Örebro Studies in Medicine 285

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Patients with hip fracture: A decade of morbidity and surgery

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Title: Patients with hip fracture: A decade of morbidity and surgery

Publisher: Örebro University, 2024
www.oru.se/publikationer

Print: Örebro University, Repro 12/2023
Cover illustration: Magnus Nordahl
Portrait photo: Magnus Nordahl

ISSN: 1652-4063
ISBN: 978-91-7529-532-9 (print)
ISBN: 978-91-7529-533-6 (pdf)

Hip fracture – just the tip of the iceberg?

To my mum, for your unconditional support.

Abstract

Hip fracture is a devastating condition causing excess mortality in older people. Over recent time, incidence has declined while mortality remains unchanged, suggesting changes in morbidity. Swedish national guidelines recommend preoperative full-body disinfection (FBD) to prevent surgical site infection (SSI) despite little evidence, a method causing patients' substantial pain. The aim of this thesis was to investigate differences in comorbidity, malnutrition, sarcopenia, mortality, surgical characteristics, and functional outcome in patients with hip fracture, ten years apart (I-II). Another aim was to compare preoperative FBD with local disinfection (LD) of the surgical site regarding SSI incidence (III) and experiences of nursing personnel (IV). Patients with hip fracture from 2008 and 2018 (I-II) respectively from 2018 to 2019 (III) and orthopedic nursing personnel (IV) were included. Anthropometric measurements were collected prospectively (I-II) and data from medical records (I-III) and the Swedish hip fracture register (II) were collected retrospectively. Focus group discussions were conducted and analyzed by content analysis (IV). Results suggest increasing levels of comorbidity over time while malnutrition and sarcopenia decreased, potentially explaining the unaltered mortality (I). Concurrently, choice of surgical method seems to have changed, potentially contributing to the seen improvements in functional outcome (II). Study III presented no significant difference in SSI incidence between 2018 (FBD) and 2019 (LD) in the adjusted regression analysis and in study IV nursing personnel testified to an increased wellbeing in patients after the switch to LD. In conclusion, patients who succumb to hip fracture today are not the same as they were yesterday, highlighting the importance of continuous adjustment of treatment and care.

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Original papers

I. Probert N, Lööw A, Akner G, Wretenberg P, Andersson ÅG, 2020. "A Comparison of Patients with Hip Fracture, Ten Years Apart: Morbidity, Malnutrition and Sarcopenia". *The Journal of Nutrition, Health & Aging, DOI: 10.1007/s12603-020-1480-2*

II. Probert N, Andersson ÅG, 2023. "Functional outcome in patients with hip fracture from 2008 and 2018 and the significance of hand grip strength - a cross-sectional comparative study". *BMC Geriatrics, DOI: 10.1186/s12877-023-04398-9*

III. Probert N, Andersson ÅG, Magnusson A, Kjellberg E, Wretenberg P, 2022. "Surgical site infection after hip fracture surgery: preoperative full-body disinfection compared to local disinfection of the surgical site - a population-based observational cohort study". *European Geriatric Medicine, DOI: 10.1007/s41999-022-00640-6*

IV. Probert N, Blomberg K, Wretenberg P, Andersson ÅG, 2023. "Traditional compared to modified method of disinfection before hip fracture surgery - Experiences of nursing personnel". *International Journal of Orthopaedic and Trauma Nursing, DOI: 10.1016/j.ijotn.2023.101002*

Abbreviations

SNBHW	Swedish National Board of Health and Welfare
ICD-10	International Classification of Diseases 10^{th} Revision
CCI	Charlson Comorbidity Index
ECM	Elixhauser Comorbidity Measure
ASA	American Society of Anesthesiologists'
PIM	Potentially Inappropriate Medication
FRID	Fall-Risk Increasing Drug
GLIM	Global Leadership Initiative on Malnutrition
EWGSOP	European Working Group on Sarcopenia in Older People
HGS	Hand grip strength
CC	Calf circumference
LOS	Length of stay
HA	Hemiarthroplasty
THA	Total hip arthroplasty
ADL	Activities of daily living
SSI	Surgical site infection
FBD	Full-body disinfection
LD	Local disinfection
SHR	Swedish hip fracture register
FGD	Focus group discussion
BMI	Body mass index

