and adverse outcomes, discharge destination, and inpatient LOS in geriatric trauma patients, [6–8,14–16] few target fracture patients specifically.[6–8] There is a need for more high-quality research exploring the FI in relation to discharge destination, LOS and adverse outcomes in geriatric hip fracture patients.

The research questions for this study were as follows:

1. Does the FI predict discharge disposition from the hospital and from the discharge facility?
2. What is the correlation (ρ) between the FI and LOS in the hospital and discharge destination?
3. Does the FI predict 90-day hospital readmissions, 90 day mortality, and return to home after rehabilitation?

The authors hypothesize that the FI is a robust predictor for discharge disposition, 90-day hospital readmissions, 90 day mortality, and return to home after rehabilitation and that there is a strong correlation (i.e. $\rho > 0.70$) between the FI and LOS.

MATERIALS AND METHODS

In this retrospective cohort study, all patients 65 years and older presenting to a level 1 trauma center with an orthogeriatric comanagement service for elderly fracture patients. Patients presenting between 2014 and 2018 with a hip fracture and a calculated FI were eligible for inclusion.[11] The FI was calculated by a geriatrician in the emergency department. Patients were identified using the our electronic patient database, the Research Patient Data Registry (RPDR). The rehabilitation discharge facility to which the patient was discharged was contacted by telephone. Patients were excluded if the facility did not have or did not wish to share the required patient information. A medical chart review of the included patients' inpatient stay was conducted.

The primary outcome for this study was discharge disposition from the hospital. Secondary outcomes were hospital length of stay (days), discharge facility length of stay (days), discharge disposition from the rehabilitation facility, 90-day hospital readmissions, and 90-day mortality and return to home at the end of follow-up. Secondary outcomes were not known for patients who were discharged home, and these patients were thus excluded from these analyses.

The following baseline data was collected from chart review: age, sex, FI, pre-injury living situation (i.e. at home with or without ADL-assistance or in an institutional care facility), type of hip fracture (i.e. femoral neck, intertrochanteric, or subtrochanteric), type of surgical procedure (i.e. closed reduction with percutaneous pinning (CRPP), dynamic hip screw (DHS), hemiarthroplasty (HA), intramedullary nail (IMN), or total hip arthroplasty (THA), pre-existent diagnosis of dementia upon presentation (yes/no), hospital length of stay (days), 90-day readmissions, date of death (if deceased), and discharge disposition (i.e. skilled nursing facility or inpatient rehab facility).

Additionally, the facility to which the patient was discharged was contacted to obtain the following data: LOS at discharge destination (days), discharge disposition from discharge destination (i.e. home, home with services, skilled nursing facility, or hospital), and date of death (if deceased). The end of follow-up was defined as discharge from the rehabilitation facility or death.

Statistical analysis

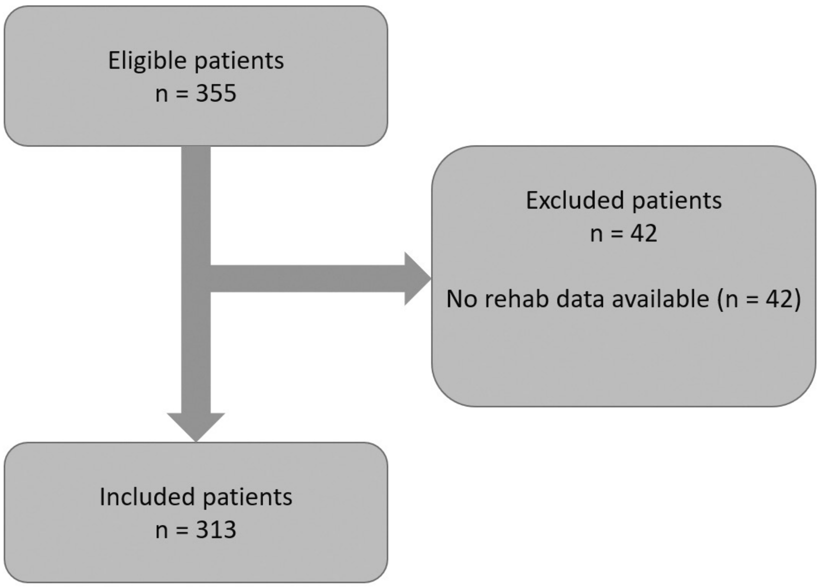
Descriptive statistics were used to report quantitative variables. Normality was determined for continuous variables by examining the boxplots and histograms. Normally distributed data were tested using a Students paired t test, while non-normally distributed data were tested with a Mann-Whitney U-test. Qualitative variables were described with numbers and percentages and compared with a Chi-square test. To determine the ability of the FI to predict discharge destination, 90 day readmission, and 90-day mortality, a multivariable logistic regression analysis was performed to obtain adjusted odds ratio's (OR) and 95% confidence intervals (CI) after correcting for covariates sex, age, and a prefracture diagnosis of dementia. For correlation between the FI and hospital LOS and discharge destination LOS, the two-tailed Spearman correlation ρ (rho) was calculated. A correlation below 0.20 was considered negligible, a correlation between 0.20 and 0.40 was defined as weak, a correlation between 0.40 and 0.70 was defined as moderate, and a correlation above 0.70 was considered strong.[17] To determine if the FI was associated with discharge disposition from the hospital and from their rehabilitation facility, a Kruskall-Wallis test was performed.

The threshold for significance was set at 0.05. All analyses were conducted using SPSS statistics for Windows, version 25 (IBM). This study was registered and approved by the institutional review board and medical ethical committee. This article was written in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines[18].

RESULTS

A total of 355 patients were eligible for the study, and 42 were excluded because the discharge facility did not provide data (Figure 1). These excluded patients had a median FI of 0.44 (IQR 0.31-0.54). This resulted in a total of 313 patients being included in the study. The majority of patients (216, 69%) were discharged to a skilled nursing facility while 80 (26%) were discharged to an inpatient rehabilitation hospital and 17 (5%) were discharged home.

Figure 1: Patient flow chart



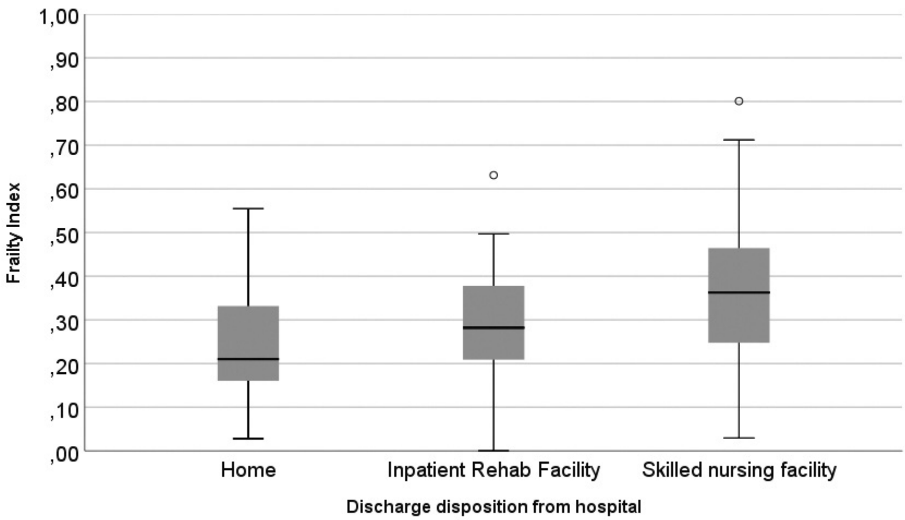
As can be seen in Table 1 and Figure 2, the FI was associated with discharge disposition from the hospital in the univariable analysis. There was a statistically significant difference in the median of patients who were discharged to a skilled nursing facility (median 0.36 IQR 0.25-0.47), patients who were discharged to an inpatient rehabilitation facility (median FI 0.28, IQR 0.21-38), and patients who were discharged home (median 0.21, IQR 0.15-0.38, $p<0.001$). Interestingly, only a small difference in median was found between patients discharged home and to an inpatient rehabilitation facility, so a subgroup analysis (Mann-Whitney U test) was performed between the median FI of patients who were discharged home and patients who were discharged to an inpatient rehabilitation facility. This analysis showed no statistically significant difference (*p*=0.29). After correcting for covariates, the FI was a robust predictor of discharge to a skilled nursing facility (OR 1.440 per 0.1 point increase in FI, 95% CI 1.185-1.751, *p*<0.001).

A total of 296 patients were discharged to inpatient facilities, 26 (9%) of whom died during their stay. The median follow-up time was 20 days (IQR 13-31). At discharge from the hospital, 216 (73%) of all patients were transferred to a skilled nursing facility and 80 (27%) were transferred to an inpatient rehabilitation facility. There two groups were not different at baseline in terms of age, sex, prefracture living situation, fracture type, or type of surgical procedure (Table 1). Patients who were discharged to a skilled nursing facility more often had dementia (24%) than patients who were discharged to an inpatient rehabilitation facility (11%, p=0.015).

Table 1: Baseline characteristics of patients discharged to skilled nursing facilities and inpatient rehabilitation facility facilities

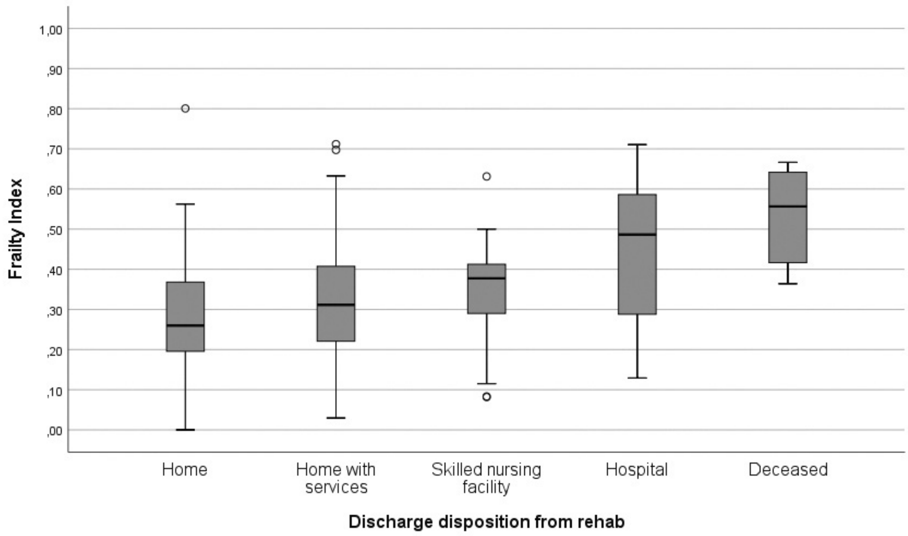
Variable	**Missing n (%)**	**Skilled nursing n= 216 (69)**	**Inpatient rehabilitation facility n= 80 (26)**	**Home n = 17 (5)**	***p*-value**
Age; median (IQR)	0 (0)	84 (78-89)	84 (79-89)	81 (74-90)	0.30
Male sex; n (%)	2 (1)	60 (28)	24 (30)	4 (25)	0.87
Frailty index; median (IQR)	0 (0)	0.36 (0.25-0.47)	0.28 (0.21-38)	0.21 (0.15-0.38)	<0.001
Prefracture diagnosis of dementia; n (%)	0 (0)	52 (24)	9 (11)	1 (6)	0.02
Prefracture living situation was in an institutional care facility; n (%)	10 (3)	27 (13)	5 (6)	1 (14)	0.296
Type of fracture; n (%)	0 (0)				0.23
Femoral neck		82 (38)	31 (39)	11 (65)	
Intertrochanteric		116 (54)	44 (55)	6 (35)	
Subtrochanteric		18 (8)	5 (6)	0 (0)	
Type of surgery; n (%)	2 (1)				0.14
Closed reduction with percutaneous pinning		4 (2)	1 (1)	1 (7)	
Dynamic hip screw		32 (15)	12 (15)	3 (20)	
Hemiarthroplasty		48 (22)	22 (28)	3 (20)	
Intramedullary nail		115 (53)	41 (51)	4 (27)	
Total hip arthroplasty		17 (8)	4 (5)	4 (27)	

Figure 2: Boxplot of frailty index versus discharge disposition from hospital (p<0.001, Kruskall-Wallis test)



Discharge disposition from the rehabilitation facility was associated with the FI (*p*<0.001) (Figure 3). Patients who were discharged home/independent living without services had the lowest FI (median 0.26 IQR 0.19-0.37). Patients who were discharged home/independent living with services had a median FI of 0.31 (IQR 0.22-0.41). Patients who were discharged from an inpatient rehab facility to a skilled nursing facility had a median FI of 0.38 (IQR 0.28-0.42). Patients who were readmitted to the hospital had a median FI of 0.49 (IQR 0.28-0.59). Deceased patients had the highest median FI of 0.56 (IQR 0.42-0.64).

Figure 3: Boxplot of frailty index versus discharge disposition from rehabilitation facility (p<0.001, Kruskall-Wallis test)



The median hospital LOS was 3 days (IQR 3-4) for all patients. As can be seen in Figure 4A, there was a weak correlation between a higher FI and a longer time from surgery to discharge from the hospital, with a Spearman correlation of ρ=0.30 (p<0.001). The median LOS at the discharge facility was 20 days (IQR 13-31). As can be seen in Figure 4B, there was a weak correlation between a higher FI and a longer LOS at the discharge destination, with a Spearman correlation of ρ=0.26 (p<0.001).

There were 24 (9%) readmissions to the hospital from the rehabilitation facilities. The results of the multivariable analysis for secondary outcomes are shown in Table 2. The FI was not a predictor of 90-day readmissions in this study (OR 1.338 per 0.1 point increase, 95% CI .992-1.805 p=0.056). However, FI was a robust predictor of 90-day mortality and return to home/independent living after rehabilitation stay. Patients with a higher FI were at higher risk of 90-day mortality (OR 1.690 per 0.1 point increase, 95% CI 1.263-2.263, p<0.001). Patients with a higher FI were less likely to return to home at the end of follow-up (OR 0.741 per 0.1 point increase, 95% CI 0.581-0.946, p = 0.016).

Figure 4A: Scatterplot and Spearman correlation for Frailty Index and hospital length of stay

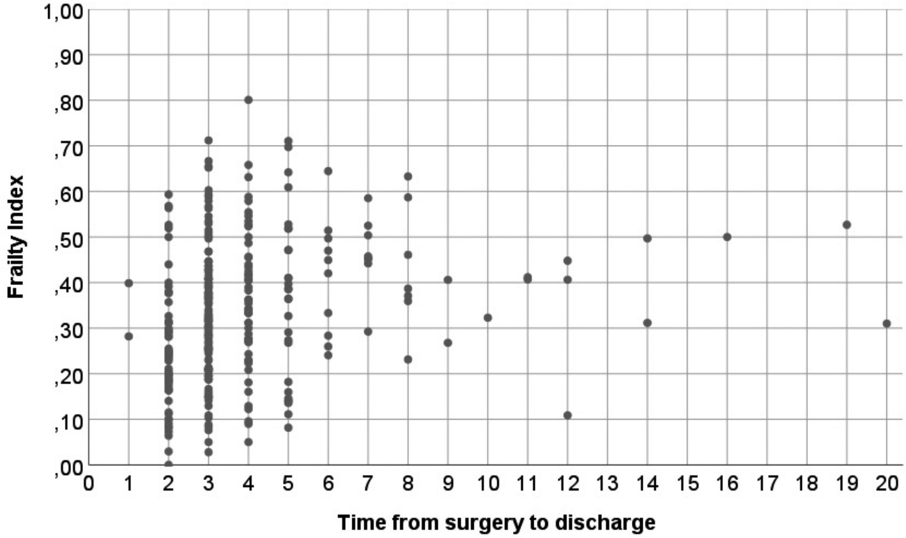


Figure 4B: Scatterplot and Spearman correlation for Frailty Index and discharge facility length of stay

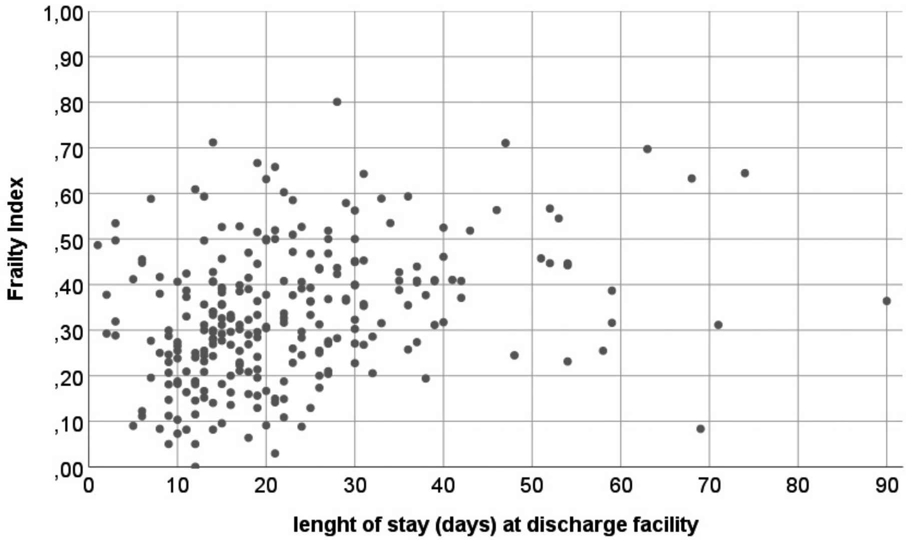


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Table 2: Multivariable logistics regression analysis of predictors of discharge disposition

Predicted outcome	**Adjusted odds ratio of the frailty index (per 0.1 point increase)**	**95% confidence interval of adjusted odds ratio of the frailty index (per 0.1 point increase)**	***p*-value**
Discharge to skilled nursing facility	1.440	1.185-1.751	<0.001
90-day hospital readmissions	1.338	0.992-1.805	0.056
90-day mortality	1.690	1.263-2.263	<0.001
Return to home after rehabilitation*	0.741	0.581-0.946	0.016

*at the end of the follow-up period, deceased patients and patients with an unknown discharge destination from the rehabilitation facility were excluded from this analysis (n=62).

DISCUSSION

As our understanding of elderly fracture patients has evolved it has become clear that frailty is a useful tool in understanding the overall clinical picture and physiologic reserve of geriatric patients. The Rockwood Frailty Index is based on a 0 to 1 point scale and has been validated to measure frailty. It is not meant to be categorized, but Rockwood et al. present an empirical cut-off of 0.25 for frailty. In a study comparing the FI to the frailty phenotype, they describe a “robust” patient group to have a median FI of 0.12, “pre-frail” patients to have a median FI of 0.33 and “frail” patients to have a median FI of 0.44.[9,19] In this study, a higher FI was associated with discharge to a skilled nursing facility, rather than to an inpatient rehabilitation facility or home. No significant difference was found between the median FI of patients discharged home or to an inpatient rehabilitation facility. The authors speculate that this may be due to a small sample size of patients discharged home. Interestingly, extremes in FI occurred frequently of patients who were discharged home. This could indicate that these patients are often either robust or very frail, which merits further investigation.

After correcting for covariates, a higher FI was a robust predictor of discharge to a skilled nursing facility. For each 0.1 point increase in FI, there is a 44% higher chance of discharge to a skilled nursing facility (OR 1.440 per 0.1 point increase in FI, 95% CI 1.185-1.751, $p<0.001$).

This corresponds with two previous studies, in which patients with a higher FI were more likely to have an "unfavorable" discharge destination, defined as discharge to a skilled nursing facility or death.[7,8] These findings suggest that patients who are extremely frailty are often unable to fully participate in the physical and occupational therapy requirements of acute rehabilitation hospitals and may not be able to fully benefit from this type of environment.

The correlation between the FI and LOS in either the hospital (ρ=0.30) and in the discharge destination (ρ=0.26) found in this study was weak, despite sufficient statistical power. A previous study found a statistical significant, but also low correlation between the FI and hospital LOS (ρ= 0.44).[6] Thus, our null hypothesis assuming a strong correlation (ρ>0.70) between FI and LOS is rejected. It is likely that frailty as captured by the FI alone does not fully account for LOS, and there are likely other factors that have a stronger correlation to this outcome such as prefracture living situation and prefracture ADL dependence.

A higher FI was found to be a robust predictor of 90-day mortality (69% increase in chance per 0.1 point increase in FI) and a lower chance of return to home/independent living (25% less chance to return to home per 0.1 point increase in FI), but it did not predict 90-day readmissions.

There are several modified versions of the FI for geriatric patients with a hip fracture, such as the 19-item FI,[20] 11-item FI,[21,22] 5-item FI,[23] a 15-item trauma-specific FI.[24] All are predictive of mortality, but there is little evidence to suggest that there is a strong relation between these frailty indices and hospital LOS. The trauma-specific FI is predictive of discharge to an "unfavorable" discharge destination, defined as discharge to a skilled nursing facility or death.[24] Although these modified versions of the FI require less items to be collected for each patient, their use remains debatable. It is unclear to what extent they are able to capture the dynamic nature of frailty, and their predictive value for adverse outcomes is insufficiently validated.[20–24] Some have criticized the FI because it requires the collection of 30 or more health deficits and requires calculation.[25] For an experienced geriatrician, collecting the items required to calculate a FI can be done during the comprehensive geriatric assessment and does not necessarily take a long time or add an extensive additional burden on the patient. The authors recommend the use of the unmodified FI, which is more commonly used and thoroughly validated.[6–8,10–13,26]

This study had a few limitations. Only patients with a known FI were included in this study. It is possible that this has led to selection bias. The correlation between the FI and LOS in the hospital and rehabilitation facilities found in this study was weak. LOS is dependent on many factors including discharge policy, but it is possible that mortality was a confounding factor in this study. Patients who died during their stay have a shorter LOS. This may have introduced bias, particularly for rehabilitation facilities, where inpatient mortality was 9%. Another source of selection bias may be the exclusion of patients with no follow-up data available. Patients for whom the discharge destination did not provide follow-up data had a higher FI (n=42, median 0.44). In this study, only short term outcomes were measured, and it remains unclear what the effect of the FI on long term functional outcomes and quality of life is. Additionally, it is likely that the regression analysis for 90-day readmissions was underpowered. There were 6 events per variable for this analysis, which is lower than recommended 10 events per variable, so it is likely that the limited frequency of this outcome prevented us from finding a statistically significant relationship.[27]

The FI can be measured in the emergency department and can be a helpful tool to help clinicians in their medical decision making and management of geriatric patients with hip fractures in an early stage. Patients that are severely frail may not be able to fully recover to their original level of functioning, and are at higher risk for adverse outcomes,[6–8,14–16] because the treatment intensity required to achieve this is too high for them (e.g. inpatient rehabilitation). These patients may benefit more from discharge to a facility where a lower rehabilitation treatment intensity is offered (e.g. skilled nursing facility). This also illustrates the importance of goals of care discussions prior to surgery and the consideration of palliative care, which may or may not include surgery.