1 Introduction

1.1 Hip fracture in retrospect

Hip fractures have since the beginning of man been a common injury and cause of death within human populations. Palaeopathological literature demonstrates that age-associated osteoporosis was present in prehistoric populations and documented cases of hip fracture related to osteoporosis date back to the XIIth dynasty in Egypt (1990-1786 B.C.) [1-3]. Charles the IVth, king of Bohemia and Roman Emperor, living in the XIVth century is one of the earliest documented cases of femoral neck fracture in a known person. Anthropological examinations of his remains have revealed an intracapsular fracture of the left femoral neck sustained from a fall or jump most certainly causing his death [2].

In the first half of the 19th century, fractures were predominantly treated non-operatively due to fear of infection and pain. The most common surgery at that time was amputation of the limb. The inventions of anaesthesia (year 1846), antiseptic methods (year 1865) and X-ray (year 1895) majorly influenced the development of operative treatment. Osteosynthesis, up until 1886 conducted with ivory pegs, wires, and primitive external fixation, was revolutionized between 1886-1921 and methods of osteosynthesis such as plates, cerclage, external fixation, and intramedullary nailing was integrated in clinical practice. In 1925 the first mold arthroplasty, initially made of glass, was created by Marius Smith-Petersen [4]. Sir John Carnley later fashioned the first low friction cemented hip implant in the late 1950s, modernizing the method of arthroplasty, majorly used as a treatment for femoral neck fractures today [5].

1.2 Demography

Today, hip fracture is a global health problem engaging all human populations. In the year of 2000, the global incidence was estimated to 1.6 million. Furthermore, since a hip fracture generally incurs disability for a much longer period than a year after the incident, the concurrent prevalence was estimated to 50 million worldwide [6].

The greatest number of osteoporotic fractures, including hip fractures, is seen in Europe. Sweden represents one of the highest incidences of hip fracture globally [6, 7] with approximately 16000 registered cases annually [8]. Incidence of hip fractures is expected to rise with a growing population and increasing longevity [9], a major concern due to the following economic burden, disability, and excess mortality, subsequently increasing demands on healthcare in prevention and management [6, 10, 11]. However, in contradiction to earlier estimates, hip fracture incidence has declined or remained constant during the last decades in Sweden as well as in other western countries. Causes for this are unclear, the rise of anti-osteoporotic treatment is a known and debated factor but does not seem to solely explain the seen trends [12-15].

1.3 Patient characteristics

General characteristics

Patients who succumb to hip fracture are to a greater extent women, representing approximately 70% of the population and globally the peak number of hip fractures occur between the ages of 75-79 years [6]. The latest national figures in Sweden present that 66% of the patients are female and that the mean age is 82 years. Furthermore, figures also present that the mean age and the proportion of male patients has increased during the last decades [8].

Osteoporosis

Osteoporosis is a key factor in why women constitute a larger proportion of patients who succumb to hip fracture. Humans reach peak bone mass in young adulthood and until midlife, bone mineral density remains relatively stable for both genders. Following menopause however, women undergo a phase of rapid bone loss due to an age-related decrease in levels of serum estradiol, resulting in 20-30% loss of trabecular/cancellous bone as well as 5-10% loss of cortical bone. Trabecular bone is most prominent in the vertebrae and distal forearm while cortical bone is most prominent in the mid forearm and proximal femur. This phase of rapid bone loss is most commonly present during the first 15-20 years after menopause and can result in the syndrome called type 1 osteoporosis. Type 1 osteoporosis is characterized by compression fractures of the vertebrae and fractures of the forearm.

Men are not exposed to this rapid loss of bone. However, present in both men and women is also a slow, purely age-related, late phase of bone loss which continues indefinitely. This type of bone loss results in losses of approximately 20-30% of cortical bone and can cause the syndrome called type II osteoporosis. Loss of cortical bone is mostly associated with fractures of the vertebrae and proximal femur [16].

Type I osteoporosis is directly caused by loss of estrogen causing increased absorption of bone accompanied by inadequate formation. Research suggests that the slow phase of bone loss in type II osteoporosis is mediated by an increased bone turnover caused by age-related increases of parathyroid hormone [16, 17].