Conclusion

The FI can be used to predict discharge destination from both the hospital and rehabilitation facility, as well as 90-day mortality, and return to home/independent living after rehabilitation. In this study, the FI had a statistically significant but weak correlation with LOS in the hospital and in discharge destination. The FI can be used to help guide medical decision making, goals of care discussions, and to help predict which patients may benefit from intensive rehabilitation.

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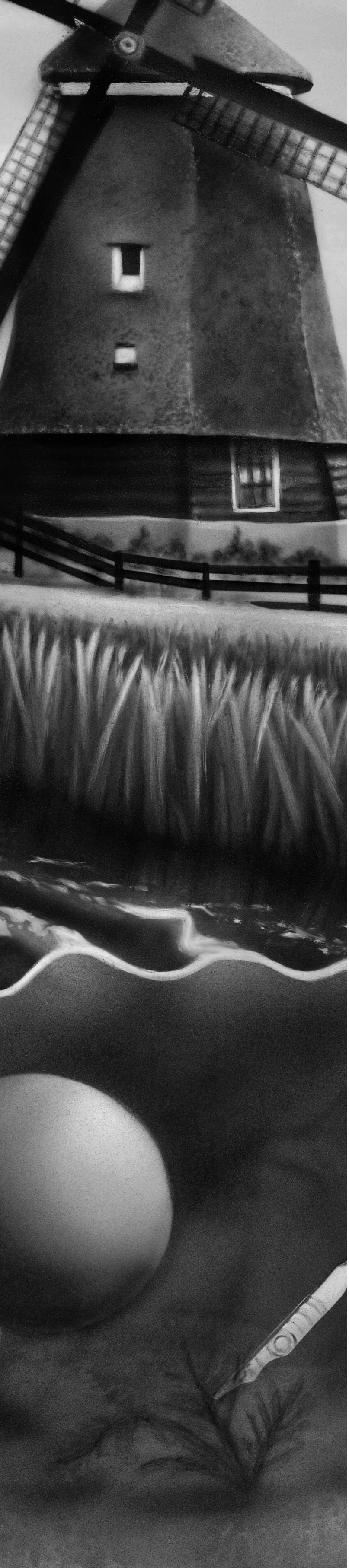

CHAPTER 8

Liver cirrhosis among patients with hip fractures: liver dysfunction dictates prognosis

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ABSTRACT

Background: Liver cirrhosis (LC) is associated with osteoporosis, increased chance of falling and (fragility) fractures. Prognosis of hip fracture (HF) patients, suffering from LC of varying severity at time of injury, is unknown.

Study Questions: (1) Is there an association between LC of varying severity and mortality in HF patients? (2) Is there an association between LC of varying severity and HF related postoperative complications?

Methods: Ninety-nine HF patients with LC at two level 1 trauma centers between 2015 and 2019 were retrospectively included. Ninety-four patients were stratified based on model for end-stage liver disease (MELD) score subgroup ($MELD_{6-9}$, $MELD_{10-19}$, $MELD_{20-40}$) and 99 were stratified based on (de)compensation, both scores displaying LC severity. Primary outcome was 1-year and 2-year mortality. Secondary outcomes were thromboembolic and infectious complications during hospitalization. LC etiologies were not different between MELD- and (de)compensated groups. The primary outcome was assessed by Cox proportional hazard analysis for MELD and (de)compensation classifications and the secondary outcomes by the Fisher exact test.

Results: (1) $MELD_{20-40}$ patients had a higher 1-year (HR, 3.12; 95%CI, 1.52-11.21; p<0.01) and 2-year (HR, 3.65; 95%CI, 1.68-7.93; p<0.01) mortality compared with $MELD_{6-9}$ patients. Decompensated patients had a higher 1-year (HR, 4.39; 95%CI, 2.02-9.54; p<0.01) and 2- year (HR, 3.80; 95%CI 2.02-7.15; p<0.01) mortality compared with compensated patients. The 1-year mortality was 55% for $MELD_{20-40}$ and 53% for decompensated patients as compared with 16% for $MELD_{6-9}$ and 15% for compensated patients. (2) Thromboembolic as well as infectious complications were not different between MELD-subgroups (0%,6%, 3%,p=0.77 and 23%,9%,6%,p=0.19, respectively) nor between (de)compensated patients (2%,9%,p=0.12 and 11%,15%,p=0.75, respectively).

Conclusions: Mortality of HF patients with pre-existent LC is high and related to the degree of cirrhosis and liver function decline, especially signs of decompensation. HF patients with severe/decompensated LC require multidisciplinary, possibly nonoperative management and intensified aftercare.

INTRODUCTION

Background

Liver cirrhosis (LC) represents the end stage of chronic fibrotic liver disease, of which most common causes in developed countries are chronic viral hepatitis, alcoholic liver disease and non-alcoholic fatty liver disease.[1,2] Depending on degree of LC, severe complications may occur, and life expectancy can be reduced.[3] Once serious complications such as variceal hemorrhage, ascites, hepatic encephalopathy, portal hypertension and hepatocellular carcinoma (HCC) occur, patients are considered decompensated.[4–6] Prognosis of decompensated patients is poor, with 1-year survival rates of approximately 60%.[7]

Liver disease patients are prone to develop osteoporosis, increasing the risk of (fragility) fractures.[8,9] Different liver disease related mechanisms, such as disturbances in the vitamin D and insulin-like growth factor metabolism, combined with bilirubin-related osteoblast proliferation inhibition and osteoclast-mediated bone resorption, play a role in the development of osteoporosis.[10] In addition, LC related signs and symptoms such as encephalopathy, alcohol intoxication and neuropathy increase the chance of falling and concomitant (hip) fractures.[11,12] Hip fractures (HF) greatly reduce quality of life and physical function, and are associated with serious mortality in the first year after injury.[13–15] In HF patients above 65-years old, a 1-year mortality rate of approximately 27% is reported.[15] Pre-hospital health conditions (e.g., liver diseases) are associated with short- term absolute excess HF mortality and long-term relative excess HF mortality.[16]

Rationale

The impact of HFs on prognosis in liver disease patients is relatively unknown. One study reports that liver disease in HF patients is associated with increased mortality, and that 30- day and 1-year mortality in all LC patients with HFs approaches 13% and 26%, respectively.[17] However, this study does not specify liver disease severity and therefore does not enable treating physicians to determine HF prognoses based on degree of LC. As this prognosis of may depend on degree of cirrhosis and sequela of liver function decline, the cirrhosis-degree related HF prognosis is yet to be determined. In addition, the impact LC on HF related thromboembolic and infectious complications is unknown.

Study Questions

1) Is there an association between LC of varying severity and mortality in HF patients?
2) Is there an association between LC of varying severity and HF related postoperative complications?

METHODS

Study design and setting

Our institutional review board approved a waiver of consent between January 1st 2015 and January 1st 2019 for this retrospective study at two level 1 trauma centers located in the United States. Date of last follow-up was March 31st 2021.

Participants/study subjects

The Institutional Research Patient Data Registry was queried for corresponding International Classification of Disease 9 & 10 codes for HFs and LC. Patients < 18 years, those with incomplete medical records, fractures other than HF or peri-prosthetic HF, non-cirrhotic liver disease, status post liver transplantation, early-stage fibrotic liver disease and metastatic cancer other than HCC were excluded. Ultimately, 99 HF patients ≥ 18 years with LC at time of injury were included in this study (Figure 1).

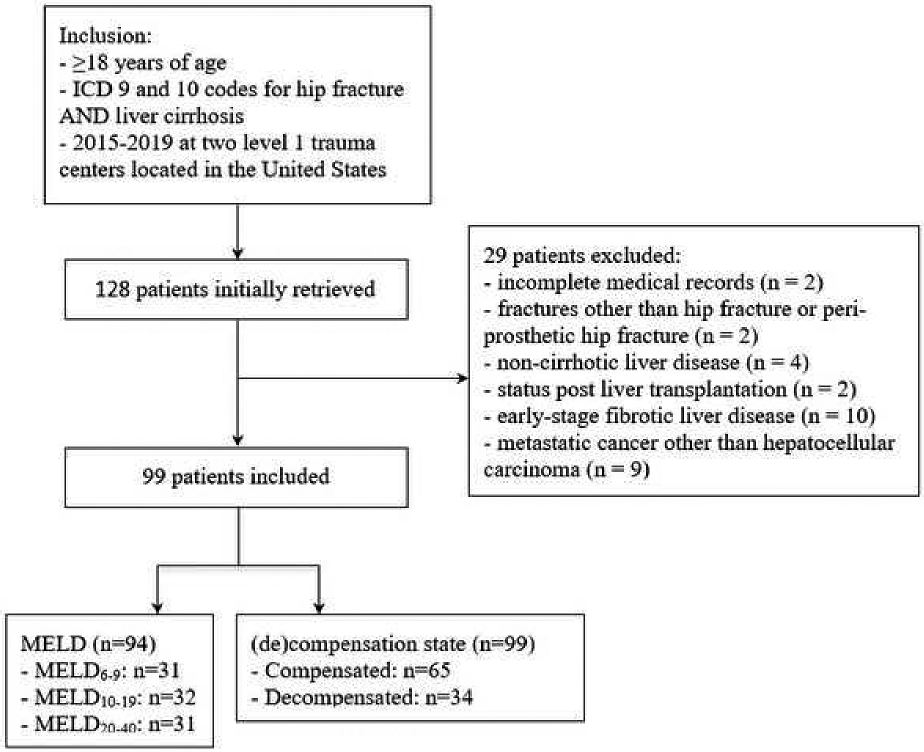
Description of experiment, treatment or surgery

Choice of HF treatment was decided by mutual agreement between the patient and surgeon, based on fracture and other patient characteristics.

Aftercare

During the study period, postoperative care and rehabilitation duration varied depending on the patients' hip fracture characteristics, comorbidities, and rehabilitation potential.

Figure 1. Flow diagram of included patients.



Description of follow up routine

All outpatient encounters were reviewed, in order to determine post-discharge outcomes. Time to follow-up was defined as time between discharge and most recent out-patient visit or reported date of death.

Variables, outcome measures, data sources, and bias

Electronic health records were manually reviewed to obtain all clinical characteristics (Table 1 & 2). The two scores described in detail below display LC severity. Preoperative laboratory values, nearest to surgery with a maximum range of 7 days, included hemoglobin concentration (Hb, mmol/L), platelet concentration (x 10^9/L), prothrombin time (PT), INR, serum albumin (g/dL), total serum bilirubin concentration (mg/dL), serum sodium (mmol/L), serum creatinine (mg/dL) and alkaline phosphatase (IU/L).

Table 1. Characteristics & comorbidities of hip fracture patients at time of admission, stratified according to MELD subclassification (n=94) and (de) compensation state (n=99).*

	MELD $_{6-9}$ (n = 31)	**MELD $_{10-19}$** (n = 32)	**MELD $_{20-40}$** (n = 31)	**p-value**	**Compensated** (n = 65)	**Decompensated** (n = 34)	**p-value**
Age (years)	67 [60 – 75]	66 [60 – 76]	75 [66 – 80]	0.08	69 [62 – 78]	71 [60 – 79]	0.65
Male	23 (3)	50 (16)	71 (22)	**<0.01**	42 (27)	53 (18)	0.30
BMI	24 [21 – 30]	25 [20 – 29]	23 [22 – 28]	0.95	24 [21 – 28]	23 [20 – 29]	0.89
ASA-classification				**<0.01**	**0.02**		
2	39 (12)	6 (2)	0 (0)		20 (13)	0 (0)	
3	52 (16)	75 (24)	77 (24)		66 (43)	76 (26)	
4	10 (3)	19 (6)	23 (7)		14 (9)	24 (8)	
Hip fracture type				0.16	0.47		
Femoral neck	52 (16)	41 (13)	65 (20)		52 (34)	56 (19)	
Pertrochanteric	39 (12)	41 (13)	29 (9)		34 (22)	38 (13)	
Subtrochanteric	6 (2)	16 (5)	6 (2)		12 (8)	3 (1)	
Periprosthetic	3 (1)	3 (1)	0 (0)		2 (1)	3 (1)	
Anti-coagulation use	10 (3)	31 (10)	39 (12)	**0.03**	25 (16)	29 (10)	0.64
Anti-platelet use	26 (8)	25 (8)	35 (11)	0.66	35 (23)	21 (7)	0.17
Laboratory values							
Hb (mmol/L)	6.9 [6.0 – 7.8]	6.7 [5.8 – 8.0]	6.9 [5.8 – 7.6]	0.76	7.0 [6.0 – 8.0]	6.7 [5.6 – 7.2]	0.11
Platelets (x 10^9/L)	166 [111 – 236]	121 [78 – 184]	142 [90 – 181]	0.21	156 [92 – 202]	124 [92 – 190]	0.49
PT	14.2 [13.6 – 15.0]	15.6 [15.0 – 18.3]	16.1 [14.7 – 23.5]	**<0.01**	15.1 [13.9 – 16.4]	15.4 [14.4 – 17.3]	0.34
INR	1.1 [1.1 – 1.2]	1.3 [1.2 – 1.6]	1.3 [1.2 – 2.2]	**<0.01**	1.2 [1.1 – 1.3]	1.2 [1.1 – 1.4]	0.57
Albumin, serum (g/dL)	3.7 [3.2 – 4.0]	3.5 [3.1 – 3.9]	3.3 [2.9 – 3.7]	**0.04**	3.7 [3.3 – 4.0]	3.2 [2.9 – 3.5]	**<0.01**
Bilirubin, total (mg/dL)	0.5 [0.3 – 0.7]	1.3 [0.7 – 1.65]	1.0 [0.6 – 2.3]	**<0.01**	0.7 [0.5 – 1.4]	1.2 [0.6 – 2.2]	**0.04**
Sodium (mmol/L)	140 [137 – 141]	138 [135 – 142]	136 [131 – 138]	**<0.01**	138 [136 – 141]	137 [132 – 141]	0.08
Creatinine (mg/dL)	0.76 [0.58 – 0.96]	1.13 [0.74 – 1.34]	1.42 [0.79 – 2.65]	**<0.01**	0.85 [0.63 – 1.22]	1.17 [0.81 – 1.42]	0.13
Alkaline phosphatase	122 [95 – 196]	137 [89 – 173]	132 [103 – 199]	0.56	126 [92 – 165]	152 [112 – 238]	**0.03**
Liver cirrhosis etiology				0.23	0.12		
Alcoholic	55 (17)	34 (11)	35 (11)		37 (24)	47 (16)	

Table 1. (Continued)

	MELD $_{6-9}$ (n = 31)	**MELD $_{10-19}$** (n = 32)	**MELD $_{20-40}$** (n = 31)	**p-value**	**Compensated** (n = 65)	**Decompensated** (n = 34)	**p-value**
Chronic hepatitis	10 (3)	23 (7)	19 (6)		15 (10)	8 (6)	
Primary biliary	13 (4)	13 (4)	16 (5)		17 (11)	6 (2)	
NAFLD	6 (2)	13 (4)	10 (3)		12 (8)	6 (2)	
Unspecified	3 (1)	13 (4)	6 (2)		12 (8)	6 (2)	
Cardiac	0 (0)	6 (2)	10 (3)		3 (2)	9 (3)	
Cryptogenic	6 (2)	0 (0)	3 (1)		0 (0)	9 (3)	
Other	6 (2)	0 (0)	0 (0)		3 (2)	0 (0)	
History of alcohol abuse	65 (20)	53 (17)	55 (17)	0.65	54 (35)	62 (21)	0.53
Child-Pugh (points)	5 [5 – 7]	7 [5 – 8]	8 [7 – 9]	**<0.01**	5 [5 – 7]	9 [8 – 10]	**<0.01**
MELD score	8 [7 – 8]	14 [11 – 16]	22 [22 – 25]	**<0.01**	12 [8 – 17]	21 [10 – 22]	**0.01**
Decompensated	23 (7)	28 (9)	58 (18)	**<0.01**	-	-	**-**
Ascites				**0.01**	**<0.01**		
Minor	13 (4)	22 (7)	26 (8)		8 (5)	41 (14)	
Moderate	16 (5)	13 (4)	35 (11)		0 (0)	59 (20)	
Encephalopathy	16 (5)	28 (9)	45 (14)	**0.04**	9 (6)	65 (22)	**<0.01**
Varices	10 (3)	38 (12)	48 (15)	**<0.01**	15 (10)	65 (22)	**<0.01**
Primary liver cancer	3 (1)	0 (0)	35 (11)	**<0.01**	8 (5)	21 (7)	0.10
Diabetes	39 (12)	56 (18)	61 (19)	0.19	51 (33)	53 (18)	0.99
Atrial fibrillation	23 (7)	28 (9)	45 (14)	0.15	32 (21)	29 (10)	0.82
CHF	16 (5)	34 (11)	35 (11)	0.18	29 (19)	29 (10)	0.99
COPD	29 (29)	25 (8)	26 (8)	0.96	34 (22)	15 (5)	0.06
Osteoporosis	48 (15)	34 (11)	42 (13)	0.55	43 (28)	38 (13)	0.67
Kidney failure	16 (5)	31 (10)	61 (19)	**<0.01**	29 (19)	47 (16)	0.12

Data are presented as the % (number) or the median [IQR: 25th – 75th percentile]. MELD, Model for End-Stage Liver Disease; BMI, Body Mass Index; Hb, hemoglobin; NAFLD, non-alcoholic fatty liver disease; PT, prothrombin time; INR, international normalized ratio; ASA, American society of anesthesiologists; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disorder. **Bold** indicates significance of p<0.05.
*Five patients did not have all parameters available in order to determine MELD scores and were therefore excluded in the MELD analyses

Liver cirrhosis severity

LC patients were stratified by disease severity utilizing the Model for End-Stage Liver Disease (MELD)-score, a well-known prognostic score for LC patients based on liver dysfunction severity.[18] This score combines four laboratory parameters (serum creatinine (mg/dL), total serum bilirubin (mg/dL), international normalized ratio (INR), serum sodium (mmol/L)), and is considered to be a more accurate predictor of prognosis in LC patients compared to the Child-Pugh score.[19–21] The use of MELD-scores eliminates the use of physician related parameters noted in the patients' record. After calculating MELD-scores (minimum=6,maximum=40) using laboratory parameters upon admission, scores were stratified as an ordinal explanatory variable, using a subclassification described in literature.[22] MELD-scores ranging from 6-9 ($MELD_{6-9}$) were considered 'mild' LC severity, scores ranging from 10-19 ($MELD_{10-19}$) were considered 'moderate' LC severity, and scores 20-40 ($MELD_{20-40}$) were considered 'severe' LC.

Initial MELD(i) score: $10 \times (0.957 \times \ln(\text{creatinine}) + 0.378 \times \ln(\text{bilirubin}) + 1.120 \times \ln(\text{INR}) + 0.643$
If MELD(i) score>11, an additional calculation was performed accounting for serum sodium: MELD score: $\text{MELD(i)} + 1.32 \times (137 - \text{sodium}) - 0.033 \times \text{MELD(i)} \times (137 - \text{sodium})$.

Decompensated and compensated state

In addition to MELD-scores, stratification based on physical signs of decompensation was performed using the Baveno clinical staging criteria.[23,24] Decompensation is associated with high mortality rates.[4–7]Patients without a history of variceal bleeding or ascites up to 1-year prior to and during admission were defined as compensated. Those with a history of variceal bleeding were defined as decompensated. Patients with ascites present during, or a year prior to, admission were classified as decompensated if the amount of ascites described in their records was considered moderate to severe. If ascites present was noted to be minor, patients were defined as decompensated if they had concomitant hepatic encephalopathy or esophageal varices present. Two reviewers (DH&HS) assigned decompensated and compensated states based on the above criteria and discussed any uncertainties with a senior traumatologist (MH).

Outcomes

Primary outcome measures were 1-year and 2-year mortality after surgery by any cause. Date of death was determined using the Social Security Index and reviewing medical records. Loss to follow-up was 0 within 1-year and 4.0% (4/99) at 2-years. The median follow-up was 750 (IQR 232-1000) days. Secondary outcomes were in-hospital thromboembolic and infectious complications. Thromboembolic complications were defined as symptomatic deep venous thromboembolisms and pulmonary embolisms diagnosed during hospital stay. Infectious complications were defined as all infections diagnosed during hospital stay requiring antibiotics and/or surgical treatment. All complications were extracted from the medical charts while blinded for predictors by different extraction sheets.

Demographics, description of study population

In total, 128 patients were identified according to corresponding ICD codes for HFs and LC. Twenty-nine patients were excluded. In total, 99 patients were included, of which 94 had all necessary laboratory parameters available for MELD-subgroup analysis (Figure 1). Median age at time of injury was 69 (IQR, 62–78) years and 54% (54/94) were female. Most common HF type and treatment modality were femoral neck fractures in 54% (53/99) and trochanteric femur nails in 35% (35/99). Most frequent LC etiology was alcoholic in 40% (40/99;). Baseline characteristics are displayed according to the MELD-subclassification and (de)compensation (Table 1).

In total, 95% (94/99) of patients were stratified according to MELD-score subclassification as five patients had missing laboratory values. MELD subclassifications consisted of 33% (31/94) in $MELD_{6-9}$, 34% (32/94) in $MELD_{10-19}$, and 33% (31/94) in $MELD_{20-40}$ subgroups.

$MELD_{20-40}$ consisted of more men (71%) compared to the other groups (23%;50%,p <0.01). Comorbidities between MELD-groups were comparable, with the exception of primary liver cancer (3%;0%;35%,p<0.01) and kidney failure (16%;31%;61%,p<0.01) being more common as MELD-scores increased. This could be expected as the MELD-classification allocates extra points for HCC presence, and incorporates serum creatinine concentrations in the calculation (Table 2). All 99 patients were stratified according to a (de)compensated state.

Of these, 66% (65/99) were compensated and the other 34% (34/99) patients were decompensated (Table 1).