1.4 Morbidity

Multimorbidity

Morbidity, which increases with age [18], is typically high within this patient category [19-22] and associated with postoperative mortality [23, 24]. Multimorbidity, most commonly defined as suffering from two or more chronic comorbidities, although no definition consensus exists [25], has been associated with an increased risk of hip fracture [26]. The Swedish National board of Health and Welfare (SNBHW) defines multimorbidity as having been admitted to institutional care at least three times due to diagnoses in at least three different groups of the classification system International Classification of Diseases 10^{th} Revision (ICD-10) during a 12-month period [27].

Comorbidity

Comorbidities are coexisting diseases and conditions that are distinct from the primary diagnosis under investigation. Considering specific comorbidities among patients with hip fracture, diseases of the circulatory system such as hypertension and ischemic heart disease as well as cognitive disorders have been found to be specifically prevalent [28, 29]. There is no gold standard for quantifying the burden of comorbidities in research and therefore multiple comorbidity indices have been introduced in literature, varying in their predictive performance. Two commonly used indices in research of orthopaedic surgery are the Charlson Comorbidity Index (CCI) and the Elixhauser Comorbididty Measure (ECM) [30-32] where studies have suggested that the ECM is superior to the CCI in predicting postoperative mortality, hospital stay, and adverse events in patients with hip fracture [30, 31]. In 2021 Ludvigsson et al. introduced a new coding system for the CCI adapted for register-based research in Sweden which majorly simplified and further validated the use of the CCI [33].

American Society of Anesthesiologists' Physical Status Classification System

American Society of Anesthesiologists' (ASA) Physical Status Classification System is a scale for assessing and categorizing a patient's physical health preoperatively. It was introduced in 1941 and has since then undergone some modifications in improving reliability and minimizing the effect of subjectivity. The classification is a six-point scale ranging from an otherwise healthy patient (ASA I) to a patient classified as brain dead (ASA VI) [34]. ASA class is frequently used in research based on registered data as a measure of morbidity and has been significantly associated with postoperative complications and mortality in patients with hip fracture [35, 36].

1.5 Drug use

Polypharmacy

The use of prescribed drugs is another factor affecting the population with hip fracture. Polypharmacy is commonly defined as the use of five or more medications, yet there is no consensus to this definition [37]. The risk of hip fracture has been seen to increase with the number of medications used, specifically 10 or more, and in coherence with comorbidity the prevalence of polypharmacy is specifically high [29, 37]. Previous studies report inconclusive results regarding weather polypharmacy increases mortality post hip fracture or not [38, 39].

Potentially Inappropriate Medications

Certain drug categories become inappropriate for the elderly due to physiological changes related to aging, causing adverse events greater than the benefits. In USA during the mid-1980's the value of evaluating drug use in older people became apparent when it was highlighted that nursing home residents were regularly inappropriately treated with psychotropic medications. As a results of this, to improve the drug use in older patients and to alert physicians of the high risk of adverse events, a list of inappropriate medications was compiled by Beers et al., published in 1991 in USA [40] and latest updated in 2019 [41]. Several European lists have since then been introduced, there among in Sweden by the SNBHW [42] and studies commonly refer to these drugs as potentially inappropriate medications (PIMs). Studies of patients with hip fracture have presented that PIMs are associated with an increased mortality post hip fracture [43, 44].

Fall Risk Increasing Drugs

Introduced in literature are also medications known to increase the risk of falling and therefore the risk of hip fracture, commonly referred to as fall risk increasing drugs (FRIDs) [38, 45]. Swedish studies report that approximately 60-99% of hip fracture patients are treated with FRIDs prior to their fracture incident and that prescription of these drugs significantly increases at or after discharge [45, 46]. The use of FRIDs has been associated with an increased mortality post hip fracture [38]. A list of FRIDs has also been compiled by the SNHBW [47].

1.6 Mortality and morbidity over time

Mortality is high among patients with hip fracture and studies present that patients compared to the general population have a significantly increased mortality rate for up to two years postoperatively [23]. Swedish national data reports of a four-month mortality rate of 17% and a one-year mortality rate over 25% [8, 13].

During the last decades in Sweden, as well as internationally, mortality rates seem to have remained unaltered despite a concurrently declining incidence of hip fracture. This has in turn been suggested to be a consequence of an increase in morbidity and frailty within the population [13, 19, 21]. A few studies have examined the development of the population and its morbidity over time presenting homogenous results of an increased comorbidity burden and polypharmacy while mortality and incidence has decreased or remained unchanged, potentially witnessing of a decrease in frailty by advances in treatment of comorbidities, hip fracture and a more individualized care [19, 21, 22, 48, 49].

1.7 Frailty

Frailty is a current and central concept when it comes to older populations and specifically patients with hip fracture, increasing with age and being predictive of falls, disability, hospitalization, and death [50]. The concept was introduced in literature during the 1950s and since then, multiple operational definitions have emerged. The frailty phenotype including weight loss, exhaustion, weakness, slow walking speed and low physical activity introduced by Fried et al. in 2001 is considered the birth of frailty [50]. Multidimensionality and multimorbidity are important manifestations, although since frailty is neither a disease nor an unavoidable consequence of aging it has been difficult to define or measure and a consensus definition does not exist [50, 51]. It has been suggested by previous studies that the elderly population might be too heterogenous to be assessed by one tool and that the research purpose and population characteristics should instead determine the most appropriate definition to be applied [51]. Malnutrition, sarcopenia, and comorbidity are factors that majorly overlap with and contribute to frailty, being a multifaceted condition [52, 53].

1.8 Malnutrition

Prevalence of malnutrition is increasing with life expectancy and age-related pathological conditions. Nutritional disorders are specifically prevalent in older people due to several mechanisms such as decline of physiological functions, reduced resilience to stressors, chronic diseases, inflammation, and factors such as disabilities, depressive or cognitive disorders, among others, causing an insufficient dietary intake [54]. Malnutrition can be caused by a decreased intake or assimilation of nutrients although there is also a growing appreciation of that malnutrition can be disease- or injury related, caused partly by acute or chronic inflammation altering body composition and compromising biological function [55, 56]. A central aspect in both malnutrition and frailty is loss of body tissue and the syndromes are often present in the same patients due to similar aetiologies and definitions [52, 57]. Premorbid malnutrition has been shown to be common in patients with hip fracture associated with poorer outcomes and mortality. However, the reported prevalence varies greatly between studies owing to the variety of assessment tools used historically [58, 59].

Despite malnutrition being a global concern there has been a lack of acceptance and global unity in diagnostic criteria for clinical settings. However, in 2019 consensus was reached regarding a definition of malnutrition by the Global Leadership Initiative on Malnutrition (GLIM) [56]. This definition includes a two-step approach, first identifying individuals "at risk" and then diagnosing, respectively, grading the severity of malnutrition. The definition includes three phenotypic criteria and two etiologic criteria where at least one phenotypic criterion and one etiologic criterion is required for diagnosis. The phenotypic criteria include weight loss, low body mass index (BMI) (under a certain cut-off) and reduced muscle mass (measured by validated techniques) and the etiologic criteria include reduced food intake or assimilation loss and inflammation due to acute or chronic disease or an acute injury such as hip fracture [56].