Table 2. Clinical and treatment related outcomes of hip fracture patients, stratified according to MELD subclassification (n=94) and (de)compensation state (n=99).*

	MELD $_{6-9}$ (n = 31)	**MELD $_{10-19}$** (n = 32)	**MELD $_{20-40}$** (n = 31)	**p-value**	**Compensated** (n = 65)	**Decompensated** (n = 34)	**p-value**
Time from presentation to surgery (days)	1 [1 – 2]	1 [0 – 3]	2 [1 – 3]	0.62	1 [1 – 3]	1 [1 – 2]	0.78
Medicine / Geriatrics consultation	77 (23)	84 (27)	97 (29)	0.08	84 (53)	88 (30)	0.77
Hip fracture treatment				0.86			0.28
TFN	32 (10)	44 (14)	23 (7)		37 (24)	24 (8)	
HA	23 (7)	19 (6)	35 (11)		28 (18)	21 (7)	
THA	6 (2)	13 (4)	10 (3)		9 (6)	12 (4)	
CCS	23 (7)	9 (3)	13 (4)		15 (10)	15 (5)	
DHS	10 (3)	3 (1)	10 (3)		6 (4)	12 (4)	
NOM	3 (1)	13 (4)	10 (3)		5 (3)	15 (5)	
RA	3 (1)	0 (0)	0 (0)		0 (0)	3 (1)	
Procedural blood loss (ml)	150 [100 – 330]	250 [100 – 400]	100 [75 – 300]	0.30	200 [100 – 300]	200 [100 – 400]	0.47
Operating time (minutes)	76 [48 – 100]	85 [47 – 113]	70 [41 – 118]	0.97	78 [49 – 109]	82 [40 – 112]	0.98
LOS (days)	6 [4 – 12]	7 [4 – 15]	10 [6 – 22]	**0.048**	6 [4 – 15]	7 [6 – 14]	0.35
Hip fracture re-intervention	6 (2)	3 (1)	10 (3)	0.52	6 (4)	9 (3)	0.69
Median survival in days	837 [610 - 1207]	814 [588 – 1006]	325 [91 – 731]	**<0.01**	857 [610 – 1088]	262 [91-744]	**<0.01**

Table 2. (Continued)

	MELD $_{6-9}$ (n = 31)	**MELD $_{10-19}$** (n = 32)	**MELD $_{20-40}$** (n = 31)	**p-value**	**Compensated** (n = 65)	**Decompensated** (n = 34)	**p-value**
Mortality**							
In-hospital	0 (0)	0 (0)	10 (3)	0.07	0 (0)	9 (3)	**0.04**
1-year	16 (5)	16 (5)	55 (17)	**<0.01**	15 (10)	53 (18)	**< 0.01**
2-year	29 (9)	25 (8)	74 (23)	**<0.01**	29 (19)	68 (23)	**< 0.01**
Overall***	45 (14)	44 (14)	84 (26)	**<0.01**	46 (30)	76 (26)	**< 0.01**
Complications							
Thromboembolic	0 (0)	6 (2)	3 (1)	0.77	2 (1)	9 (3)	0.12
Infections	23 (7)	9 (3)	6 (2)	0.19	11 (7)	15 (5)	0.75

Data are presented as the % (number) or the median [IQR: 25th – 75th percentile]. MELD, Model for End-Stage Liver Disease; TFN, trochanteric femur nail; HA, hemi arthroplasty; THA, total hip arthroplasty; CCS, cannulated compression screws; DHS, dynamic hip screw; NOM, non- operative management; RA, resection arthroplasty; LOS, length of stay. The p-values of 1-year, 2-year, and overall mortality were calculated using Cox proportional hazard models. The hazard ratios are provided in Table 3.
Bold indicates significance of $p<0.05$.
* Five patients did not have all parameters available in order to determine MELD scores and were therefore excluded in the MELD analyses.
** Loss to follow-up was 0 for 1-year mortality and 4% (4/99) for 2-year mortality.
*** Up until follow-up moment.

Accounting for all patients / study subjects

No sample size was calculated since all eligible patients between 2015-2019 were included. The MELD-scores for five patients could not be determined due to multiple missing laboratory values. Since multiple (missing) values were necessary in order to calculate MELD-scores for the individual patients, imputation was deemed unreliable. Therefore, for the MELD analyses these 5% (5/99) patients were excluded. All 99 patients were included for the (de)compensated state analysis. All other variables did not contain missing values.

Statistical analysis, study size

Normality was determined by using the Shapiro-Wilk test. Ordinal explanatory variables were assessed using a Spearman's rank correlation for continuous/ordinal outcome variables and the Kruskal-Wallis test for nominal variables. Dichotomous explanatory variables were assessed using the Mann-Whitney U test for non-parametric continuous outcome variables and the Fisher's exact test for dichotomous outcomes. Primary outcomes and secondary outcomes were assessed by Cox proportional hazard analysis and Fisher exact test, respectively. Kaplan-Meier plots demonstrated survival curves for LC severity subgroups. A two-tailed p-value of < 0.05 was considered significant. Data was analyzed using STATA® statistical software (StataCorp 2017. Release 15. College Station, TX: StataCorp LLC.).

RESULTS

In the MELD analyses, in-hospital mortality was not different between groups (0%;0%;10%; p=0.07). $MELD_{20-40}$ patients had a higher 1-year (HR,3.12;95%CI,1.52-11.21;p<0.01) and 2- year (HR,3.65;95%CI1.68-7.93;p<0.01) mortality compared with $MELD_{6-9}$ patients (Table 3). In the (de)compensation analyses, in-hospital mortality was higher in the decompensated group as compared with the compensated group (9%;0%;p=0.04). All in-hospital deaths were related to liver failure. Decompensated patients had a higher 1-year (HR,4.39;95%CI,2.02- 9.54;p<0.01) and 2-year (HR,3.80;95%CI2.02-7.15;p<0.01) mortality compared with compensated patients (Table 3). Additional analyses controlling for age and gender did not change the results (data not shown). As shown in the Kaplan-Meier survival curves, both the $MELD_{20-40}$ patients and decompensated patients rapidly reached ~50% mortality rate in the first year. In comparison, 1-year mortality rate after HF in both the $MELD_{6-9}$, $MELD_{10-19}$, and compensated patients was around 75% (Figure 2).

Figure 2. (Left) Kaplan-Meier survival curve displaying 2-year survival of hip fracture patients with liver cirrhosis stratified according to the Model for End-Stage Liver Disease (MELD) score for liver disfunction; p<0.01. (Right) Kaplan-Meier survival curve displaying 2-year survival of hip fracture patients with liver cirrhosis stratified by (de)compensated state; P<0.01.

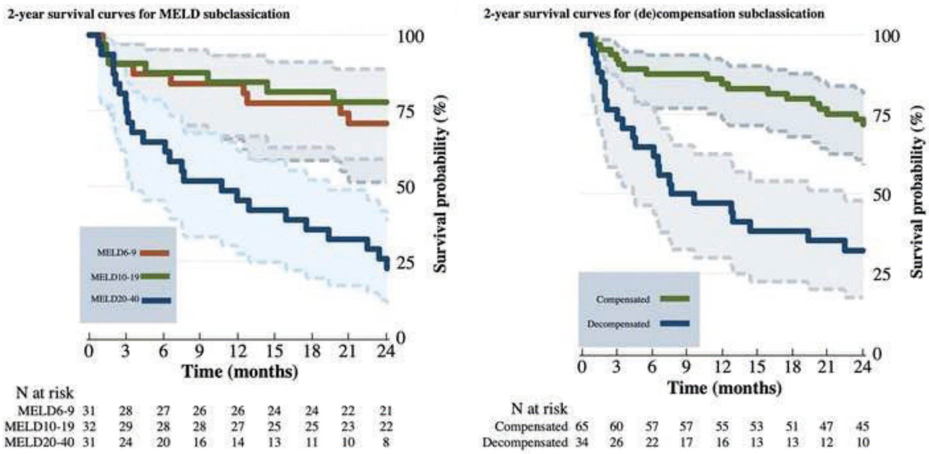


Table 3. Cox proportional hazard analysis for 1-year and 2-year mortality for both MELD (n=94) subclassification and (de)compensation state (n=99).

	1-year			2-year		
Liver scores	***Hazard ratio (95% CI)***	***Standard error***	***p-value***	***Hazard ratio (95% CI)***	***Standard error***	***p-value***
MELD*						
$MELD_{6-9}$	*Reference value*			*Reference value*		
$MELD_{10-19}$	0.96 (0.28-3.32)	0.607	0.95	0.75 (0.28-2.01)	0.377	0.95
$MELD_{20-40}$	3.12 (1.52-11.21)	2.104	**<0.01**	3.65 (1.68-7.93)	1.446	**<0.01**
(de)Compensation state**						
Compensation	*Reference value*			*Reference value*		
Decompensation	4.39 (2.02-9.54)	1.738	**<0.01**	3.80 (2.02-7.15)	1.226	**<0.01**

CI, confidence interval; MELD, Model for End-Stage Liver Disease. **Bold** indicates statistical significance (p<0.05). * Loss to follow-up was 0 at 1-year and 1.0% (1/94) for $MELD_{6-9}$, 3.0% (3.94) for $MELD_{10-19}$, and 0 for $MELD_{20-40}$ at 2-year. ** Loss to follow-up was 0 at 1-year and 3.0% (3/99) for compensated and 1.0% (1/99) for decompensated at 2-year.

In the MELD analyses, thromboembolic (0%;6%;3%;p=0.77) and infectious complications (23%;9%;6%;p=0.19) were not different between all three groups. In the (de)compensation analyses, no differences were found in both thromboembolic (2%;9%;p=0.12) and infectious complications (11%;15%;p=0.75) between compensated and decompensated patients (Table 2). Post-hoc power analyses demonstrated that with an alpha level at 0.05 our power was less than 50% to find a difference in both MELD and (de) compensation analyses.

DISCUSSION

Background and rationale

LC may lead to the development of osteoporosis, increasing the risk of (fragility) fractures.[8,9] Signs and symptoms associated with LC, such as encephalopathy, alcohol intoxication and neuropathy increase the chance of falling and HFs.[11,12] HFs are associated with serious mortality in the first years after injury, and the presence of comorbidities before hospital admission are associated with short- and long-term excess mortalit.[13,14,16,25] The impact of LC on the prognosis of HF patients is relatively unknown. This study shows that prognosis of LC patients that sustained HFs depends on LC severity. Considering patients with the most severe liver function decline ($MELD_{20-40}$), 1-year mortality of 55% and 2-year mortality rates of 74% were found. In contrast, patients with LC of mild ($MELD_{6-9}$) or moderate ($MELD_{10-19}$) severity had 1- and 2-year mortality rates of approximately 16% and 26%.

Limitations

This study has several limitations. First, this was a retrospective study, potentially leading to excluded HF patients that had undiagnosed LC upon admission (detection bias). Second, although we accounted for age and male sex in additional analyses, including other confounding variables into multivariate analyses was limited by our sample size as this would lead to overcorrection. In addition, there may have been unidentified covariables related to unidentified comorbidities which may have resulted in mortality differences. As LC severity is largely based on laboratory parameters, separately entering laboratory parameters in a multivariable analysis would result in overcorrecting for LC severity. Also, other variables that were different between the groups such as varices, encephalopathy, and anti-coagulation use are considered surrogates for LC severity. Although our results are not controlled for various confounding factors, we believe that the observed higher mortality rate in LC patients is justifiable. Third, the exclusion of patients with metastasized cancers other that HCC may have led to better reported prognoses. Alcohol abuse, one of the most common causes for LC, may have played a role in the occurrence of these metastasized cancers. As these metastasized cancers are prevalent among the LC patient's population with HFs, actual prognoses may be worse than those reported in this study. This further emphasizes the need for careful consideration of the patients and goals of care. Future larger studies should include more patients to control for confounding factors to elucidate the real effect of LC on mortality and reach power to detect any differences – if present – in complications.

Nevertheless, the current study bypasses prior work by providing a detailed description of LC severity, and by the use of the objective MELD score, providing treating physicians a tool for determining the individual's HF prognosis in patients suffering from LC. This study indicates that the consequences of LC severity influences survival outcomes in patients who undergo surgical treatment for HF.

1. *Is there an association between LC of varying severity and mortality in HF patients?*

This study highlights the poor prognosis of patients with advanced/decompensated LC who sustained HFs, compared to those with milder disease severity. No differences regarding HF types or surgical treatment modalities were found, although prognoses of those with advanced/decompensated LC were remarkably worse. This does raise the question if LC patients with varying disease severity require the same (surgical) HF treatment, and if treatment should focus on return to pre-injury level of daily life functioning or should focus on (palliative) pain reduction and quality of life.

The relatively low in-hospital, 1- and 2-year mortality rates among $MELD_{6\text{-}9}$, $MELD_{10\text{-}19}$ and all compensated LC patients justifies regular HF treatment, and should have minor influence on determining the appropriate course of treatment. Considering the relatively good prognosis of these patients, comparable to the described 27% 1-year mortality rate for all HF patients (>65 years old), treatment should focus on functional outcomes and mobilization.[15] Future research should determine the walking ability of these patients, and how signs and symptoms of LC may impair this ability.

Considering those with advanced/decompensated disease, other treatment-related considerations may be appropriate. It may be more prudent that treatment of advanced LC patients should focus on pain reduction (by adequate analgesia or operative treatment) and quality of life, rather than seeking functional outcomes, based on their poor prognosis and unknown walking ability. However, it must be noted that choice of treatment in these patients may depend on individual characteristics such as presence of primary liver cancer, liver

transplantation candidacy, comorbidities, HF type, patient preference and expected walking ability. This may lead to considerable heterogeneity among advanced LC patients. In addition to surgical treatment consideration, determining appropriate analgesic regimens is based on individual characteristics as well. Based on the degree of liver- and renal function decline, fewer analgesia options remain and dosages are generally reduced, posing multiple challenges for treating physicians. Although no evidence-based guidelines on peri-operative pain reduction in LC patients exists, available literature suggests a multi-disciplinary approach focusing on the individual patient, and taking nutritional status, renal function, and liver transplant candidacy into account. [26–28]

Determining an individual's prognosis and course of treatment among HF patients can be based on shared decision making and multidisciplinary care. This study seeks to begin the groundwork of determining the best individual course of operative or non-operative treatment in these vulnerable patients through understanding the prognosis of this population. We speculate that this study is the first important step in providing this complex category of patients the care that is tailored to their situation.

Future studies should determine the level of physical activity and adverse events during mobilization of all LC subgroups after sustaining HFs, as controversy regarding the benefits of physical activity and exercise in patients with advanced/decompensated LC remains.[29,30] Theoretically, increased portal pressure during physical activity could result in variceal bleeding and lead to worse outcomes.[29] In addition to prognoses described in this study, gaining insight into the potential walking ability of LC patients that sustained HFs, and the presence and management of post-operative pain would be helpful when determining the optimal course of treatment and post-operative care.

2. *Is there an association between LC of varying severity and HF related postoperative complications?*

No significant differences regarding thromboembolic or infectious complications were observed between (de)compensated LC patients and MELD-subclassifications, and overall thromboembolic complication rates were relatively low. Several studies have raised concerns regarding an increased risk of (venous)thromboembolic complications in hospitalized LC patients. A systematic review reports that (venous) thromboembolic prophylaxis should be individualized to the individual patient in this complex population, as bleeding tendencies may be variable.[31] Due to the low number of observed thromboembolic complications among the HF population with LC, we were unable to identify subgroups at risk for thromboembolic complications. Regarding infectious complications among hospitalized LC patients, literature states that physicians should have a high degree of suspicion that LC patient may develop infections.[32] In accordance with this statement, we found that 12% of all patients developed infections during hospitalization, which was independent of LC degree. Treating physicians should be vigilant in order to prevent further deterioration in liver function, based on peri-operative infections in this vulnerable patient group.

Conclusions

This study shows that mortality of HF patients suffering from LC is high and is related to the degree of cirrhosis and liver function decline. In addition, 1- and 2-year mortality rates of patients with lower degrees of LC appear to be relatively good. Choice of HF treatment modality in LC patients may depend on LC related prognosis. We recommend that those with minor to moderate LC severity should receive usual care. Patients with severe LC and those with decompensated disease may require patient-tailored, possibly nonoperative management and intensified aftercare.

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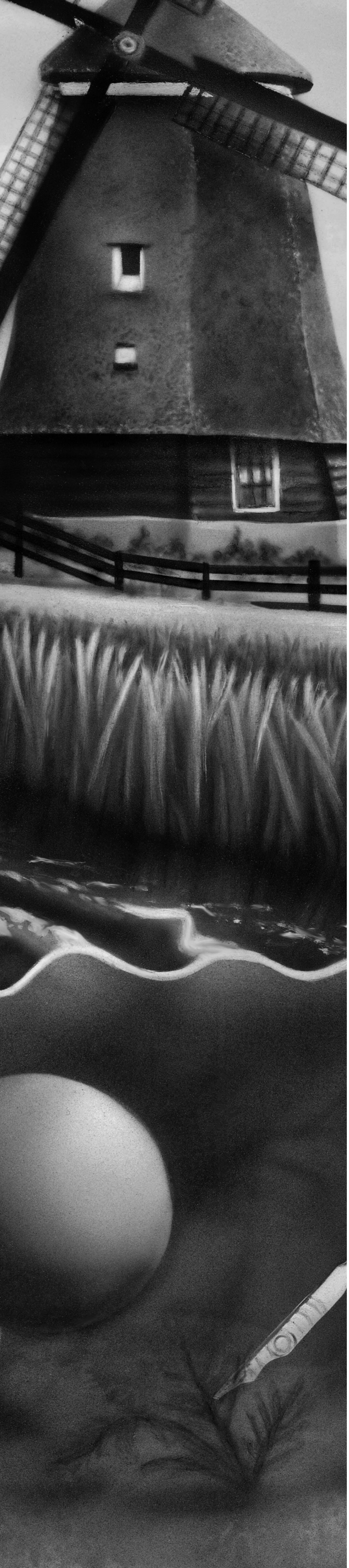

CHAPTER 9

Orthogeriatric trauma unit improves patient outcomes in geriatric hip fracture patients

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ABSTRACT

Introduction: An aging population in developed countries has increased the number of osteoporotic hip fractures and will continue to grow over the next decades. Previous studies have investigated the effect of integrated orthogeriatric trauma units and care models on outcomes of hip fracture patients. Although all orthogeriatric care models mentioned above perform better than usual care, there is no conclusive evidence which care model is superior. More confirmative studies reporting the efficacy of orthogeriatric trauma units are needed. The objective of this study was to evaluate outcomes of hip fracture patients admitted to the hospital before and after implementation of an orthogeriatric trauma unit.

Materials and methods: This retrospective cohort study was conducted at a level 2 trauma center between 2016 and 2018. Patients aged 70 years or older with a hip fracture undergoing surgery were included to evaluate the implementation of an orthogeriatric trauma unit. The main outcomes were postoperative complications, patient mortality, time spent at the emergency department, time to surgery, and hospital length of stay.

Results: A total of 806 patients were included. After implementation of the orthogeriatric trauma unit, there was a significant decrease in postoperative complications (42% vs. 49% in the historical cohort, $p = 0.034$), and turnaround time at the emergency department was reduced by 38 minutes. Additionally, there was significantly less missing data after implementation of the orthogeriatric trauma unit. After correcting for covariates, patients in the orthogeriatric trauma unit cohort had a lower chance of complications (OR 0.654, 95% CI 0.471-0.908, $p = 0.011$) and a lower chance of one-year mortality (OR 0.656, 95% CI 0.450-0.957, $p = 0.029$).

Conclusions: This study showed that implementation of an orthogeriatric trauma unit leads to a decrease in postoperative complications, one-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, three models of orthogeriatric trauma care are described:

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

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

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

MATERIALS AND METHODS

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

The complete care pathway and the interventions of the orthogeriatric trauma unit are shown in Supplemental figure 1. Hip fracture patients are admitted from the ED to the orthogeriatric trauma unit within one 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)[12], prefracture living situation (i.e., independent at home, at home with assistance for activities of daily living, institutional care facility, or nursing home), type of fracture (i.e., medial femoral neck, trochanteric femur or subtrochanteric femur), and type of surgical procedure (i.e., hemiarthroplasty, cannulated hip screw, dynamic hip screw, intramedullary nail, or conservative treatment).

The primary outcome of this study was postoperative complications. A complicated course was defined as one or more of the following complications according to the Dutch Hip Fracture Audit guidelines: congestive heart failure (confirmed by chest radiograph), pressure ulcer (diagnosed by attending physician), delirium (diagnosed by either geriatrician or physician assistant of the consultative orthogeriatric trauma team), pulmonary embolism (CTA-confirmed), deep venous thrombosis (duplex ultrasound confirmed), renal insufficiency (>24ml/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 one year. Mortality data were acquired by consulting the municipal citizen registry.

Statistical methods

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

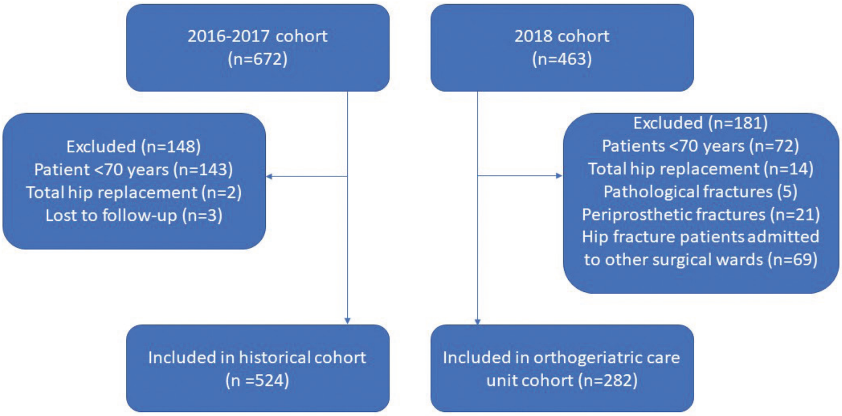
Differences between patients who were admitted before and after the implementation of the orthogeriatric trauma unit were analyzed using descriptive statistics. Continuous variables were tested for differences between groups with an unpaired t-test or Mann-Whitney U test, depending on normality. Normality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

Figure 1: Patient flow chart



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 two cohorts at baseline in terms of living situation, fracture type or surgical procedure.

Table 1: Baseline characteristics

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

Statistically significant differences are shown in bold. *Mann Whitney U Test was performed for variables with a non-normal distribution at the p<0.001 level (Shapiro-Wilk test).

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 2: Patient outcomes before and after implementation of the orthogeriatric trauma unit, univariable analysis

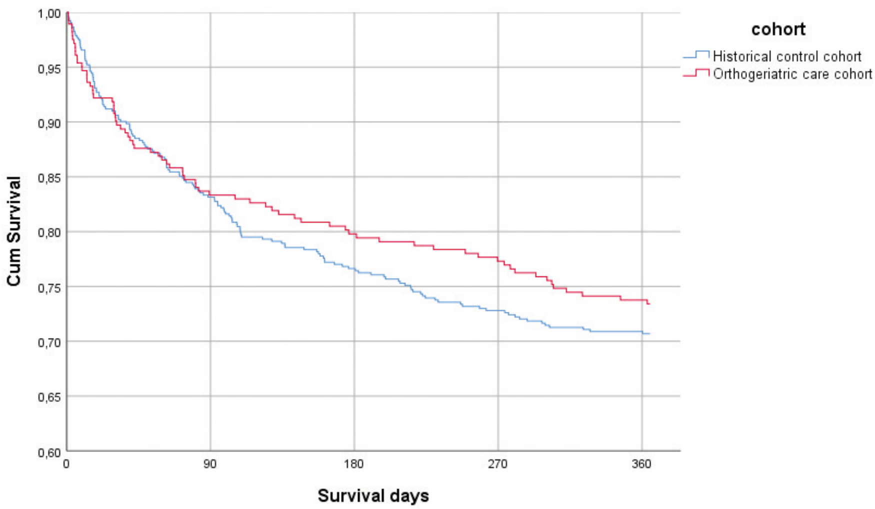
	Missing n (%)	Orthogeriatric care unit cohort (n=282)	Historical cohort (n=524)	*p*-value	Relative reduction**
Complication during admission; n (%)	3 (0)	117 (42)	257 (49)	**0.034**	**14%**
Time spent at the ED in minutes; median (IQR)	54 (7)	160 (110-228)	198 (142-257)	**<0.001***	**19%**
Time to surgery 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	
One-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

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

Figure 2: Kaplan Meijer analysis. survival functions between the three cohorts (log-rank test p=0.428)



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 one-year mortality (OR 0.656, 95% CI 0.450-0.957, $p = 0.029$).