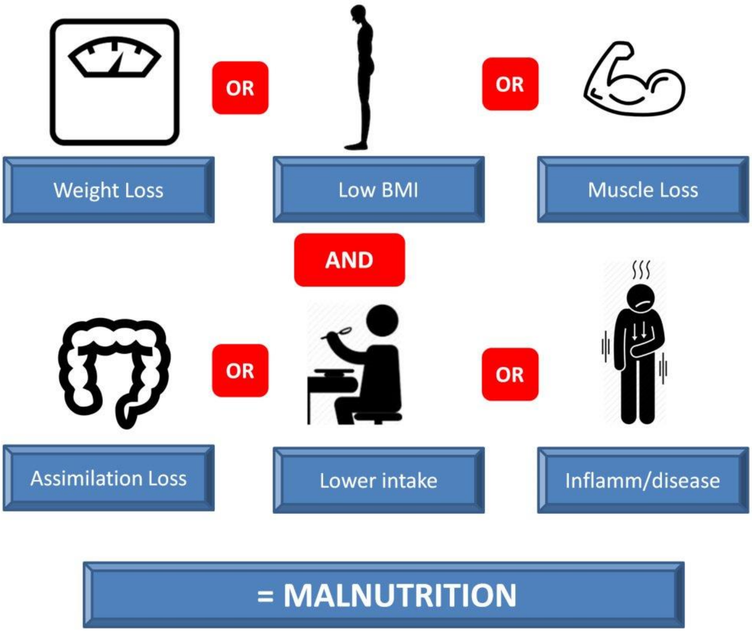

Figure 1. The phenotypic and etiologic criteria included in the diagnosis of malnutrition as defined by GLIM. Reprinted with permission from the *European Society of Clinical Nutrition and Metabolism, GLIM! Global Consensus for Diagnosing Malnutrition. (espen.org).*

1.9 Sarcopenia

Muscle mass and strength vary across a lifetime, naturally declining with age. Skeletal muscle is vital for breathing, posture, and movement although studies have also presented linkages with protein metabolism, nutritional status and ultimately frailty [60]. Sarcopenia is a progressive and generalised muscle disease defined as a certain extent of age-related loss of skeletal muscle and strength in turn causing disability and dependence. Thus, sarcopenia is largely attributable to aging although research also presents how genetic and lifestyle factors have a role in development and progression of the disease. Sarcopenia can be classified as acute or chronic and as primary with no evident cause but age or as secondary with an evident cause such as systemic disease, inactivity, or malnutrition [61, 62].

There is a clear association between sarcopenia and an increased risk of falls, fractures, and all-cause mortality [62, 63]. The physical phenotype of frailty as described by Fried et al. in 2001 significantly overlaps with sarcopenia where low muscle strength and weight loss are important characteristics of both conditions [50, 52]. Studies indicate that sarcopenia is a predictor of hip fracture, also associated with an increased postoperative mortality [64, 65]. The prevalence of sarcopenia among patients with hip fracture varies between 20-70% in studies, differing in their applied tool of assessment [64, 66, 67].

In 2010, the European Working Group on Sarcopenia in Older People (EWGSOP) introduced a sarcopenia definition that has since then been recognized and used globally and in 2019 an update to this definition was published (EWGSOP2) [61]. The definition consists of three steps where initially probable sarcopenia is identified, diagnosis is confirmed and finally the severity of sarcopenia is assessed. Probable sarcopenia is identified by criterion 1 in confirming low muscle strength by any validated tool such as measuring hand grip strength (HGS) or by the chair stand test. Diagnosis is confirmed by criterion 2 in confirming low muscle quantity or quality which can be estimated by several objective techniques such as magnetic resonance imaging, computed tomography, or dual-energy X-ray absorptiometry. An anthropometric measurement such as calf circumference (CC) is recommended as a diagnostic proxy for muscle quantity in older people and acute settings where no other superior methods are available. Finally, the severity of sarcopenia is assessed in criterion 3 by evaluating physical performance [61].