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
One-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

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

Interpretation of results

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

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

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

Strengths and limitations

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

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

Conclusion

In conclusion, this study showed that implementation of an orthogeriatric trauma unit led to a decrease in postoperative complications, one-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 uni.

Pre-operative care

Emergency department

1.Early radiological diagnosis: X-ray hip and chest X-ray, CT head in case of possible head injury
2.Preoperative investigations: ECG, sodium, potassium, ureum, glomerular filtration rate (GFR), glucose, lactate dehydrogenase, liver enzymes, full blood count, coagulation profile, renal function, type & screen, urine testing and microscopic exam
3.Comprehensive clinical assessment by a resident dpt. of surgery: for other injuries or comorbidities, Parker Mobility Score, assessment and documentation of cognitive baseline function
4.Appropriate pain management: according to the World Health Organization (WHO) pain ladder
5.Antibiotic prophylaxis
6.Venous thromboembolism prophylaxis, fluid resuscitation
7.Medication review by an assistant pharmacist
8.Contact between the orthogeriatric team and anesthetists to plan for surgery within 24 h of admission
9.Placement of indwelling catheter, if necessary
10.Transfer to orthogeriatric ward within 60 minutes
11.Preoperative screening by an anesthetist

Orthogeriatric trauma unit

1. Comprehensive geriatric assessment by a geriatrician
2. Consultation by a physiotherapist and dietician
3. Monitoring vital parameters, fluid and food intake, visual analogue scale three times a day

Post-operative care

Orthogeriatric trauma unit

1.Daily visit of the trauma surgeon and geriatrician
2.Wound assessment and care
3.Pain management based on assessments of pain levels according to the VAS
4.Correction of post-operative anemia: local transfusion protocol
5.Attention to pressure sores, nutritional status and renal function, regulation of bowel and bladder function
6.Assessment of hip X-ray after surgery
7.Early removal of indwelling catheter, preferably <24 h after surgery
8.Monitoring blood results until baseline levels have regained
9.Early postoperative weight-bearing and mobilization
10.Fall assessment and osteoporosis screening
11.antibiotic prophylaxis continued according to surgeon's protocol
12.delirium screening and prevention

Discharge planning

Orthogeriatric trauma unit

1.Multidisciplinary assessment of a patients' needs based on health, functional, and social needs by a dedicated care mediator
2.Short lines of communication with rehabilitation clinics and medical and social services
3.Start fall prevention treatment
4.Notify a patients' general practitioner of medical needs
5.Follow-up after 1-2 months with a control hip X-ray

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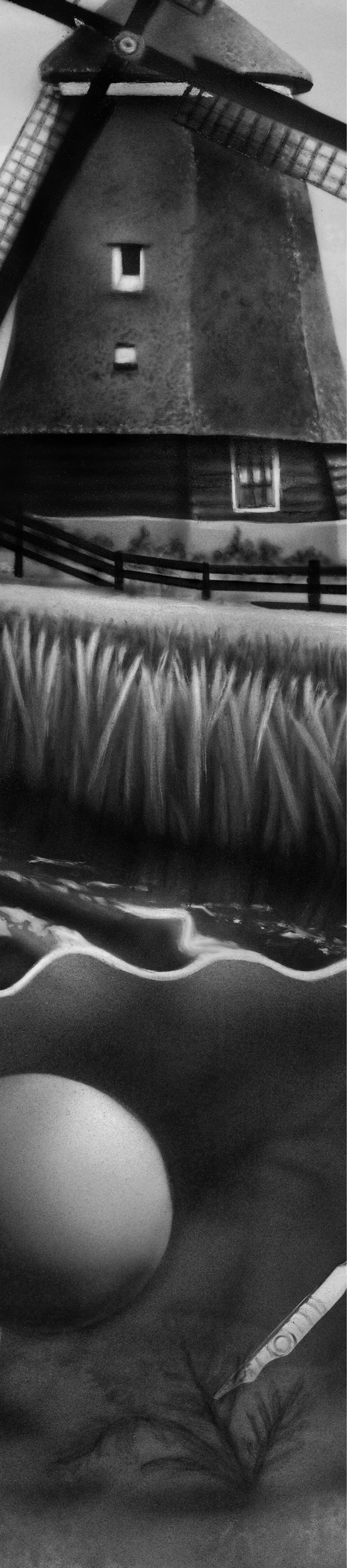

CHAPTER 10

Study quality and cognitive impairment in geriatric orthopedic trauma research; a scoping review

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Submitted

ABSTRACT

Background: Study quality in the field of geriatric traumatology is highly variable. Given the high prevalence of cognitive impairment in this patient population, it is hard to generalize results to all geriatric patients without including these subjects.

Objectives: The primary objective of this study is to evaluate the quality of evidence published in geriatric traumatology and to evaluate the differences between prospective cohort studies and randomized clinical trials. The secondary objective is to investigate how many studies include patients with cognitive impairment, and which methods are used to determine cognitive impairment.

Methods: A search was conducted in PubMed for all publications in 154 selected journals. Clinical studies investigating patients aged 65 years and above with fractures in the appendicular skeleton or pelvis were included. The principal approach to data synthesis was a narrative review. A comparative analysis was performed for prospective cohort studies and RCT's. Limitations of this review include a restriction in year of publication, and no risk of bias assessment across studies.

Results: A total of 2711 publications were screened for eligibility, after exclusion a total of 723 papers were included. Most papers were retrospective cohort studies (n = 505, 70%), while (n =130, 18%) were prospective cohort studies, and only (n =57, 8%) were randomized clinical trials. Patients with cognitive impairment are selectively excluded from clinical studies, and no consensus exists on how cognitive impairment is diagnosed.

Conclusions: The overall quality of studies in this field is poor, with a focus on retrospective studies that investigate mortality and complications. Few prospective studies and RCTs focus on patient reported outcomes and quality of life. Every effort should be made to include patients with cognitive impairment in clinical studies, as they may benefit most from them and selective exclusion of these patients has led to bias across the field of geriatric trauma research.

BACKGROUND

The age group of patients aged 65 or above is growing rapidly worldwide and is expected to continue to grow[1]. This has resulted in a shift in focus for many medical specialties. Geriatric traumatology is a rapidly growing subspecialty within orthopedic trauma surgery and there is an increasing interest for scientific studies in this field. Since the beginning of the 21st century, the number of geriatric orthopedic trauma papers published per year has more than tripled (Figure 1.).

Figure 1. The increase of geriatric trauma publication is the last half century

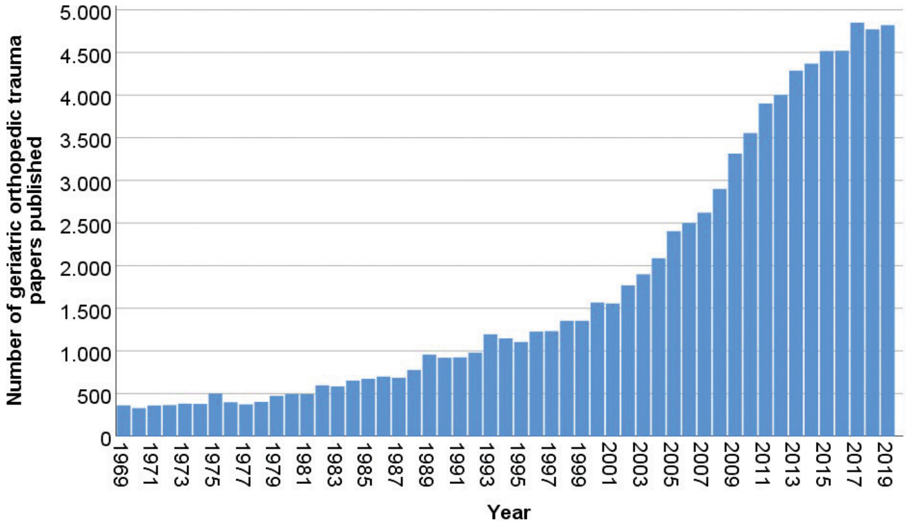

Figure 1 shows the increase of geriatric publications within trauma. This figure was constructed by searching for all trauma publications with the search string that is presented is Supplemental Content 1.

There are several challenges in designing clinical studies that involve geriatric orthopedic trauma patients. First, older patients are more likely to refuse participation in clinical studies[2]. Second, older patient populations are prone to selective loss to follow-up and typically have a high mortality rate following fractures[3–7]. Third, randomization for randomized clinical trials (RCTs) is difficult in trauma research[6,8]. Fourth, patients with cognitive impairment offer additional challenges related to participation in studies both in terms of recruitment and informed consent from a proxy. The ability to collect data, most notably patient reported outcomes, is also more difficult among patients with cognitive impairment. For these reasons, patients with cognitive impairment are often excluded from clinical studies[9].

To gain insight into the quality of the evidence in geriatric orthopedic trauma research, it would be helpful to review recent literature in this field, identify pitfalls, and make recommendations for future studies.
The purposes of this review are as follows:

1. To critically review the overall quality of evidence in this field by investigating study characteristics of geriatric orthopedic trauma publications in terms of journal of publication, study design, region where research is conducted, outcomes studied, and differences between prospective cohort studies and RCTs.
2. To investigate how many prospective cohort studies and RCTs in this field include patients with cognitive impairment and which methods are used in this field to determine cognitive impairment.

The authors conducted a scoping review of all papers published in the last 3 years in selected journals.

METHODS

Protocol registration and adherence with guidelines

In order to evaluate the quality of evidence and assess the scope of literature in the field of orthopedic geriatric trauma, we performed a scoping review. This scoping review was reported in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews guidelines (PRISMA-ScR)[10]. No previously published protocol for this study exists.

Journal selection

All 118 Abridged Index Medicus core clinical journals were included in the search. This is a set of clinical journals covering all specialties relevant to practicing physicians selected by the United States National Library of Medicine (e.g. JAMA, Lancet, NEJM, etc.)[11]. Additionally, 18 journals were selected by reviewing all journals in Web of Science Orthopedics and Emergency Medicine categories[12]. Journals with a focus on sports medicine or pediatrics, journals not in English, and non-indexed journals were excluded. The authors added another 18 journals to the search that they deemed relevant. This resulted in a total of 154 journals included in the search (Figure 2).

Search strategy

A search was conducted in PubMed on February 7th, 2020 for all publications in the selected journals between 01/01/2017 and 12/31/2019 for papers concerning fracture patients aged 65 or above. This restriction in year of publication was applied to get an overview of recent literature and for feasibility, since all articles had to be full-text screened in order to determine eligibility for this review and for data collection. A medical librarian helped with study design, journal selection and the construction of the search string. The search string and journal selection process can be found in Supplemental Digital Content 1.

Article screening for eligibility

Two independent reviewers (BM and AW) performed the full-text screening for all papers. Discrepancies between reviewers were solved by author HS. The inclusion criteria were: 1. Clinical studies (i.e. RCTs, prospective cohort studies including nonrandomized clinical trials, retrospective cohort, cross-sectional, or cohort studies not otherwise specified); 2. Studying fracture patients with a median or mean age of 65 and above; 3. With any fracture in the appendicular skeleton or pelvis.

Exclusion criteria were: 1. Other publication types (i.e. editorials, opinion papers, case reports, non-clinical investigations, cost-effectiveness studies, cadaveric studies, technical trick papers, study protocols, review papers, or errata); 2. A reported mean or median age below 65 years; 3. Non-orthopedic trauma papers or studies investigating non-appendicular fractures (e.g. spine or skull fractures); 4. Age of participants not specified (with the exception of studies that used age of 65 year or above as an inclusion criterion, these were included even if age of the population was not specified); 5. Study population not adequately described; 6. Full text unavailable in English

Data extraction

Data extraction was done by authors HS, BM, AW and LF by reading the full text of all included papers. If a full text was unavailable after consulting a librarian, the abstract was read to collect as much data as possible. The following variables were collected for all included studies using a data extraction sheet: journal of publication, study design (i.e. retrospective cohort, RTC, cross-sectional, etc.), region (i.e. North America, South America, Africa, etc., if research was conducted in multiple regions of the world, the region of the first author was collected), sample size (i.e. number of patients in the study), mean or median age of total included population (taken from paper if possible, if not, the mean was calculated if possible), whether the study included patients with cognitive impairment (for prospective cohort studies and RCTs only), the method of assessment of cognitive impairment (e.g. previous medical history, Confusion Assessment Method (CAM)[13], Mini-mental state examination (MMSE)[14], Abbreviated mental test (AMT)[15], Short Portable Mental Status Questionnaire (SPMSQ)[16], Montreal Cognitive Assessment (MoCA)[17], etc.), the percentage of females in the study (taken from paper if possible, if not, calculated whenever possible), level of evidence (i.e. reported yes/no, and, if reported, what level), and outcomes studied (i.e. mortality/survival, complications, functional outcome measures, patient reported outcome measures (PROMs), quality of life (QoL), etc.).

Data synthesis and statistical analysis

The primary approach to data synthesis was a narrative review of the characteristics of studies in this field in terms of design, evidence, and outcome measures used. A comparative analysis was performed for prospective cohort studies and RCT's in terms of study design, sample size, level of evidence, and outcomes studied, and whether these studies included patients with cognitive impairment. Descriptive statistics were used to report quantitative variables. Normality was tested by examining histograms and/or boxplots. All continuous variables were non-normally distributed and were presented as a median with interquartile range (IQR) and were tested with a Mann-Whitney U test. Qualitative variables were described with numbers and percentages and compared with a Chi-square test. The threshold for significance was be set at 0.05. All analyses were conducted using SPSS statistics for Windows, version 25 (IBM).

RESULTS

Study screening

A total of 2711 publications were screened for eligibility, of which 1988 were excluded (Figure 2). A total of 723 papers were included, with a combined total of 16,690,375 included geriatric fracture patients.

Figure 2. Flow chart for journal & study selection

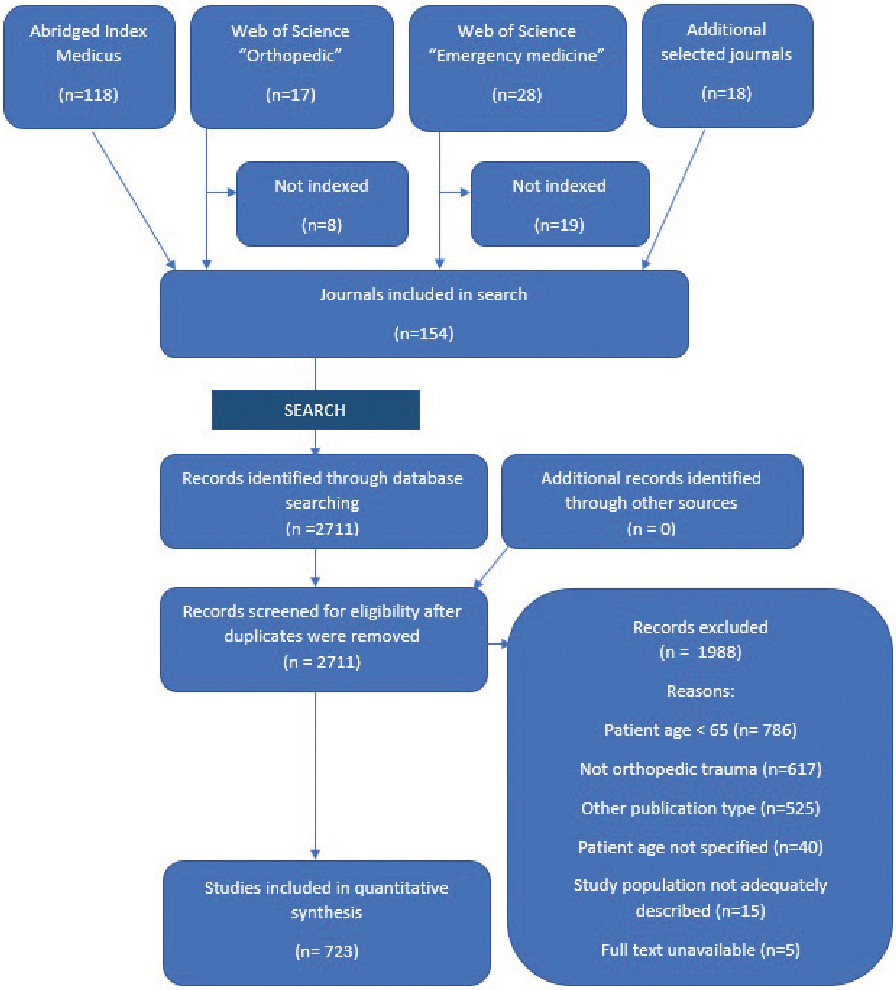

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Figure 2 shows the flow chart noting the selected journals and the numbers of articles identified initially, then the exclusion steps with the numbers left after each stage of the review process

Study characteristics of geriatric orthopedic trauma publications

Most papers were published in "Injury" (n=170, 24%) and "the Journal of Orthopaedic Trauma" (n =74, 10%), together accounting for over one-third of all publications included in this study. The majority of research was conducted in Europe (45%), Asia (26%) or North-America (26%) (Table 1). The majority of papers were retrospective cohort studies (n = 505, 70%), with fewer included prospective cohort studies (n =130, 18%) and RCTs (n =57, 8%) (Table 2, Supplemental Content 2). The median sample size was 203 (IQR 72-825), and median reported age was 79 (IQR 75-82). The median reported percentage of female participants was 71 (IQR 67-77). The outcomes most frequently studied were complications (63%), mortality (52%), functional outcomes (37%). Less frequently studied outcomes included patient-reported outcome measures (22%), length of stay (21%), radiological outcomes (20%), union rates (11%), and QoL (9%). A level of evidence was reported in 24% of all studies.

Table 1. Study and journal characteristics

Variable		Total geriatric orthopedic trauma publications (n=723)
Journal, n (%)	**Impact Factor (2019)**	**Number of publications in journal**
Injury	2.11	170 (24)
Journal of Orthopaedic Trauma	1.89	74 (10)
Geriatric Orthopaedic Surgery & Rehabilitation	1.34	55 (8)
European Journal of Orthopaedic Surgery & Traumatology	1.56	50 (7)
Journal of Orthopaedic Surgery and Research	1.78	48 (7)
Archives of Orthopaedic and Trauma Surgery	2.02	37 (5)
Bone and Joint Journal	4.31	35 (5)

Table 1. (Continued)

Variable		Total geriatric orthopedic trauma publications (n=723)
Journal, n (%)	**Impact Factor (2019)**	**Number of publications in journal**
Acta Orthopaedica	2.97	30 (4)
Orthopaedics & Traumatology: Surgery & Research	1.81	30 (4)
Medicine (Baltimore)	1.55	24 (3)
European Journal of Trauma and Emergency Surgery	*2.14*	*22 (3)*
Journal of Bone and Joint Surgery	*4.58*	*22 (3)*
Journal of the American Academy of Orthopaedic Surgeons	*2.28*	*17 (2)*
Other journals *All other journals that contribute <2% to the total number of publications combined*	*N/A*	109 (15)
Region where research was conducted, n (%)		
Europe		326 (45)
Asia		187 (26)
North-America		185 (26)
Australia & Oceania		14 (2)
South-America		6 (1)
Africa		1 (0)
Not specified		4 (1)

*percentages shown are rounded to closest integer. The 2019 impact factor was collected by consulting the journals' website.

Table 2. Study design, outcomes studied and level of evidence

Variable	Total publications (n=723)
Study Design, n (%)	
Retrospective cohort	505 (70)
Prospective cohort	130 (18)
Randomized controlled trail	57 (8)
Cross-sectional	5 (1)
Cohort study, not otherwise specified	26 (4)
Sample size, median (IQR)	203 (72-825)
Participant age, median (IQR)	79 (75-82)
Not reported, n (%)	*56 (8)*
Percentage of female participants, median (IQR)	71 (67-77)
Not reported, n (%)	*64 (9)*
Outcomes studied, n (%)	
Complications	458 (63)
Mortality/survival	379 (52)
Functional outcome measures	264 (37)
Patient-reported outcome measures	159 (22)
Length of stay	151 (21)
Radiological outcomes	147 (20)
Union or nonunion rate	77 (11)
Quality of life	65 (9)
Blood loss	55 (8)
Discharge destination	44 (6)
Reoperation	37 (5)
Readmission	35 (5)
Time to surgery	33 (5)
Costs	27 (4)
Reported level of evidence, n (%)	
1	8 (1)
2	20 (3)
3	96 (13)
4	50 (7)
Not reported, n (%)	*549 (76)*

Numbers rounded to closest integer. Age and number of female participants values are unweighted on sample size.

Table 3. Differences between prospective cohort studies and randomized clinical trials in geriatric orthopedic trauma research and studies in/excluding patients with cognitive impairment

Variable	Prospective cohort studies (n = 130)	RCTs (n = 57)	*p*-value	Prospective cohort and RCTs studies excluding patients with cognitive impairment (n=92)	Prospective cohort and RCTs studies including patients with cognitive impairment (n=95)	*p*-value
Sample size, median (IQR)	137 (49-346)	131 (81-267)	0.66	95 (50-238)	199 (82-436)	**<0.01**
Participant age, median (IQR)	79 (75-83)	80 (76-83)	0.61	77 (73-80)	82 (77-83)	**<0.01**
Not reported, n (%)	*6 (5)*	*1 (2)*		*3 (3)*	*4 (4)*	
Percentage of female participants, median (IQR)	71 (63-78)	72 (66-77)	0.72	71 (63-77)	71 (67-78)	0.60
Not reported, n (%)	*13 (10)*	*1 (2)*		*4 (4)*	*10 (11)*	
Included patients with cognitive impairment, n (%)	66 (51)	29 (51)	0.99	0%	100%	N/A
Outcomes studied, n (%)						
Mortality/survival	61 (47)	28 (49)	0.78	35 (38)	54 (57)	**0.01**
Complications	76 (59)	40 (70)	0.13	55 (60)	61 (64)	0.53
Functional outcome measures	64 (49)	35 (61)	0.13	53 (58)	46 (48)	0.21
PROM's	41 (32)	31 (54)	**<0.01**	42 (46)	30 (32)	**0.05**
Quality of life	20 (16)	20 (35)	**<0.01**	21 (23)	19 (20)	0.64
Reported level of evidence, n (%)			**<0.01**			0.64
1	1 (1)	7 (12)		5 (5)	3 (3)	
2	10 (8)	4 (7)		8 (9)	6 (6)	
3	7 (5)	0		4 (4)	3 (3)	
4	4 (3)	0 (0)		3 (3)	1 (1)	
Not reported, n (%)	*108 (83)*	*46 (81)*		*72 (78)*	*82 (86)*	

Numbers rounded to closest integer. Age and number of female participants values are unweighted on sample size. Studies that did not specify whether patients with cognitive impairment were excluded were assumed to have included these patients.

There were no significant differences in sample size, percentage of female participants, age, or the inclusion of patients with cognitive impairment (Table 3). RCTs more often used PROMs as an outcome (n = 31, 54%) than prospective cohort studies (n = 38, 31%, $p<0.01$), and QoL (n = 20, 35%) than prospective cohort studies (n=20, 16%, $p<0.01$). Of all RCTs, 19% reported a level of evidence (12% level 1 and 7% level 2, 81% did not report a level of evidence). For prospective cohort studies this was 17% (1% level 1, 8% level 2, 5% level 3, and 3% level 4, 83% did not report a level of evidence). RCTs had a higher reported level of evidence ($p<0.01$).

Cognitive impairment in geriatric trauma research

A total of 66 (51%) of all prospective cohort studies included patients with cognitive impairment, which was not statistically different form RCT's (n = 29, 50%, $p = 0.99$) (Table 3). Prospective cohort studies or RCTs including patients with cognitive impairment had a larger median sample size and a higher median age. In term of outcomes studied, they more frequently reported mortality and less frequently reported PROMs in comparison to studies that did not include patients with cognitive impairment.

Irrespective of study design, of all included studies, 177 (25%) reported a method to determine cognitive impairment. The most frequently used method was consultation of medical records (n = 92, 52%). Validated screening tools for cognitive impairment were not used as frequently; MMSE (8%), AMT (6%), SPMSQ (5%), CAM 3%, or cognitive components of the Short Form 12 or 36 (2%). Clinical judgment was often used to assess cognitive impairment (n = 18, 10%), as was a clinical diagnosis of delirium (n = 10, 6%) (Table 4).

Table 4: methods of assessment of cognitive impairment in clinical studies in geriatric trauma

Studies that specified a method of the assessment of cognitive impairment, n (%)	177 (25)
Previous medical history (e.g. dementia, delirium, or cerebrovascular disease)	92 (52)
Qualitative (presence or absence of cognitive impairment based on clinical judgment)	18 (10)
Mini Mental State Exam	15 (8)
Clinical diagnosis of delirium	10 (6)
Abbreviated Mental Test	10 (6)
Short Portable Mental Status Questionnaire	8 (5)
Confusion Assessment Method	5 (3)
Short Form 12 or Short Form 36	4 (2)
Other method of assessment	15 (8)

The method of assessment of cognitive impairment as shows here was collected irrespective of study design and whether the study included or excluded patients with cognitive impairment.

DISCUSSION

Study characteristics of geriatric orthopedic trauma publications

Overall the quality of most of the published literature with a focus on geriatric orthopedic trauma is poor. The significant majority were retrospective in design. Most geriatric orthopedic trauma papers included in this review were published in Northern-American or European journals with a relatively low impact factor. Notably, very few papers were from Australia & Oceania, South-America, or Africa. Most studies used traditional outcomes measures such as mortality and complications, while reporting of functional outcomes and quality of life was less common. Few studies examined costs, which is interesting considering the high healthcare costs in this population[18,19].

Only a small minority of studies reported a level of evidence. Reporting of level of evidence is dependent on the policy of the journal where a paper is published. For example, some journals report a level of evidence for almost all papers, such as the Journal of Bone and Joint Surgery (100%), Clinical Orthopaedics and Related Research (100%), and the Journal of Orthopaedic Trauma (92%), whereas the Bone and Joint Journal (0%) instructs authors not to include a level of evidence in their papers in their manuscript preparation checklist[20].

There were few notable differences between prospective cohort studies and RCTs in terms of design. Traditional outcomes were used frequently without significant differences between study designs. About one-third of all prospective cohort studies used PROMs, compared to half of all RCTs. QoL measures are not routinely used in prospective cohort studies (16%), although they are used in about one-third of all RCTs. When including patients with cognitive impairment, prospective cohort studies and RCTs much less frequently reported PROMs in comparison to studies selectively excluding patient with cognitive impairment, although there were no significant differences in the use of QoL measures. Neither RCTs, nor prospective cohort studies frequently reported a level of evidence. RCTs had a higher reported level of evidence, which is inherent to study design.

Cognitive impairment in geriatric trauma research

The results of this review give reason for serious concern: it appears that selective exclusion of patients with cognitive impairment constitutes a potentially major source of selection bias across the field of geriatric orthopedic trauma research. This is particularly evident for studies with a prospective design. In geriatric trauma, cognitive impairment is present in around 30% of all patients[21–23]. These patients cannot give informed consent and are thus excluded from most prospective clinical studies[9]. However, results from studies that exclude these patients cannot be extrapolated to this patient group. This is problematic because geriatric fracture patients with cognitive impairment are at higher risk for mortality, complications, and experience worse functional outcomes[23–25]. Thus, researchers in this field exclude those patients from clinical studies that might benefit most from them.

A comparison was made between prospective cohort studies and RCTs that included patients with cognitive impairment and those that did not (Table 3). Although there was no significant difference between the two study designs in terms of the percentage of studies that included patients with cognitive impairment, it should be noted that roughly half of these studies selectively exclude these patients. Studies that include patients with cognitive impairment frequently use traditional outcome measures such as survival or mortality (Table 3). They less often use PROMs. There was no statistically significant difference in the evaluation of QoL, although this is most likely caused by the fact that very few geriatric trauma studies investigate this outcome to begin with.

Finally, no consensus exists in this field on how cognitive impairment is reported in clinical studies (Table 4.). It should be noted that cognitive impairment is heterogeneous, ranging from temporary mild cognitive impairment as a result from delirium to severe end-stage dementia. Additionally, it can be dynamic in nature. The use of medical record documentation is not a reliable method to determine cognitive impairment[26,27]. The authors recommend the use of validated screening tools such as the MMSE, AMT, SPMSQ, or MoCA[14–17].

The concerning findings of this review are in line with a previous systematic review that investigated selective exclusion of patients with cognitive impairments in geriatric trauma patients aged 65 year or above, which reported 39% selective exclusion rate, and found that 91% of all included studies did not report the methods of assessing cognitive impairment[9].

To guarantee scientific integrity, clinical research ethics and optimal patient care, the authors of this paper propose a three-step plan to improve the inclusion of these patients. Step one is the use of less restrictive eligibility criteria. If patients with cognitive impairment are excluded, an evidence-based justification should be explicitly stated[28]. Step two would be to use validated cognition screening tools rather than subjective clinical judgment or past medical history. The scientific community should reach consensus on which cognitive screeners are useful for determining cognitive impairment for geriatric trauma research. The final step consists of the use of appropriate outcome measures for these patients. Very little research has been done to investigate to reliability of proxy reported outcomes, and results vary[24,29,30]. Still, the use of proxies in clinical research may greatly improve inclusion of these patients in studies.

Strengths and limitations

A strength of this comprehensive scoping review is that it included a very large sample of recent literature in this field. This review was done in a selected number of representative journals. A selection had to be made for feasibility, which introduces the chance of selection bias. We identified 14,442 papers in total in the field of geriatric trauma in the period between January 1st, 2017 and December 31st, 2019, (Figure 1, Supplemental Content 1). It should be noted that this total includes papers not written in English and papers not of interest to this review. A total of 2711 records were screened in this study (Figure 2, Supplemental Digital Content 1), which is about one-fifth of all available literature over the last three years. The authors feel that this is a good reflection of the literature in this field. Another strength is the identification of pitfalls in this field, a topic on which few studies have been published. Finally, this review makes recommendations to navigate these issues for future studies, thus presenting our colleagues with an opportunity to improve the quality of literature in this field.

The study had a few limitations. First, although the authors recognize that English is and should be the primary language for publication in the scientific community, selectively excluding papers not published in English may have induced selection bias. Second, studies that did not report whether or not patients with cognitive impairment were included, were assumed to have included these patients. This means that the selective exclusion of patients with cognitive impairment as reported in this review may still be an underestimation of unknown magnitude. The magnitude of this effect is partly illustrated by the fact that only 25% of all studies reported their method of the assessment of cognitive impairment regardless of whether they included patients with cognitive impairment (Table 4). Third, the authors chose to accept the risk of bias inherent to the scoping review study design and did not do a risk of bias assessment across studies, as it was not feasible due to the large sample size of this study and is not required for a scoping review[10].

Conclusion

This review identified pitfalls in the field of geriatric trauma and provides recommendations to navigate these issues for future studies. Overall the quality of studies is relatively poor. There is a focus on retrospective studies that focus on mortality and complications. There are relatively few prospective studies and RCTs with a focus on patient reported outcomes and quality of life. Overall, cognitive impairment is poorly addressed in geriatric orthopedic trauma research. Every effort should be made to include patients with cognitive impairments in clinical studies, as they may benefit most from them and selective exclusion of these patients has led to bias across the field of geriatric trauma research.

Supplemental Content 1

This search was constructed by a professional librarian from the Harvard Countway Library of Medicine and includes journals in the National Library of Medicine's Abridged Index Medicus list (https://www.nlm.nih.gov/bsd/aim.html), journals currently index in MEDLINE which are included in the Web of Science categories Orthopedics and Emergency Medicine, plus an additional selection of orthopedics, emergency medicine, and general journals. A total of 154 journals were included in the search. The search was conducted in PubMed on February 7th, 2020

Search string:

(jsubsetaim[text] OR "J Orthop Traumatol"[Journal] OR "Clin Orthop Relat Res"[Journal] OR "J Orthop Res"[Journal] OR "Orthop Clin North Am"[Journal] OR "Orthop Traumatol Surg Res"[Journal] OR "Orthopedics"[Journal] OR "J Orthop Sci"[Journal] OR "J Orthop Surg Res"[Journal] OR "Orthop Surg"[Journal] OR "Acad Emerg Med"[Journal] OR "West J Emerg Med"[Journal] OR "Scand J Trauma Resusc Emerg Med"[Journal] OR "Am J Emerg Med"[Journal] OR "J Emerg Med"[Journal] OR "CJEM"[Journal] OR "J Emerg Manag"[Journal] OR "J Orthop Trauma"[Journal] OR "Arch Orthop Trauma Surg"[Journal] OR "Eur J Orthop Surg Traumatol"[Journal] OR "Injury"[Journal] OR "J Bone Joint Surg Am"[Journal] OR "Bone Joint J"[Journal] OR "Acta Orthop"[Journal] OR "Geriatr Orthop Surg Rehabil"[journal] OR "BJS Open"[journal] OR "Trauma Surg Acute Care Open"[journal] OR "Trauma Emerg Care"[journal] OR "Curr Trauma Rep"[journal] OR "J Trauma Treat"[journal] OR "J Clin Orthop Trauma"[journal] OR "Curr Orthop"[journal] OR "J Trauma"[journal] OR "Acta Orthop Belg"[Journal] OR "Arch Orthop Trauma Surg"[Journal] OR "J Am Acad Orthop Surg Glob Res Rev"[Journal] OR "J Am Acad Orthop Surg"[Journal] OR "Eur J Trauma Emerg Surg"[Journal])

AND

("aged"[mesh] OR elder*[tiab] OR frail[tiab] OR oldest old[tiab] OR aged patient*[tiab] OR aged individual*[tiab] OR older patient*[tiab] OR older adult*[tiab] OR oldest adult*[tiab] OR old patient*[tiab] OR old people[tiab] OR older people[tiab] OR older veteran*[tiab] OR older men[tiab] OR older women[tiab] OR geriatric*[tiab] OR age 60[tiab] OR age 65[tiab] OR age 70[tiab] OR age 75[tiab] OR age 80[tiab] OR 60 year*[tiab] OR 65 year*[tiab] OR 70 year*[tiab] OR 75 year*[tiab] OR 80 year*[tiab] OR late life[tiab])

AND

("Fractures, Bone"[Mesh] OR fractur*[tiab] OR broken bone*[tiab] OR bone trauma[tiab])

AND

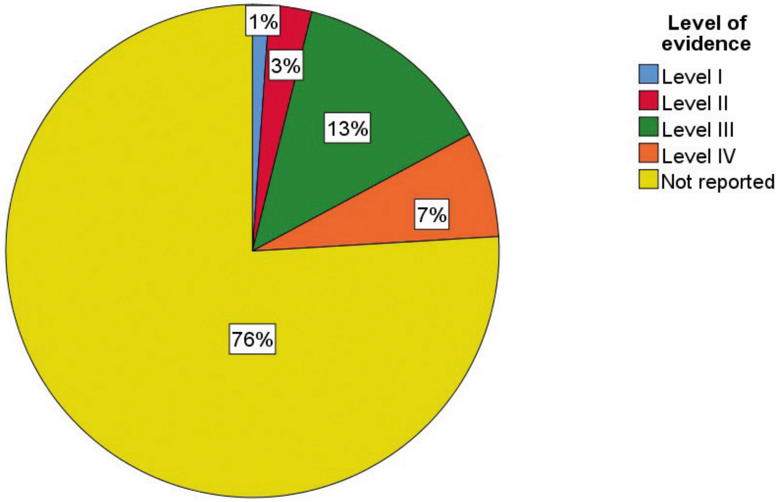
("2017/01/01"[PDAT] : "2019/12/31"[PDAT])

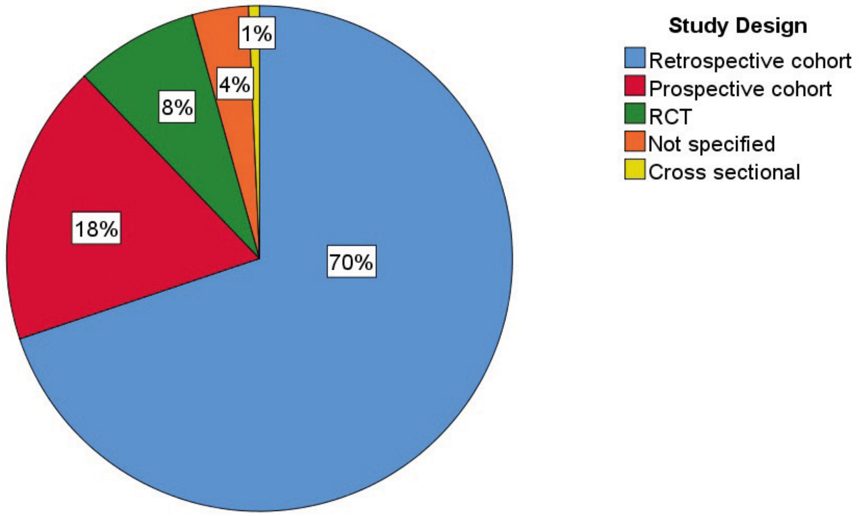
Journals included in this search from the web of science category "orthopedics"	
(9 included)	
Journal of orthopaedics and traumatology	Included
Current trauma reports	NOT INDEXED, NOT INCLUDED
Clinical orthopaedics and related research	Included
Journal of Orthopaedic Research	Included
Orthopedic clinics of North America	Included
Orthopaedics & Traumatology: Surgery & Research (OTSR)	Included
World J Orthop Title(s): World journal of orthopedics	NOT INDEXED, NOT INCLUDED
ORTHOPEDICS	Included
Advances in Orthopedics	NOT INDEXED, NOT INCLUDED
Journal of Orthopaedic Science	Included
Journal of Orthopaedic Surgery and Research	Included
Orthopaedic surgery	Included
journal of orthopaedics	NOT INDEXED, NOT INCLUDED
archives of trauma research	NOT INDEXED, NOT INCLUDED
Chinese Journal of Traumatology	NOT INDEXED, NOT INCLUDED
Malaysian Orthopaedic Journal	NOT INDEXED, NOT INCLUDED
Orthopedic Research and Reviews	NOT INDEXED, NOT INCLUDED

Journals included in this search from the web of science category "Emergency Medicine"	
(9 included)	
Orthopaedics and Trauma	NOT INDEXED, NOT INCLUDED
Trauma Case Reports	NOT INDEXED, NOT INCLUDED
journal of orthopaedics trauma and rehabilitation	NOT INDEXED, NOT INCLUDED
Annals of Emergency Medicine AIM	Included
Academic Emergency Medicine (AEM)	Included
World Journal of Emergency Surgery	NOT INDEXED, NOT INCLUDED
Emergency Medicine Journal	NOT INDEXED, NOT INCLUDED
Western journal of emergency medicine	Included
Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine	Included
American Journal of Emergency Medicine	Included
The Journal of Emergency Medicine	Included
The European Journal of Emergency Medicine	NOT INDEXED, NOT INCLUDED
CJEM	Included
International Journal of Emergency Medicine	Included
Journal of Emergencies, Trauma and Shock	NOT INDEXED, NOT INCLUDED
Open Access Emergency Medicine	NOT INDEXED, NOT INCLUDED
The Turkish Journal of Emergency Medicine	NOT INDEXED, NOT INCLUDED
African Journal of Emergency Medicine	NOT INDEXED, NOT INCLUDED

IJEM	NOT INDEXED, NOT INCLUDED
Archives of Academic Emergency Medicine / "emergency"	NOT INDEXED, NOT INCLUDED
journal of Emergency Management	Included
Emergency Medicine International	NOT INDEXED, NOT INCLUDED
Journal of Trauma Management and Outcomes	NOT INDEXED, NOT INCLUDED
Hong Kong Journal of Emergency Medicine	NOT INDEXED, NOT INCLUDED
Journal of Emergency Medicine, Trauma and Acute Care	NOT INDEXED, NOT INCLUDED
Chinese Journal of Emergency Medicine	NOT INDEXED, NOT INCLUDED
EMERGENCY MEDICINE®: The Practice Journal for Emergency Physicians	NOT INDEXED, NOT INCLUDED
The Visual Journal of Emergency Medicine	NOT INDEXED, NOT INCLUDED

Supplemental Content 2





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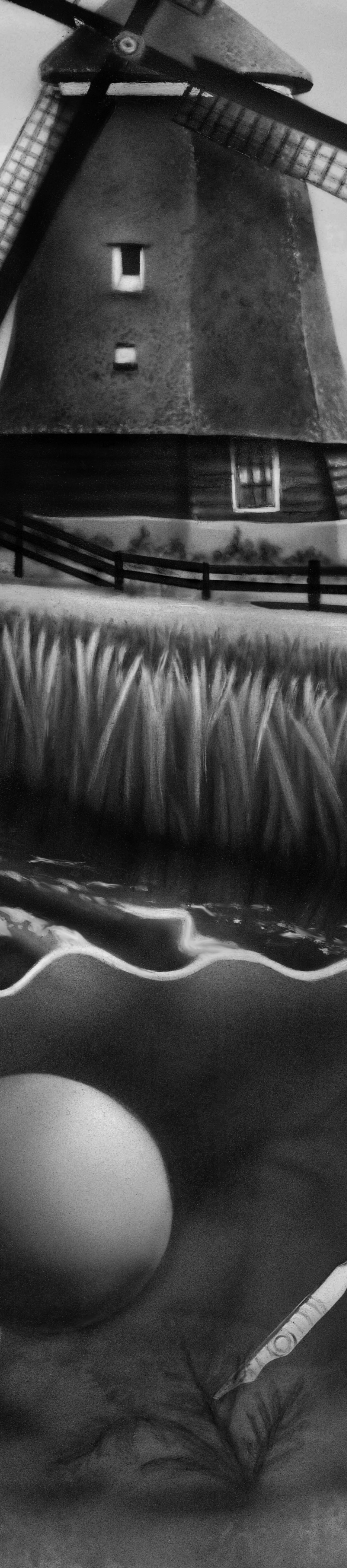

CHAPTER 11

Recommendations for improved patient participation in decision-making for geriatric patients in acute surgical settings

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ABSTRACT

Geriatric patients often present to the hospital in acute surgical settings. In these settings, shared decision-making as equal partners can be challenging. Surgeons should recognize that geriatric patients, and frail patients in particular, may sometimes benefit from de-escalation of care in a palliative setting rather than surgical intervention. To provide more person-centred care, better strategies for improved shared decision-making need to be developed and implemented in clinical practice. A shift in thinking from a disease-oriented paradigm to a patient-goal-oriented paradigm is required to provide better person-centred care for older patients. We may greatly improve the collaboration with patients if we move parts of the decision-making process to the non-acute phase. In the non-acute phase appointing legal representatives, having goals of care conversations, and advance care planning can help give physicians an idea of what is important to the patient in acute settings. When making decisions as equal partners is not possible, a greater degree of physician responsibility may be appropriate. Physicians should tailor the “sharedness” of the decision-making process to the needs of the patient and their family.

INTRODUCTION

The goal of shared-decision making (SDM) is to tailor treatment decisions to what is important to a patient (i.e. person-centred care), and in line with the professional standards of healthcare providers. [1–4] SDM is desirable and recommended in most situations, and surgeons should work together with their patients as much as possible. SDM is based on self-determination (the intrinsic motivation to preserve well-being) and relational autonomy (the idea that an individual's identity and values are formed by interpersonal relationships and social context).[3,5,6]

Geriatric patients often present to the hospital in acute surgical settings. Surgeons who treat these patients on a regular basis will recognize the many challenges and the dilemmas concerning treatment decision-making that these patients , their families, and surgeons are faced with. This usually occurs in situations where treatment decisions have the greatest consequences for the patient.[7,8] Consequently, in acute settings, surgeons and patients do not always succeed to make person-centred treatment plans. To provide more person-centred care, better strategies for improved SDM need to be developed and implemented in clinical practise.

Essentially, the main problem in these settings boils down to three aspects: (1) working together with geriatric patients as equal partners is not always feasible, (2) the acute setting provides us with little time to carefully deliberate on the consequences of treatment decisions, and (3) there is always a degree of uncertainty in prognosis that compounds decision-making.

In this narrative review, we will discuss the challenges of decision-making for geriatric patients in the acute surgical setting. Moreover, we make recommendations to improve patient participation in decision-making in these settings.

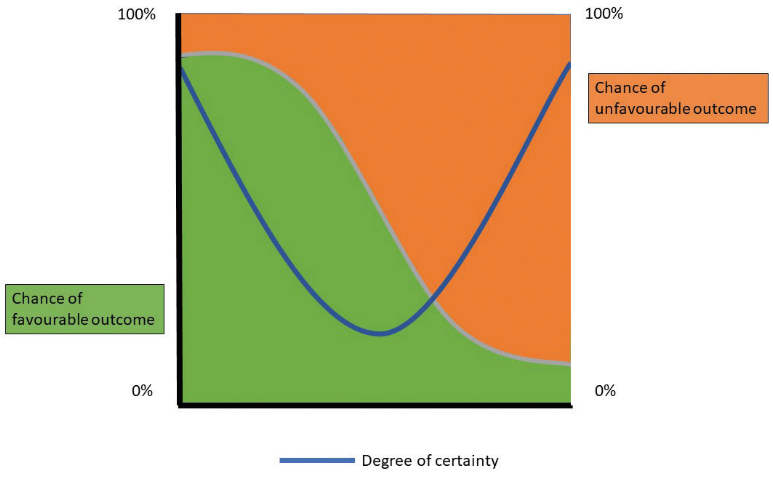
Challenges for shared decision-making for geriatric patients in acute settings

Surgeons should recognize that geriatric patients, and frail patients in particular, may sometimes benefit from de-escalation of care in a palliative setting rather than surgical intervention.[9–11] Although every effort should be made to involve the patient in decision-making, daily practice shows us that SDM as equal partners is not always realistic in acute surgical settings. Some of these aspects are inherent to acute surgical settings in general, while other aspects are specific to geriatric patients.