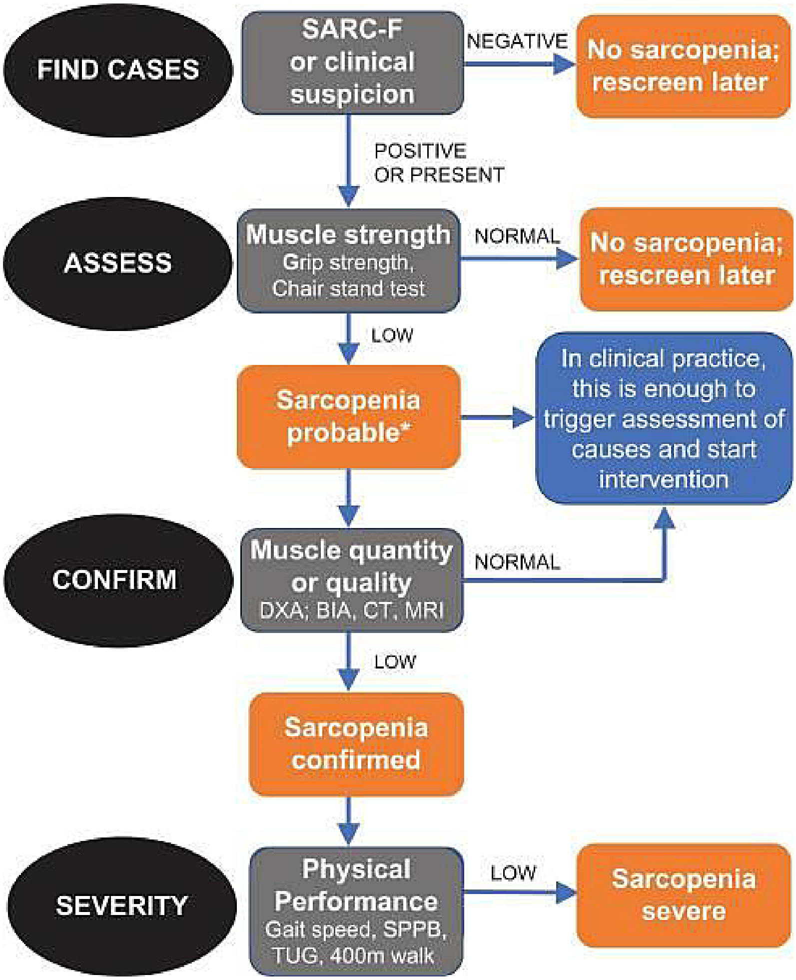

Figure 2. The EWGSOP2 algorithm for identifying, diagnosing, and assessing severity of sarcopenia in clinical practice as defined by the EWGSOP.
Reprinted with permission from *Age and Aging [61].* SARC-F is a screening tool/questionnaire for sarcopenia. DXA: dual-energy X-ray absorptiometry, BIA: bioelectrical impedance analysis, CT: computed tomography, MRI: magnetic resonance imaging, SPPB: Short Physical Performance Battery, TUG: Timed-Up and Go test.

1.10 Clinical characteristics

Fall characteristics

Over 95% of hip fractures are predisposed by a fall and low-energy trauma by a coplanar fall from standing height is the most common scenario. Most patients do not manage to break the fall with for example an outstretched arm and the impact is often to the greater trochanter or to the posterolateral aspect of the pelvis. However, only 1-2% of all falls result in a hip fracture and studies have found that biomechanics such as fall direction and impact location play a major role in determining the outcome [68, 69]. Younger patients who succumb to hip fracture have more commonly suffered from a high-energy trauma [70].

Clinical signs of hip fracture typically include bruising at the trochanter area, a shortened and externally rotated leg and hip pain specifically during rotation [71].

Anatomical classification

The hip is a synovial joint consisting of the femoral head and the acetabulum formed by the ischium, pubis, and ilium of the pelvis. The femoral head is attached to the femoral shaft via the femoral neck which is localized between the greater and lesser trochanter. Hip fractures are commonly classified according to their relationship to the hip capsule as either intracapsular or extracapsular. Intracapsular hip fractures are fractures within the hip joint although excluding fractures of the femoral head and therefore including fractures of the femoral neck also known as cervical fractures. Femoral neck fractures are classified as either subcapital, transcervical or basicervikal depending on what region of the femoral neck is fractured, in addition to being either nondisplaced or displaced [72, 73]. Patients with femoral neck fractures tend to be slightly younger with a better pre- and post-fracture functional ability than patients with trochanteric fractures [74]. Extracapsular fractures are those distal to the hip joint to a limit of 5 cm distal to the lesser trochanter. Extracapsular fractures are classified as either intertrochanteric also known as pertrochanteric fractures or subtrochanteric depending on their relationship with the lesser trochanter [72, 73]. According to national data approximately 50% of hip fractures in Sweden are intracapsular respectively extracapsular where intertrochanteric fractures are more common than subtrochanteric fractures [8].