In general, in acute surgical settings, there is usually a limited amount of time before treatment decisions need to be made, and decisions are often final.[12]

Additionally, a degree of uncertainty regarding prognosis further complicates decision-making (Figure 1). Even though there is an increasing interest in research investigating end of life care for surgical patients, there is still much to be learned about measuring person-centred outcomes, communication, prognostication, decision-making, and the delivery of palliative care.[13,14] Clinical research is certainly useful, but reducing uncertainty by increasing evidence does not always help decision-making in clinical practice, as discussed further on in the paper.

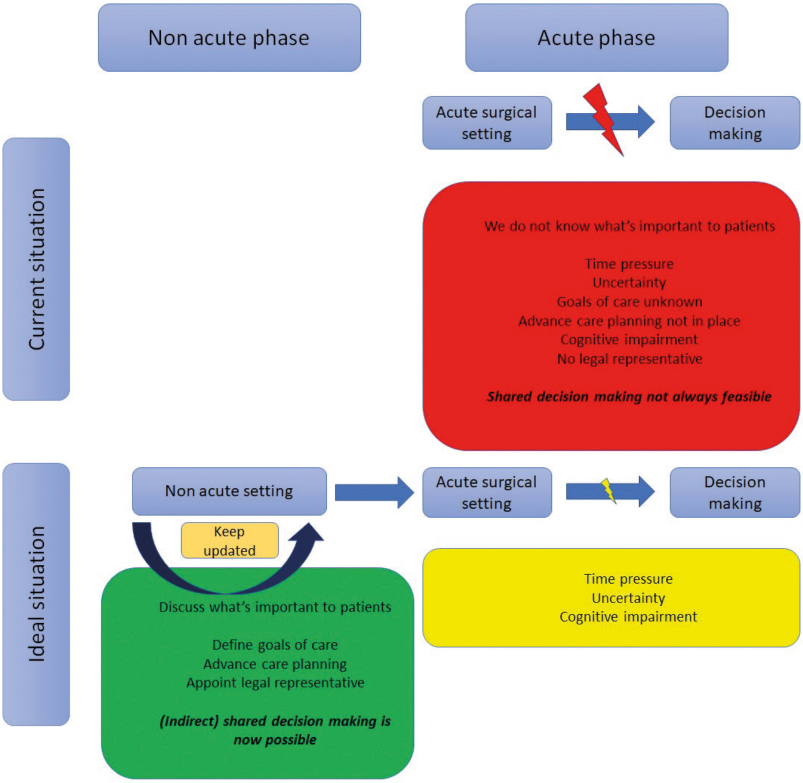
Figure 1: A degree of uncertainty regarding prognosis complicates decision-making



For geriatric patients in acute surgical settings, decision-making may be more complex. First, geriatric patients often present with multiple comorbidities, psychological problems, and a constellation of other medical and social issues that could complicate decision-making.[11,15,16] Second, geriatric patients often have cognitive impairments that may limit their decision-making capacity.[16] Third, although the introduction of patient-reported outcomes measures has helped gain understanding of the subjective patient experience, it is debatable whether these outcomes are truly person-centred.[17] *"What makes life worth living when we are old and frail and unable to care for ourselves?"* This question is raised in "Being mortal; medicine and what matters in the end".[18] It is precisely this question that surgeons dealing with decision-making at the end of life should be asking their geriatric patients. This is an inherently subjective matter that can only be answered directly or indirectly by patients themselves. However, there are significant discrepancies between what patients find important and what surgeons *think* patients find important.[19] In acute surgical settings, patients are not always able to convey this. Fourth, geriatric patients often present to the emergency department without a legal representative or family member, and usually without advance care planning directives.[20] Even though some patients may have given thought to their goals of care and advance care planning or may have discussed this with their primary care physician, this information is rarely available at the emergency department.

All these factors that make SDM between geriatric patients and treating physicians (including surgeons) challenging in acute settings are shown in Figure 2. In these circumstances, we are unable to make holistic treatment plans as equal partners, by taking patient preferences and autonomy into account. It would be appropriate to address these issues as best we can in acute settings. Better still would be to prevent these issues from becoming a problem altogether, adopting an approach similar to preventative medicine.

Figure 2: Challenges and recommendations for shared decision making in acute setting



Uncertainty about prognosis for the individual

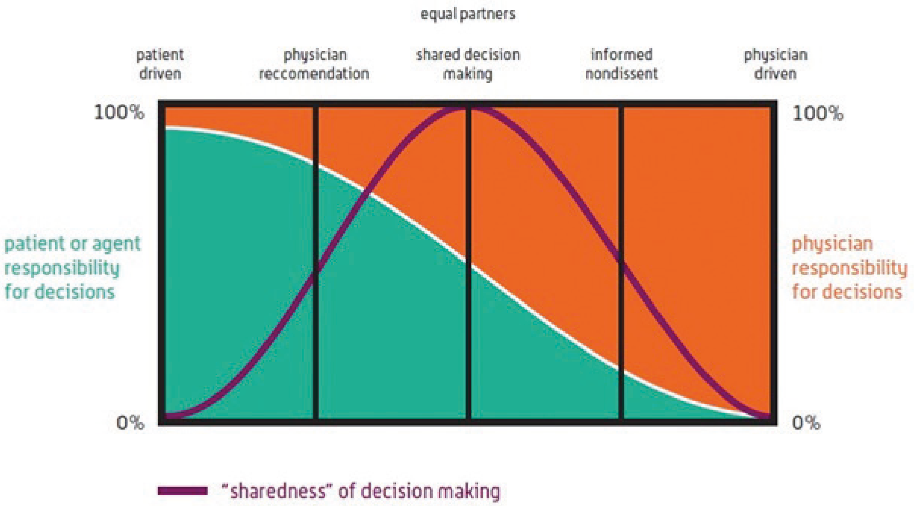
Uncertainty regarding prognosis can be partially reduced by increased clinical experience, increasing evidence by conducting research, or developing tools that can help guide decision-making. Patients and physicians are often confronted with a probability of a certain outcome (Figure 1). This probability is never 0% or 100%, but usually somewhere along the lines of "an approximately 80% probability of a favourable outcome". It is usually unclear what "favourable" means to a patient's unique situation.

The uncertainty in this context is twofold. First, an 80% probability of something is hard to interpret in any setting, let alone the acute surgical setting, as patients are left with a 20% probability of an unfavourable outcome. Second, the probability of an outcome is never *exactly* 80% on the individual level, but *roughly* 80% on a population level with a prediction interval around the predicted probability. This uncertainty makes it much more difficult to relate the prognosis on the population level to the prognosis of the patient in front of you. A patient will either experience an outcome or not, there is usually no in-between. It is possible to reduce uncertainty, and to narrow the prediction interval of the prognosis, but this does not necessarily make decision-making less difficult because we do not know how these probabilities relate to the outcome of the individual and to their goals of care.

Decision-making exists on a spectrum of "sharedness"

It should be recognized that decision-making exists on a spectrum, previously described in literature as the "shared decision-making continuum" (Figure 3).[21] The extremes of the spectrum, i.e. patient-driven decision-making and physician-driven decision-making, are clearly defined and hardly truly shared. Yet, in clinical practice, situations where these extremes occur are uncommon and these forms of decision-making are undesirable. Physician driven decision-making is paternalistic, and patient-driven decision-making, where patients are provided with information and evidence, does not stroke with the role of the physician as counsellor. We should offer patients a conversation, not information.[2,22] The centre of the spectrum is SDM. However, situations exist where SDM is not feasible, particularly for critically ill patients.[23] There are ways to make decisions with a lesser degree of "sharedness" that still result in treatment decisions that are in line with what is important to patients.

Figure 3: Decision making exists on a spectrum



How should we be working together with the patient?

A shift in thinking is required to provide better person-centred care for older patients. Physicians and medical students are trained to diagnose pathophysiological abnormalities and apply medical guidelines with the intention of restoring homeostasis. However, this approach does not take the totality of the patient into account. A shift from the pathophysiological paradigm to a person-centred paradigm will help to realize health outcomes that allow patients to achieve their goals of care.[24] Not everything that is broken needs to be fixed.

In acute surgical settings where SDM for geriatric patients is not feasible, we must find other ways to work together with patients. A patient and surgeon preference for some form of SDM has been well-documented in many fields of surgery.[25–27] However, few of these studies investigate the degree of "sharedness" patients desire on the decision-making spectrum.[21,25–30] The idea that some patients may prefer "participation" in decision-making as opposed to true equal partnership in SDM has been previously described in literature. This is particularly the case for geriatric patients and patients who require emergency surgery.[27,31–36]

Fortunately, there are ways to improve participation in decision-making for geriatric patients in acute surgical setting. First and foremost, deliberating on the goals of care (GOC) should be part of decision-making for all surgical patients, both in the elective and non-elective setting. Ideally, the GOC should be established after multiple conversations with the patient and their families, because GOC are highly personal and must be in line with what is important to the individual patient.[16,37] Unfortunately, this is often not possible in acute settings, so alternatives are needed.

Second, when GOC are established, advance care planning (ACP) can help surgeons to work together with their patients indirectly. In ACP documents, such as a living will, patients can document their wishes for medical situations in which the patient no longer has capacity to decide for themself, even if this means having another person make treatment decisions on their behalf (e.g. durable power of attorney).[38] ACP has been widely endorsed by regulatory organizations and the judicial system. Unfortunately, the large majority of geriatric hospitalized patients does not have ACP in place.[20,39] Also, ACP is not always adequate in acute surgical settings and for end-of-life decisions, because situations where these decisions must be made cannot always be foreseen.

Still, ACP can be very helpful in decision-making. Patients should be motivated to think about what is important to them in hypothetical medical settings, and discuss this with their families and primary caregivers. The current COVID pandemic has once again shown us the importance of having GOC and ACP conversations well before patients end up in an acute medical setting.[40,41] These discussions should be considered standard of care preventative medicine, and may be very well suited for primary care settings.

Third, communication is key. It is important to clearly communicate the consequences of treatment decisions. Even for an experienced clinician, this is easier said than done. Patient decision aids have been suggested as a supplemental tool for end-of-life decision-making. Although a large variety of such tools exists, currently developed patient decisions aids fail to meet the complexity of end-of-life decisions and fail to address patient needs.[42–44] Scenario planning is a communication strategy that can help facilitate decision-making in the setting of uncertainty. The "best case/worst case" framework combines a narrative description and graphical aids of possible outcome scenarios and can help with shared surgical decision-making in acute surgical setting at the end of life for geriatric patients.[45,46]

Finally, when decision-making as equal partners is not possible, a greater degree of physician responsibility may be appropriate, and informed nondissent has been suggested as alternative in such instances. Surgeons should be familiar with, and skilled at, the wide range of acceptable decision-making approaches in the spectrum (Figure 3).[23] This does not mean that decision-making should revert to paternalism, but rather to tailor the "sharedness" of decision-making to the needs of the patient and their family.

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All these options are helpful, but may ultimately not fully solve the decision-making dilemmas that we are faced with in acute surgical settings. Therefore, we propose a revised model for better patient participation in treatment decision-making.

Recommendations for improved patient participation in decision-making

The acute nature of the setting cannot be changed, cognitive impairment may not be modified easily, and a degree of uncertainty will always make decision-making more difficult. In cases where cognitive impairment can be modified (e.g. delirium), decision making should be postponed until the patient is *compos mentis*. We can greatly improve the collaboration with patients if parts of the decision-making process are moved to the non-acute phase (Figure 2). To achieve this, it is imperative to identify patients who are likely to land in acute surgical setting and start a dialogue about what is important to them. Every older individual (including, but not limited to patients) should be motivated to deliberate on what their goals of care are. It is important to realize that what is important to patients and their GOC can change in time. Therefore, it is important to re-evaluate this on a regular basis. Additionally, they should make sure that ACP directives are in place and legal representatives are appointed. The question is; how are we going to communicate this to patients and implement these recommendations for person-centred care? We should consider these discussions in the non-acute phase to be a form of preventative medicine, much like well-established screening programs for breast or colon cancer.[47,48] And similar to these established screening programs, awareness campaigns, GOC discussions in the outpatient clinic, and improved collaboration with primary care physicians and nursing homes must all be part of the solution. The entire care pathway needs to be involved for this goal-based approach to succeed. The information about patient preferences should be carefully documented and be kept up to date, preferably by a primary care physician. This information should become a standard part of the referral to the hospital and be integrated in electronic patient records. Of course, primary care physicians could also decide together with patients to not refer a patient to the hospital at all, and instead remain at home with comfort care.

Conclusion

Surgical decision-making with geriatric patients is complex in acute surgical settings. Although all effort should be taken to involve the patient in decision-making, clinical practice shows us that this is not always feasible in this setting. We do not know what is important to the individual patient, GOC are often unclear, ACP directives are not in place, legal representatives are not appointed, cognitive impairments impede SDM, uncertainty about the prognosis makes treatment decisions more difficult, and the acute setting provides us with little time to carefully deliberate on the consequences of treatment decisions. All these factors combined make SDM between geriatric patients and treating physicians challenging in acute settings. In this review, we made recommendations to address some of these issues. Better still would be to prevent these issues from becoming a problem altogether, by moving parts of the decision-making process to the non-acute setting. A shift in thinking from disease-oriented to a patient goal oriented paradigm is required to provide better person-centred care for older patients. When making decisions as equal partners is not possible, a greater degree of physician responsibility may be appropriate. Physicians must tailor the “sharedness” of decision-making to the needs of the patient and their family.

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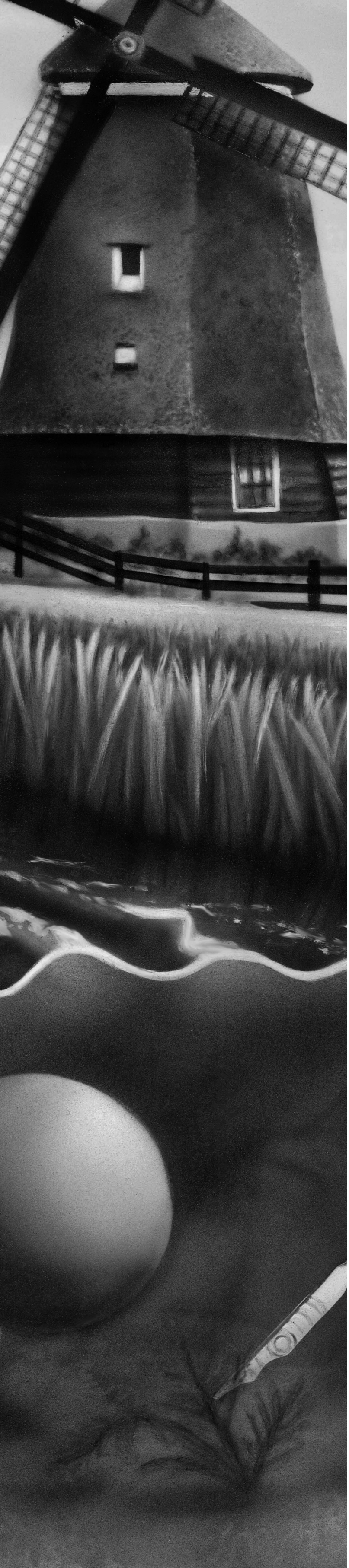

CHAPTER 12

A culture change in geriatric traumatology; holistic and patient-tailored care for frail fracture patients

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ABSTRACT

Medical decision-making in frail geriatric trauma patients is complex, especially towards the end of life. The goal of this paper is to review aspects of end-of-life decision-making, such as frailty, cognitive impairment, quality of life assessment, goals of care discussions, and palliative care. Additionally, we make recommendations for composing a patient-tailored treatment plan. In doing so, we seek to initiate the much-needed discussion regarding end-of-life care for frail geriatric patients.

A CASE VIGNETTE

Mr. Smith is a 93-year-old gentleman presenting to the emergency department after a fall from his bed at hospice care. He has an extensive previous medical history including metastatic lung cancer, cardiovascular disease, and dementia. Radiographs confirm the presence of a displaced distal femur fracture (Figure 1).

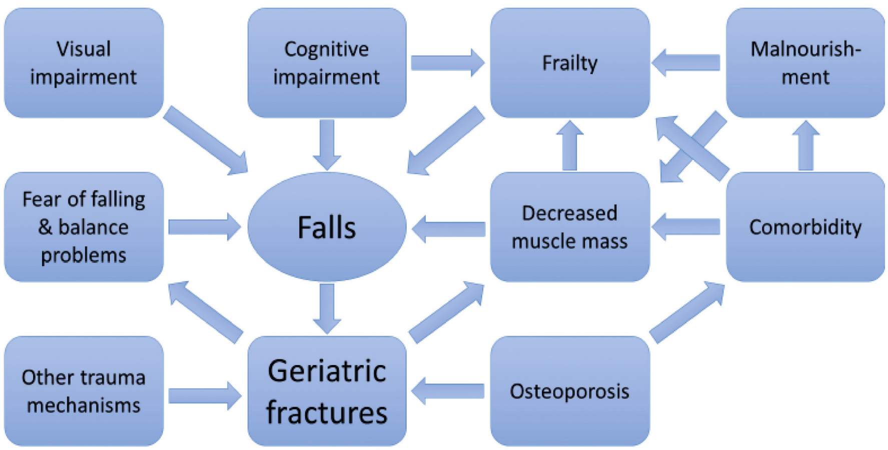
Figure 1: X-rays of the left distal femur

Radiographs showing an oblique displaced fracture of the left distal femoral diaphysis.

Fractures in the geriatric population are not just a diagnosis in isolation

Fractures in the geriatric age group represent a significant health concern and often result in morbidity, mortality, disability, decreased quality of life and are associated with a substantial financial burden on the healthcare system.[1–3] Prognosis is determined by many factors including fracture type, injury severity, age, frailty, sex, comorbidity, and multidisciplinary orthogeriatric comanagement.[4–7] Regardless, overall 30-day mortality for any geriatric fracture patient is around 10%, and one-year mortality is between 15 and 33%.[8–20] Clinicians should realize that fractures in frail geriatric patients are not just a diagnosis in isolation, but a symptom of multifactorial pathology (Figure 2). For many frail geriatric fracture patients, their injury is a terminal event.[21]

Figure 2: Fractures in the geriatric population are not a diagnosis in isolation, but the result of failure to maintain normal physiology and homeostasis, and decreased resistance to stressors



Shared decision-making is challenging in geriatric fracture patients

Generally speaking, most geriatric hip fractures, femur shaft fractures, and tibia fractures are considered operative injuries, while many upper extremity fractures in the elderly can be treated nonoperatively.[22] Nonoperative management of geriatric femur fractures is associated with a very high short- and long-term mortality.[23] The benefits of surgery include restoration of ambulatory status, reduced pain (once surgical pain subsides), improved mobilization, easier nursing care, and a decreased risk of medical complications resulting from immobilization such as pneumonia, pulmonary embolism, and pressure ulcers.[22] However, surgery is invasive, painful, and is associated with significant risks in the frail patient population.[11,12]

As illustrated by the case vignette, geriatric fracture patients are often frail, with multiple medical comorbidities and low physiologic reserve that make surgical interventions precarious.[12] Cognitive impairment and the sudden nature of trauma make decisions even harder and make it more difficult for patients and their families to fully explore their wishes. Other contextual features of geriatric trauma patients include their social situation, living situation, dependence on others for assistance in day-to-day care and decision-making.

It is critical to consider what is important to the patient. We do not know, if we do not ask. Furthermore, we need to ask; *"how does surgery help address these issues"*? While surgery may be the primary decision point, de-escalation of care like "Do Not Resuscitate (DNR)/ Do Not Intubate (DNI)" directives, pain management, less invasive testing and potentially hospice care, are all options even when surgery seems appropriate. This constellation of issues underscores the importance of considering the whole patient and their family, their situation, their prognosis, palliative treatment options, what is important to them, and goals of care (GOC) before proceeding with surgery. A culture change in geriatric traumatology is required to provide more holistic and patient-tailored care.

Geriatric fracture patients require geriatric assessment

Fractures in geriatric patients can be seen as the common pathway of increased frailty (Figure 2.).[24,25] They require a workup for underlying osteoporosis, comorbidities (including cognitive impairment), falls assessment, and frailty. The risk for secondary fractures, complications, and mortality is high.[4,26] Frailty and cognitive impairment have a close relationship, deterioration of one may lead to a decline in the other.[27] The prevalence of cognitive impairment in this population is 20-50%.[18,28–31] Additionally, the possibility of elder abuse or neglect should be considered.[32] All this can be accomplished by geriatric assessment.

Geriatric patients with fractures benefit from geriatric assessment and management to help evaluate frailty and surgical risk.[6] Frailty is defined as a dynamic syndrome that is often associated with ageing, characterized by decreased reserves and resistance to stressors, resulting from a decline in multiple physiological systems.[25] Frailty can be determined by diagnostic tools such as the Rockwood Frailty Index (FI) and the Fried phenotype criteria.[25,33–35] These tools offer insight in multiple physiological systems and can provide the physician with target domains for intervention. The Fried phenotype is feasible for certain geriatric populations, but it requires gait speed and grip strength, which is problematic for patients with fractures.[25] The FI not only offers insight in multiple systems, but is also a quantitative measure of frailty. It can capture the dynamic change of frailty in patients, and is a robust predictor of mortality, which can be used to assess surgical risk.[10,20] Another way to assess surgical risk is by using prediction tools. A few prediction models have been developed for hip fracture patients.[36–38] A more general surgical risk assessment tool is the American Society of Anesthesiologists physical status classification system.[39] Although these tools can offer a reasonably accurate prediction of perioperative mortality, they cannot identify different domains of frailty, nor evaluate the patient's GOC or specific mobility needs, whereas geriatric assessment can. A combined approach of prediction tools and geriatric assessment may be the optimal strategy.

Falls assessment is an important part of the geriatric assessment. Geriatric fractures and falls are usually the result of a larger set of problems (Figure 2). The question arises whether treatment of the fracture alone will adequately address these issues. For example: if a geriatric patient with cognitive impairment sustained a fracture due to a fall, gaining safety insight and evaluating the living environment to reduce hazards should be an integral part of the geriatric assessment.[40]

The high prevalence of cognitive impairment further complicated decision-making both in terms of dementia and delirium.[18,28,29] The degree of cognitive impairment can range from mild to very severe. Cognitive impairment assessment in a clinical setting requires separating delirium from dementia.[41] Cognitive impairment can be assessed by using cognitive screening tools, such as the confusion assessment method (CAM)[42] followed by Mini-Cog,[43] the Montreal Cognitive Assessment (MoCA)[44], or the mini-mental-state-examination (MMSE).[45] Cognitive impairment is an obstacle in shared decision-making with regard to surgery and care preferences, because it is unclear to what extent the patient can comprehend consequences of treatment decisions. It is also a risk factor for postoperative delirium, mortality, and falls.[30,46,47]

Mr. Smiths' X-rays show an oblique displaced fracture of the left distal femoral diaphysis, but no other fractures. Geriatric assessment reveals that the patient is dependent for all activities of daily living, including transfers and feeding. He is incontinent and bound to a bed or wheelchair at all times. His falls assessment shows that he is at very high risk for falls and his FI is 0.62. The FI is based on a 0 to 1 scale, with an empirical cut-off of 0.25 for frailty.[35] *Mr. Smith is in the 99th worst percentile for frailty.*[10] *Based on the CAM and Mini-Cog, the geriatrician concludes that the patient is suffering from dementia FAST-7 (end-stage).*

Quality of life

Quality of Life (QoL) is subject to personal, societal, cultural, and religious norms.[48,49] In patients with dementia or other forms of cognitive impairment, QoL is notoriously difficult to assess.[50] These medical conditions entail a deterioration in QoL as perceived by others and pose ethical dilemmas to healthcare providers. It is challenging to truthfully inform a patient with cognitive impairment about a prognosis and implications for overall QoL.[48,49] In these cases, substituted judgment can be used to assess the consequences of treatment decisions.

Patient preference should be considered whenever possible. While surgical repair of a lower extremity fracture may allow the patient to ambulate, toilet, and perform personal hygiene, each patient and family may see these elements as more or less important. Some patients value time with their loved ones, and are more willing to accept the need for a hospital bed or wheelchair. Other patients value mobility and the ability to ambulate even limited distances. The goals of the patient and family, together with the expected pain relief, and long-term prognosis must be balanced against the risks of an intervention.

> *The sons' understanding of Mr. Smiths' GOC is that he would want to prioritize comfort, which means that his QoL can be maximized by minimizing pain and discomfort.*

Impaired decisional capacity

Dementia, delirium, pain, anxiety, hospitalization, and illness are all factors that are often present in geriatric trauma patients and can reduce decisional capacity.[18,28–31] Decisional capacity is usually assessed by the treating physician by engaging in conversation with the patient. Care should be taken to perform a thorough assessment. From a legal standpoint, patients have decisional capacity when they understand all relevant information, are able to appreciate the current situation and its consequences, and are able to manipulate this information in a rational manner.[51] While many patients may at first seem like they are able to consent, the use of probing questions often reveals significant cognitive issues that may preclude the ability to provide informed consent.[28,29,52] When there is doubt regarding decisional capacity, geriatrics can help with the assessment. When a patient does not have decisional capacity, a stepwise hierarchy of three standards must be followed; 1. A patient's advance care planning

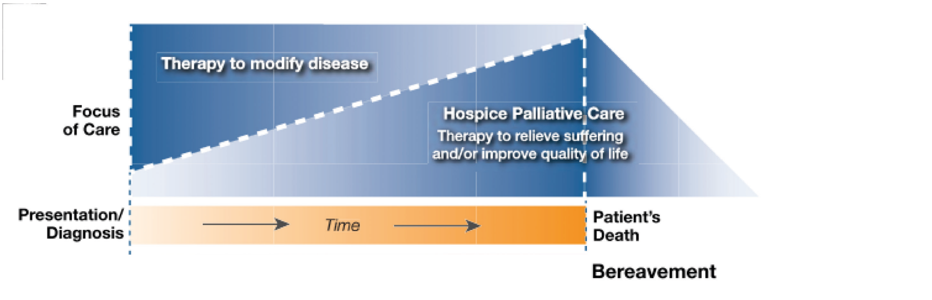
(ACP) directive, 2. Substituted judgment, meaning that decisions are made on the patients behalf by a surrogate decision maker such as a relative or legal healthcare proxy, 3. The patient's best interest.[53]

Because Mr. Smith is severely demented, he does not have decisional capacity and is unable to express his treatment preference. His care providers and his son have to carefully weigh the benefits against the risks and use substituted judgment based on their understanding of his wishes to make this treatment decision.

Palliative care in the geriatric fracture population exists on a spectrum

Surgeons and residents alike dealing with end-of-life decisions should have a basic understanding of what palliative management looks like.[54,55] A palliative approach is an interdisciplinary medical approach that focuses on controlling pain towards the end of life and other symptoms, reducing emotional distress and spiritual concerns, coordination of care, shared decision-making and consolation of family members.[56] Palliative management is a holistic approach that manages care coordination and physical, psychological, social, cultural, spiritual aspects, ethical and legal aspects of end-of-life care.[56] This form of care offers a support system to maximize quality of life and quality of dying, provides relief from pain and other distressing symptoms, affirms life and regards dying as a natural process. It is intended to neither extend life, nor hasten death.[50] Palliative management is not an "all or nothing" process, but rather a sliding scale of de-escalating treatment options targeted at modifying disease and escalating quality of life and quality of dying measures (Figure 3).[56,57]

Figure 3: Palliative care exists on a spectrum of treatment intensities



Adapted (with permission) from the Canadian Hospice Palliative Care Association[57]

The spectrum of palliative management includes interventions that are part of usual care, such as pain management or psychological support. Other measures that can be taken are "do not resuscitate" (DNR), "do not intubate" (DNI), or "do not re-hospitalize" directives. These measures can be reversed if the situation requires, although this requires patient consent. An example is the temporary reversal of a DNI directive when a patient has to undergo palliative surgery. This illustrates that palliative management can be dynamic depending on disease progression. Towards the end of life, symptom management should be tailored to the patient's needs and often be more aggressive. At this stage, withholding or withdrawing therapy are indicated if the burden of treatment is too great. In certain cases, palliative sedation may be indicated to alleviate symptoms such as pain or distress.[50]

Surgery, while invasive, may be a part of palliative management, particularly in geriatric patients. The authors advocate for an approach where surgery is considered as a treatment option to reduce pain and improve mobility. Proceeding with a surgical intervention does not necessarily mean that all possible measures are taken to prolong life. A strong knowledge of surgical care, palliative care, aging anatomy and physiology, and frailty is crucial in deciding which treatment option will give the best outcome for individual patients. This underscores the importance a multidisciplinary team to help patients make these decisions.[50,54–56] These aspects of care should be covered in residency programs.

The palliative approach is not synonymous with geriatric medicine, which the medical specialty of managing geriatric patients through comprehensive geriatric assessment. However, geriatricians can identify patients that might benefit from a palliative approach. In geriatric trauma, this approach is associated with lower treatment intensity and less burdensome care (i.e. hospitalization, intensive care unit admission, receiving life-sustaining treatment) at the end of life.[21] Although the benefits of palliative management are well recognized in the surgical geriatric patient population, it is not yet routinely considered in fracture patients and studies evaluating palliative management in this population remain scarce.[21,58–60]

Balancing patient and family preferences and finding a path forward

The information from geriatric assessment can be combined into a prognosis. The assessment of frailty, cognitive impairment, fall risk, dependency in activities of daily living, and comorbidities can be used to get an impression of the patients' prognosis in terms of mortality [10,20,33,34] and risk of complications.[30,46,47] If a patient has a limited life expectancy or low quality of life, a GOC conversation can be helpful in the decision-making process. GOC conversations are meant to explore the patients' wishes in the current clinical context, resulting in shared decision-making for the intensity of treatment. It is different from ACP, which is a directive from the patient regarding end-of-life treatment decisions that is to be observed if the patient is unable to make those decisions him/herself.[61] Studies investigating the availability of ACP directives in clinical practice report that few patients have these directives in place.[62,63] Geriatric fractures frequently occur towards the end of life, providing us with an opportunity to discuss and document treatment preferences. For example, palliative care might not be indicated for a distal radius fracture. However, if we acknowledge that fractures in the geriatric population are a symptom of frailty, these "low grade" fractures may create an opportunity to start thinking about ACP and engage in GOC conversations. In the long run, this will increase the number of patients with ACP in place who have given thought to their GOC in more acute surgical settings and discussed this with their loved ones, preventing dilemmas such as the one described in the case vignette.

> *The geriatrician estimates that Mr. Smith has a few weeks to live at best due to his frailty, falls, comorbidity, and recent steep decline in hospice care. He is a very high-risk surgical patient, with a high chance of perioperative mortality. Mr. Smith has no ACP and because his cognition is severely impaired, his son is making treatment decisions on his behalf. A GOC conversation takes place with the trauma surgeon, anesthesiologist, geriatrician, Mr. Smith and his son. Considering multiple medical comorbidities including advanced cancer, and limited life expectancy, the treatment team is in doubt whether surgery in indicated for Mr. Smith.*

A palliative treatment plan should be tailored to the goals of care of the patient and his or her medical indications.[54–56] Such a treatment plan may or may not include surgery, depending on the desired outcome. Indication for palliative surgery in geriatric fracture patients at the end of life may be cases where goals of care include safe transfers, sitting on the commode, or to avoid bone sticking through the skin (an importunate fracture). However, perioperative risks should be carefully considered. The patient may not have enough physiological reserve to tolerate surgery, in which case surgery may accelerate death (non-maleficence). Still, a high risk of perioperative mortality may be acceptable in the setting of palliative management as long as it is in line with the patients' GOC.

> *The expected benefit from surgery is pain control and to allow improved nursing care. Stabilization of the femur should reduce his pain, and allow him to be rolled in bed, avoid pressure ulcers, and allow for toileting. However, this is a high-risk procedure with a substantial risk of perioperative mortality and perioperative complications that may reduce quality of life. Since Mr. Smith is already completely unable to ambulate, no functional recovery is to be expected.*

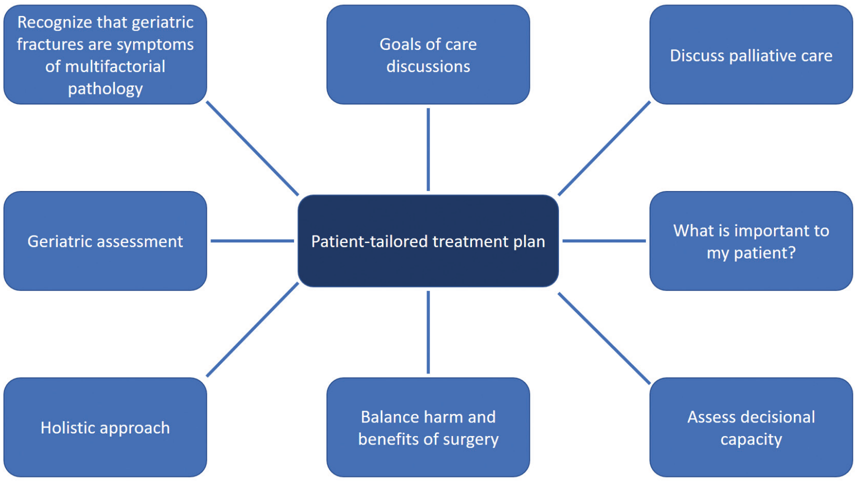
A culture change in geriatric traumatology

Because of the complexity of decision-making and ethics as described and the non-elective nature of trauma surgery, one needs a competent interdisciplinary team that can act fast.[54,55] Co-management creates established working relationships which allow quick navigation of the different ethical domains and find the appropriate fit for each patient with their own unique needs and requirements. To be truly successful comanagement services cannot just rely of the expertise of geriatricians and internists to manage the medical complexities of geriatric patients, they need to also lend their expertise and perspective to decision-making and creating treatment plans that take the entire patient and their environment into account. The case vignette illustrates the ethical dilemma that occurs when treatment decisions need to be made for frail geriatric fracture patients when an ACP directive is not present. This underscores the importance of informing patients about the need for ACP directives well before end-of-life decisions need to be made.

The authors do not advocate any one treatment plan, but rather emphasize the need for shared decision-making between patient, caregivers, and treatment team to create a comprehensive treatment plan that takes the totality of the patient into account. This patient-tailored approach will require a culture change in geriatric trauma (Figure 4). The authors encourage the medical community have an open a discussion regarding the care for frail geriatric fracture patients, and look forward to exchanging ideas about the future of geriatric traumatology.

After an extended discussion, a decision is made to forgo surgery. The intervention is part of the de-escalation strategy with planned hospice care and palliative care. The next day, he is stable enough to be discharged. With palliative care, his pain was under control and Mr. Smith was better able to tolerate toileting, re-positioning in bed and his care for hygiene. Mr. Smith passed away peacefully 12 days later.

Figure 4: Recommendations for coming up with a holistic and patient-tailored treatment plan for frail geriatric fracture patients



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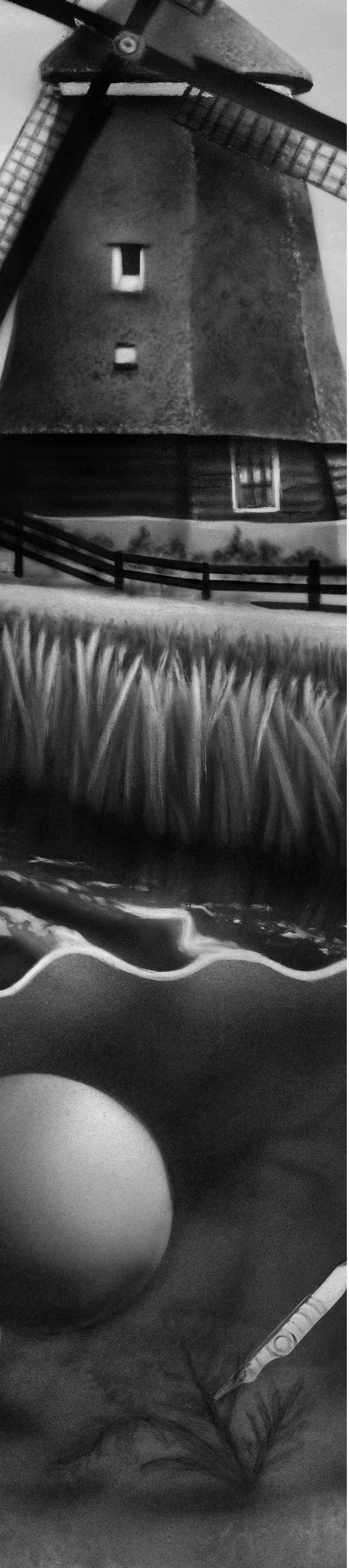

CHAPTER 13

Summary, discussion
and future perspectives

Falls and fractures in the geriatric age group are symptoms of frailty

Falls and resulting fractures in the geriatric age group represent a significant health concern. They often result in morbidity, mortality, disability, and decreased quality of life and are associated with a substantial financial burden on the healthcare system.[1–3] These fractures are heterogeneous and prognosis is determined by many factors including injury severity, age, sex, comorbidity, and multidisciplinary orthogeriatric comanagement.[4–7] They can be seen as the common pathway of increased frailty. Slow gait, decreased muscle mass, cognitive issues, visual problems, and an overall low physical function all contribute to an increased risk of falls and fractures.[8–13] Falls are the leading cause of accidental injury and death among older adults, with one in three adults over the age of 65 years experiencing a fall annually. As the size of elderly population increases, falls become a major concern for public health, and there is a pressing need to better understand the causes of falls.[14] These manifestations of frailty often act in unison to create a downward spiral that results in falls and related fractures. Thus, physicians should realize that fractures in the geriatric age group are often symptoms of underlying morbidity, and not a diagnosis in isolation (Chapter 11).

Ergo, treatment of the fracture alone will in no way solve the underlying issue; frailty. Although awareness of frailty has increased over the last decades, most surgeons who treat fractures have a limited understanding of the issue and are not trained to recognize frailty.[15] This must change, as will be discussed further on in the “culture change” section. Fortunately, a consulting geriatrician can make a big difference. There is overwhelming evidence that geriatric comanagement of geriatric fracture patients leads to improved patient outcomes, although there is still some debate as to which comanaged care model is the best (Chapter 9).[5,6,16–21] The best model of comanaged care may be strongly dependent on factors specific to each hospital. Thus, not one care model may ultimately be the best, as long as some form of comanagement is implemented. It is disappointing to see that geriatric comanagement is not yet implemented in all hospitals. In literature, geriatric comanagement is often compared to “care as usual” or “standard of care”.[5,6,16–21] This implies that geriatric comanagement is not care as usual. This must change, and as a community, we should advocate to regard geriatric comanagement standard of care for all hospitalized geriatric fracture patients.

Should reducing mortality be the primary goal?

If care for geriatric fracture patients is to be improved, reducing mortality should not be the primary goal. If we accept that geriatric fractures are manifestations of frailty, further improving surgical fracture care is unlikely to result in a large reduction in mortality. Early identification of patients who are at high risk for mortality is helpful to identify patients who may benefit from palliative management and de-escalation of care (Chapters 3 and 8). Instruments to do so are readily available (Chapters 2 through 7).[22–27] Instead of reducing mortality, the aim should be to optimize functional outcomes, quality of life, and return to independency for patients who are able to rehabilitate.[28] While one should always aspire to optimize patient-tailored care for our patients, one must also realize that it is difficult to break a downward spiral. Frailty is a dynamic syndrome.[11,29] Unfortunately, end-stage frailty is tremendously difficult to reverse. Rather than seek to aggressively and indiscriminately treat fragility fractures, one should invest in better secondary prevention of osteoporotic fractures and fall prevention, make more person-centered treatment plans and develop better palliative care programs (Chapter 11).

Should we always be doing everything for everyone?

Surgeons should recognize that geriatric patients, and frail patients in particular, may sometimes benefit from de-escalation of care in a palliative setting rather than surgical intervention (Chapters 11 and 12).[30–32] Dilemmas involving decision making frequently occur in situations where treatment decisions have the greatest consequences for the patient.[33,34] The acute nature of trauma, the prevalence of cognitive impairment in the geriatric population and other barriers to (shared) decision making all complicate making treatment decisions. Collaboration with our patients may greatly be improved if parts of the decision making process are moved to the non-acute phase (Chapter 12). Still, treatment decisions for geriatric patients are always a trade-off. The best way to work together with our patient is to simply ask them what is most important to them.[35]

Palliative care should be considered for patients who are at high risk for perioperative mortality, who do not have good prefracture ambulation status and for whom a low quality of life is to be expected after surgery (Chapter 11). Palliative care is a holistic approach that manages care coordination and physical, psychological, social, cultural, spiritual, ethical and legal aspects of end-of-life care.[36] This form of care provides a support system to maximize quality of life and quality of dying. It provides relief from pain and other distressing symptoms, affirms life and regards dying as a natural process. It is intended to neither extend life, nor hasten death.[37] Palliative care may or may not include surgery. The biggest challenge for palliative care in traumatology is pain management. Adequate pain management is required to facilitate toileting, re-positioning in bed and care for personal hygiene, so that the end of life may be dignified. For example, fascia iliaca compartment blockade provides site-specific and rapid-onset analgesia that effectively relieves pain after a hip fracture that is superior to systemic analgesia alone.[38,39] However, the effect of the blockade is dependent on the skill of the physician, and continuous nerve block catheters are prone to luxation. It is unclear whether continuous blockade is suitable for the palliative setting, and merits further investigation.

Recommendations for future research

There is an increasing interest for studies in geriatric traumatology, but the quality of studies is highly variable in this field. A thesis or paper usually ends with some form of the phrase “more research is needed”. This is not the case for geriatric trauma research. We do not need *more* research, we need *better* research. In general, future high quality research should focus more on long-term functional outcomes and quality of life, rather than short-term mortality and complications. These outcomes may be more important to patients. But rather than to focus on future clinical studies, one should first examine the validity of the methodology that is currently being used in this field. There are several aspects to geriatric trauma research that make research in this field more challenging and we must find better ways to address these issues and improve research quality (Chapter 10).

First, although patient-reported outcome measures are widely available and used in surgical research studies, they are not often used in geriatric trauma research. It is unclear to what extend these outcome measures are informative to the geriatric patient, because they are not designed for (frail) geriatric patients. The Older Persons and Informal Caregivers Survey Short Form (TOPIC-SF) is a rare example of a patient-reported outcome measure specific to the geriatric population, and merits further investigation.[40] Although not yet extensively validated, it is currently being implemented in the Dutch Hip Fracture Audit and several hospitals in the Netherlands.[41]

Second, research should be more inclusive. Selective exclusion of patients with cognitive impairment constitutes a potentially major source of selection bias across the field of geriatric orthopedic trauma research. Over half of all prospective studies selectively exclude these patients. These patients cannot give informed consent and are thus excluded from most prospective clinical studies[42]. However, results from studies that exclude these patients cannot be extrapolated to this patient group. This is problematic because geriatric fracture patients with cognitive impairment are at higher risk for mortality, complications, and experience worse functional outcomes[43–45]. Thus, researchers in this field exclude those patients from clinical studies that might benefit most from them. Medical ethics committees must also take responsibility on this matter. Literal adherence to guidelines and regulations leads to cumbersome inclusion and consent procedures that discourage researchers. As a result, they do not protect, but rather disrespect, the rights of cognitively impaired older individuals by preventing them to benefit from scientific research and progress.[42]

Third, more research is required to determine the validity of the use of proxies (e.g. family members or caregivers) as a source of data for scientific investigations in the geriatric population. Geriatric populations are prone to selective follow-up and recall bias, a problem that may be partially overcome if proxies are used as a source of information. Such proxy-reported outcome measures are frequently used in pediatric research.[46,47] Studies investigating the validity of proxy-reported outcomes in geriatric research remain scarce.[44,48–50] A review on this topic would be helpful.

In summary, future research in the field of geriatric traumatology must be of higher quality, be more inclusive, and make more use of proxy-reported outcomes.

A culture change in geriatric traumatology

To design and consolidate a more patient-tailored approach for geriatric fracture patients will require a culture change. The author proposes to regard falls and subsequent fractures in geriatric patients not just as a common pathway of frailty, but rather as an end-stage manifestation of frailty. Although exceptions exist, these fractures should be considered an ill omen and characterize patients who are nearing or who are at the end of life. If care for these patients is to be improved, a shift in thinking is required. Physicians (including surgeons) should learn to better appreciate the complexity of geriatric trauma patients and bring about a culture change in geriatric traumatology.

First, surgeons must learn to recognize frail patients and acknowledge that falls and resulting fractures are abnormal. Fractures in the geriatric population are symptoms of a larger set of problems, and merely treating the fracture does not address underlying frailty. Surgeons must also have a rudimentary understanding of geriatrics and palliative care, and be aware of the presence of cognitive impairment and reduced decisional capacity in 20% to 50% of all geriatric fracture patients.[22,43,51–53] The most effective way to raise awareness for these aspects of care would be to incorporate them in the curriculum of residency programs.

Second, we should aspire to provide more holistic and person-centered care. The first step should be to identify high-risk patients in an early stage and to have goals of care discussions. Ask patients what is important to them and balance benefits and harms of surgery against their goals of care. Palliative care, which may or may not include surgery, should be considered for severely frail patients.

Third, we must adopt better preventive medicine strategies. Appropriate screening intervals and criteria are controversial for primary prevention of osteoporotic fractures, but for secondary prevention, all patients over the age of 50 years who suffer a fragility fracture should be screened for osteoporosis.[54,55] The secondary prevention of osteoporosis is proven effective, with a low number needed to screen and number needed to treat.[56] However, a worldwide care gap remains and only a small minority of patients who suffer an osteoporotic fracture subsequently receive treatment for osteoporosis.[55,57] The primary reason for this lack of medical care is often reported to be a lack of understanding on the part of the treating physician regarding the role of osteoporosis as the cause of the fracture.[55] This illustrates the importance of a better understanding of geriatric fractures. Besides secondary prevention of osteoporotic fractures, the prevention of falls should be considered for older adults, even those who have not yet suffered a fracture. Gaining safety insight and evaluating the living environment to reduce hazards is an integral part of the geriatric assessment.[58]

Finally, and perhaps most importantly, we must find better ways to work together with our patients. The acute nature of trauma cannot be changed, cognitive impairment cannot be modified easily, and a degree of uncertainty in prognosis will always make medical decision making challenging in the field of geriatric trauma. However, collaboration with our patients may greatly be improved if parts of the decision making process are moved to the non-acute phase. Every older individual (including, but not limited to patients) should be motivated to deliberate on what their goals of care are in case of hospitalization, and to have advance care planning directives in place. To achieve this, awareness campaigns, goals of care discussions in outpatient settings, integration of geriatrics in the residency curriculum, and improved collaboration with primary care and nursing home physicians must all be part of the solution. We must encourage older individuals to think about what their treatment preferences are in case of hospitalization, long before they present to the emergency department. This will be an ambitious undertaking, but it is paramount to the culture change in geriatric traumatology.

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Fracturen als gevolg van een val bij geriatrische patiënten: een teken van kwetsbaarheid

Fracturen als gevolg van een val vormen een belangrijk gezondheidsprobleem bij geriatrische patiënten. Ze leiden vaak tot morbiditeit, mortaliteit, invaliditeit, verminderde levenskwaliteit en aanzienlijke kosten in de gezondheidszorg.[1–3] Deze prognose wordt bepaald door veel factoren, waaronder de ernst van het letsel, leeftijd, geslacht, comorbiditeit en multidisciplinaire geriatrische behandelstrategieën.[4–7] Deze fracturen kunnen worden gezien als een manifestatie van kwetsbaarheid. Een tragere loopsnelheid, verminderde spiermassa, cognitieve problemen, visuele problemen en algehele lichamelijke achteruitgang dragen allemaal bij aan een verhoogd risico op vallen en fracturen bij ouderen.[8–13] Voor een uitgebreide toelichting op kwetsbaarheid, zie tevens de Engelstalige inleiding. Vallen is de belangrijkste oorzaak van letsel en overlijden door ongevallen bij de oudere patiënt. Eén op de drie volwassenen boven de 65 jaar valt minimaal eenmaal per jaar. Naarmate het aantal ouderen toeneemt, vormen valincidenten een steeds grotere bedreiging voor de volksgezondheid. Er is dringend behoefte aan een beter begrip van de oorzaken van valincidenten.[14] De symptomen van kwetsbaarheid versterken elkaar in een neerwaartse spiraal die resulteert in valincidenten en daarmee samenhangende fracturen. Artsen moeten zich daarom realiseren dat fracturen in de geriatrische leeftijdsgroep vaak symptomen zijn van onderliggende morbiditeit, in plaats van een op zichzelf staande diagnose (Hoofdstuk 11).

Hieruit volgt dat enkel chirurgische behandeling van deze fracturen in geen geval het onderliggende probleem kan oplossen: kwetsbaarheid. Hoewel er in toenemende mate aandacht is voor kwetsbaarheid de laatste decennia, hebben de meeste chirurgen die fracturen behandelen een beperkt begrip van dit syndroom. Zij zijn niet opgeleid om kwetsbaarheid te herkennen.[15] Dit moet veranderen, zoals verder zal worden besproken in de afsluitende paragraaf "cultuuromslag". Gelukkig kan een consulterend geriater een groot verschil maken. Er is overweldigend bewijs dat geriatrische medebehandeling van de oudere fractuurpatiënt leidt tot betere patiëntuitkomsten, hoewel er nog steeds discussie is over welk model voor medebehandeling het beste is (Hoofdstuk 9).[5,6,16–21] Het beste model kan sterk afhankelijk zijn van lokale factoren die specifiek zijn voor een ziekenhuis. Het is dus mogelijk, en zelfs waarschijnlijk, dat niet één zorgmodel uiteindelijk het beste is, zolang er maar een vorm van dit zorgmodel geïmplementeerd is. Het is teleurstellend om te zien dat geriatrische medebehandeling nog niet in alle ziekenhuizen is ingevoerd. In de literatuur wordt geriatrische medebehandeling vaak vergeleken met "standaardzorg", hetgeen impliceert dat geriatrische medebehandeling geen standaardzorg is.[5,6,16–21] Dit moet veranderen. Als gemeenschap moeten we ervoor pleiten om geriatrische medebehandeling als standaard zorg te beschouwen voor alle geriatrische fractuurpatiënten die opgenomen worden in het ziekenhuis.

Is een zo laag mogelijk sterftecijfer het belangrijkste doel?

Als men de zorg voor geriatrische fractuurpatiënten wil verbeteren, dan moet het verlagen van de mortaliteit niet het voornaamste doel zijn. Als we aannemen dat geriatrische fracturen manifestaties van kwetsbaarheid zijn, dan is het onwaarschijnlijk dat verdere verbetering van de chirurgische fractuurzorg zal leiden tot een grote vermindering van de mortaliteit. Het vroegtijdig herkennen van patiënten met een hoog risico op overlijden is echter wel nuttig. Patiënten die baat zouden hebben bij een palliatief beleid kunnen op die manier in een vroeg stadium worden geïdentificeerd (Hoofdstukken 3 en 8). Instrumenten om dit te doen zijn beschikbaar (Hoofdstukken 2 tot en met 7).[22–27] In plaats van het verlagen van de mortaliteit, zou het doel moeten zijn om de functionele uitkomsten te verbeteren, evenals de kwaliteit van leven en de terugkeer naar zelfstandigheid.[28] Hoewel men altijd moet streven naar een optimale en op de patiënt afgestemde zorg, moet men zich ook realiseren dat het moeilijk is om de neerwaartse spiraal van kwetsbaarheid te doorbreken. Kwetsbaarheid is een dynamisch syndroom.[11,29] Helaas is het eindstadium van kwetsbaarheid enorm moeilijk te behandelen. In plaats van alle osteoporotische fracturen onwillekeurig chirurgisch te behandelen, zou men moeten investeren in betere secundaire preventie en valpreventie. Daarbij moeten er meer persoonsgerichte behandelplannen gemaakt worden en betere palliatieve behandelstrategieën worden ontwikkeld (Hoofdstuk 11).

Moeten we altijd alles doen voor iedereen?

Chirurgen moeten onderkennen dat geriatrische patiënten, en in het bijzonder kwetsbare patiënten, soms baat hebben bij palliatieve zorg in plaats van een chirurgische ingreep (hoofdstuk 11 en 12).[30–32] Dilemma's rondom medische besluitvorming doen zich vaak voor in situaties waarin beslissingen over behandelingen de grootste gevolgen hebben voor de patiënt.[33,34] Het acute karakter van trauma en de prevalentie van cognitieve stoornissen in deze populatie bemoeilijken (gedeelde) besluitvorming. De samenwerking met onze patiënten kan sterk verbeterd worden als delen van het besluitvormingsproces verplaatst worden naar de niet-acute fase (Hoofdstuk 12). Toch is gedeelde besluitvorming bij geriatrische patiënten altijd een wikken en wegen. De beste manier om met onze patiënt samen te werken is eenvoudigweg door te vragen wat voor hem of haar er het meest toe doet in het leven.[35]

Palliatieve zorg moet worden overwogen voor patiënten met een hoog risico om te overlijden rondom de operatie, patiënten die niet goed ter been zijn in de thuissituatie en voor patiënten bij wie na operatief ingrijpen een lage kwaliteit van leven te verwachten is (hoofdstuk 11). Palliatieve zorg is een holistische benadering die de zorgcoördinatie en de fysieke, psychologische, sociale, culturele, spirituele, ethische en juridische aspecten van zorg aan het einde van het leven behelst.[36] Deze vorm van zorg biedt ondersteuning om de kwaliteit van leven en de kwaliteit van sterven te optimaliseren, zonder het leven te verkorten of te verlengen.[37] Palliatieve zorg kan al dan niet een operatie omvatten. De grootste uitdaging voor palliatieve zorg in de traumatologie is pijnbestrijding. Adequate pijnbestrijding is nodig om toiletgang, herpositionering in bed en persoonlijke hygiëne mogelijk te maken, zodat het levenseinde waardig kan verlopen. Een echogeleid compartimentblok van de fascia iliaca biedt lokale en snel werkende pijnstilling die de pijn na een heupfractuur effectief verlicht en superieur is aan systemische pijnstilling.[38,39] De effectiviteit is echter afhankelijk van de bekwaamheid van de arts die de zenuwblokkade uitvoert en de benodigde katheters voor continue blokkade luxeren gemakkelijk. Het is onduidelijk of continue zenuwblokkade geschikt is voor de palliatieve setting. Hier zal verder onderzoek naar verricht moeten worden.

Aanbevelingen voor toekomstig onderzoek

Er is een toenemende belangstelling voor onderzoek binnen de geriatrische traumatologie, maar de kwaliteit van studies in dit vakgebied is zeer wisselend. Een proefschrift of artikel eindigt meestal met een of andere vorm van de zin “meer onderzoek is nodig”. Dit is niet het geval voor onderzoek in de geriatrische traumatologie. Er is niet *meer* onderzoek nodig, er is *beter* onderzoek nodig. Toekomstig onderzoek zou zich meer moeten richten op de functionele uitkomsten en kwaliteit van leven op de lange termijn, in plaats van op mortaliteit en complicaties op korte termijn. Dit zijn uitkomstmaten die voor de patiënt meer van belang zijn. Beter nog zou zijn om eerst de validiteit te onderzoeken van de methodologie die momenteel op dit gebied wordt gebruikt. Er zijn verschillende aspecten die wetenschappelijk onderzoek in deze populatie bemoeilijken. Men moet betere manieren vinden om deze problemen te verhelpen om daarmee de kwaliteit van onderzoek te verbeteren (Hoofdstuk 10).

Ten eerste, hoewel patiënt-gerapporteerde uitkomstmaten op grote schaal beschikbaar zijn en gebruikt worden in chirurgisch onderzoek, worden ze niet vaak gebruikt in geriatrisch trauma onderzoek. Het is onduidelijk in hoeverre deze uitkomstmaten informatief zijn voor de geriatrische patiënt, omdat ze niet zijn ontworpen voor (kwetsbare) geriatrische patiënten. De Older Persons and Informal Caregivers Survey Short Form (TOPIC-SF) is een zeldzaam voorbeeld van een patiënt-gerapporteerde uitkomstmaat specifiek voor de geriatrische populatie. Deze uitkomstmaat verdient nader onderzoek.[40] Hoewel deze TOPICS-SF nog niet uitgebreid gevalideerd is, wordt deze momenteel geïmplementeerd in de Dutch Hip Fracture Audit en verschillende ziekenhuizen in Nederland.[41]

Ten tweede moet onderzoek inclusiever zijn. Selectieve exclusie van patiënten met cognitieve stoornissen vormt een belangrijke bron van selectiebias bij onderzoek binnen de geriatrische traumatologie. Deze patiënten kunnen geen geïnformeerde toestemming geven en worden derhalve uitgesloten van de meeste prospectieve klinische studies.[42]

Resultaten van studies die deze patiënten uitsluiten kunnen echter niet geëxtrapoleerd worden naar deze patiëntengroep. Dit is een probleem omdat geriatrische fractuurpatiënten met cognitieve stoornissen een hoger risico lopen op mortaliteit en complicaties, en tevens slechtere functionele uitkomsten hebben.[43–45] Onderzoekers die klinisch onderzoek doen sluiten dus juist de patiënten uit die er ook het meeste baat bij zouden kunnen hebben. Ook medisch-ethische commissies moeten op dit punt hun verantwoordelijkheid nemen. Het letterlijk volgen van richtlijnen en voorschriften leidt tot zeer omslachtige bureaucratische toestemmingsprocedures die onderzoekers ontmoedigen. Als gevolg daarvan beschermen zij de rechten van oudere mensen met cognitieve beperkingen niet, maar schenden zij deze juist, doordat ze verhinderen dat ouderen met cognitieve stoornissen kunnen profiteren van wetenschappelijk onderzoek en vooruitgang.[42]

Ten derde is er meer onderzoek nodig om validiteit van naasten van patiënten (bv. familieleden of verzorgers) als informatiebron voor wetenschappelijk onderzoek bij geriatrische populaties vast te stellen. Geriatrische populaties zijn vatbaar voor selectieve follow-up en zogenaamde recall bias (d.w.z. dat patiënten zich soms dingen anders of niet herinneren), een probleem dat gedeeltelijk kan worden ondervangen wanneer naasten (proxies) als informatiebron worden gebruikt. Dergelijke proxy-gerapporteerde uitkomstmaten worden geregeld gebruikt in pediatrisch onderzoek.[46,47] Studies die de validiteit van proxy-gerapporteerde uitkomsten in geriatrisch onderzoek onderzoeken, zijn echter schaars.[43,48–50] Een review over dit onderwerp zou van toegevoegde waarde zijn.

Samenvattend; toekomstig onderzoek op het gebied van geriatrische traumatologie moet van hogere kwaliteit zijn, inclusiever zijn, en meer gebruik maken van proxy-gerapporteerde uitkomsten.

Een cultuuromslag in de geriatrische traumatologie

Het bewerkstelligen van een beter op de patiënt afgestemde benadering voor geriatrische fractuurpatiënten zal een cultuuromslag vereisen. De auteur stelt voor om het vallen en de daaropvolgende fracturen bij geriatrische patiënten te beschouwen als manifestatie van het eindstadium van kwetsbaarheid. Hoewel er zeker uitzonderingen bestaan, moeten deze fracturen beschouwd worden als een slecht voorteken. Ze karakteriseren patiënten die het einde van hun leven naderen of die zich aan het einde van hun leven bevinden. Om de zorg voor deze patiënten te verbeteren, is een omslag in het denken nodig. Artsen (inclusief chirurgen) moeten de complexiteit van geriatrische traumapatiënten beter leren onderkennen en een cultuurverandering teweegbrengen in de geriatrische traumatologie.

Ten eerste moeten chirurgen leren om kwetsbare patiënten te herkennen. Daarbij moeten zij onderkennen dat het vallen bij ouderen en daaruit voortvloeiende fracturen abnormaal zijn. Fracturen in de geriatrische populatie zijn symptomen van een groter geheel van problemen, en het louter behandelen van de fractuur lost de onderliggende kwetsbaarheid niet op. Chirurgen moeten ook basiskennis hebben van geriatrie en palliatieve zorg, en zich bewust zijn van de aanwezigheid van cognitieve stoornissen bij 20% tot 50% van alle geriatrische fractuurpatiënten.[22,44,51–53] De meest effectieve manier om het bewustzijn voor deze aspecten te vergroten zou zijn om ze op te nemen in het curriculum van opleidingsprogramma's.

Ten tweede moeten we streven naar meer holistische en persoonsgerichte zorg. De eerste stap moet zijn om risicopatiënten in een vroeg stadium te identificeren en de behandelwens en behandeldoelen te bespreken. Vraag patiënten wat voor hen belangrijk is en weeg de voor- en nadelen van een operatie af tegen hun zorgdoelen. Voor ernstig zieke patiënten moet palliatieve zorg, die al dan niet een operatie kan omvatten, worden overwogen.

Ten derde moeten we betere strategieën voor preventieve geneeskunde aannemen. Geschikte screeningsintervallen en -criteria voor de primaire preventie van osteoporotische fracturen zijn omstreden. In het kader van secundaire preventie zouden alle patiënten ouder dan 50 jaar die een fractuur oplopen, moeten worden gescreend op osteoporose.[54,55] De secundaire preventie van osteoporose is bewezen effectief. Het aantal mensen de gescreend moet worden om één patiënt met osteoporose op te sporen is laag, evenals het aantal mensen dat behandeld moet worden voor osteoporose om een tweede fractuur te voorkomen.[56] Wereldwijd blijft er echter een zorgkloof bestaan en slechts een kleine minderheid van de patiënten die een osteoporotische fractuur oplopen, krijgt vervolgens behandeling voor osteoporose.[55,57] Als voornaamste reden hiervoor wordt vaak een gebrek aan begrip over de rol van osteoporose als oorzaak van de fractuur bij de behandelend arts gemeld.[55] Dit illustreert het belang van een beter begrip van geriatrische fracturen. Naast secundaire preventie van osteoporotische fracturen dient ook valpreventie overwogen te worden bij oudere volwassenen, ook bij diegenen die nog geen fractuur hebben opgelopen. Het verkrijgen van inzicht in veiligheid en het evalueren van de leefomgeving om gevaren te verminderen is een integraal onderdeel van de geriatrische beoordeling.[58]

Tenslotte, en wellicht het belangrijkste; we moeten betere manieren vinden om samen te werken met onze patiënten. De acute aard van trauma kan niet veranderd worden, cognitieve stoornissen kunnen niet gemakkelijk verholpen worden en onzekerheid betreffende de prognose zal medische besluitvorming op het gebied van geriatrisch trauma altijd uitdagend maken. De samenwerking met onze patiënten kan echter sterk verbeterd worden wanneer delen van het besluitvormingsproces naar de niet-acute fase verplaatst worden. Elke oudere persoon (inclusief, maar niet beperkt tot patiënten) zou gemotiveerd moeten worden om na te denken over wat hun behandelwensen en zorgdoelen zijn in geval van een opname in het ziekenhuis. Daarbij zou het goed zijn om richtlijnen voor zorgplanning op voorhand beschikbaar te hebben. Om dit te bereiken moeten bewustmakingscampagnes, besprekingen over zorgdoelen in ambulante setting, integratie van geriatrie in het curriculum van A(N)IOS, en verbeterde samenwerking met eerstelijns- en verpleeghuisartsen allemaal deel uitmaken van de oplossing. We moeten ouderen aanmoedigen om na te denken over wat hun behandelingswens is, lang voordat ze zich op de spoedeisende hulp melden. Dit zal een ambitieuze onderneming zijn, maar zal van zwaarwegend belang zijn voor de cultuuromslag in de geriatrische traumatologie.

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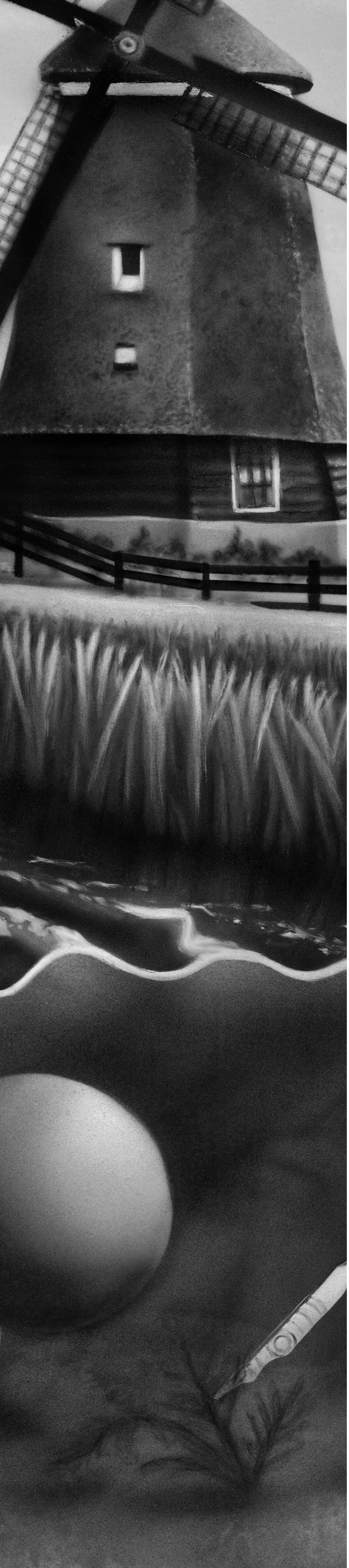

APPENDIX

Promotiecommissie

List of publications

Dankwoord

Acknowledgements

Curriculum vitae auctoris

Epilogue

Promotiecommissie

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List of publications

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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A

Curriculum Vitae Auctoris

Henk Jan Schuijt was born in Utrecht Medical Center, the Netherlands in 1992. Twenty-seven years later, he graduated medical school there. He graduated grammar school in 2010 at Christelijk Gymnasium Utrecht. In addition to his medical degree he holds a bachelor's degree in biomedical sciences. As a former high-performance rower, he likes working in a team setting to achieve the best results possible and stimulate personal development.

During his PhD research in geriatric traumatology, he received several scholarships and research grants. In 2020, he completed a research fellowship in geriatric trauma surgery at Harvard Medical School Orthopedic Trauma Initiative, Boston, United States. He is on the board of the Dutch Virtual Fracture Care taskforce and a member of the Santeon Value Based Healthcare Committee for hip fractures. He started as a house officer for the department of surgery in 2021 at St. Antonius Hospital, and hopes to continue his career in geriatric traumatology soon.

He combines his love for biology and nature in beekeeping, travel, and all sorts of outdoor adventures.

Epilogue: a personal reflection

Memento mori

Few of us realize that as we grow older, we will spend a significant part of our life in bad health. The end of life is not pretty or romantic, but it can be dignified. Some of the most difficult decisions that we have to make in life, will be those at the end.

To ignore or postpone these decisions is a failure to act with a sense of self-determination. The consequences may be severe. There is usually a trade-off between two undesirable outcomes; prolonging needless suffering or shortening valued life. It takes courage, both from patients and physicians, to make end-of-life decisions. These decisions are complicated by the dynamic nature of our personal and cultural values. What is important today, may not be as important tomorrow. From personal experience, I can testify to the immense difficulty of end-of-life decisions for patients and their families.

This thesis has been about culture: culture in surgery, culture in geriatrics, but also western culture and its views regarding the end of life. I have had the privilege to experience some of the differences between Northern-European and Northern-American culture and their views on end-of-life decision making. Although these cultures may seem very different at first glance, I have found that most of these differences are the different expressions of the same underlying common core value: the right to self-determination, and freedom of choice.

And so it occurred to me that, in the end, it does not matter much which choice we make. The freedom to make the choice that we feel reflects our core values is what matters most.

Henk Jan Schuijt

Ma dernière volonté

Moi qui ai vécu sans scrupules
Je devrais mourir sans remords
J'ai fait mon plein de crépuscules
Je n'devrais pas crier "encore"

Vivre, vivre
Même sans soleil, même sans été

Vivre, vivre
C'est ma dernière volonté

Serge Reggiani (Ma dernière volonté, 1977)

A