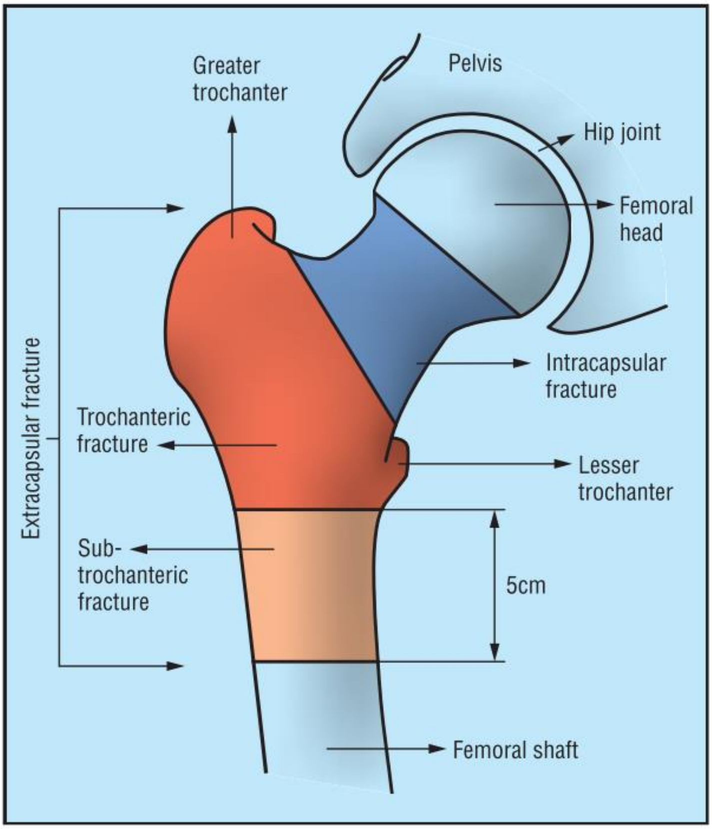

Figure 3. Anatomical classification of hip fractures. Reprinted with permission *from BMJ publishing group Ltd [75].*

1.11 Treatment, management, and functional outcome

Surgical treatment

Hip fractures generally require surgical treatment otherwise risking a significantly poorer outcome and increased mortality. Although a few cases, essentially nondisplaced intracapsular fractures, are treated conservatively, predominantly due to medical reasons [76, 77]. Swedish national data presents that approximately 0.5% of all nondisplaced femoral neck fractures were treated conservatively in the year of 2021 [8].

The major surgical methods used in hip fracture surgery are arthroplasty or internal fixation. Arthroplasty is associated with a longer surgical duration and length of stay (LOS) than internal fixation although potentially a better functional outcome [74, 78]. It is unclear whether the methods differ regarding postoperative mortality, but a higher failure rate has been seen for internal fixation, requiring further surgery [78].

Considering intracapsular fractures the surgical strategy used is majorly based on fracture displacement. Nondisplaced femoral neck fractures can generally be managed by internal fixation with osteosynthesis using either screws or pins [72]. Displaced femoral neck fractures can also be treated by internal fixation although more patients are treated with arthroplasty due to an increased risk of avascular necrosis of the femoral head [79]. Arthroplasty is either performed as hemiarthroplasty (HA) where only the femoral head is replaced or as total hip arthroplasty (THA) where the femoral head and the acetabulum are replaced. HA is associated with lowers costs, shorter surgical time, less blood loss, and lower risk of dislocation whereas THA is associated with a better functional outcome as well as a lower risk of reoperation and is therefore generally chosen for physiologically younger and more active patients [80, 81].

Intertrochanteric fractures are essentially treated by internal fixation where the choice of implant is largely based on fracture stability. The major implants used are either sliding hip screws or intramedullary devices where the later alternative essentially infers a greater biomechanical stabilization in unstable intertrochanteric fractures

[82]. Subtrochanteric fractures are most commonly treated with intramedullary devices [72].

Time to surgery

Time to surgery is a debated factor when it comes to the postoperative outcome and prognosis after a hip fracture. A prolonged time to surgery has been significantly associated with increased intra- and postoperative medical complications such as cardiovascular disorders, infections, and pressure sores as well as postoperative mortality. However, studies differ in their exact definition of a prolonged time to surgery and no exact benchmark waiting time exists. Although, it is generally agreed upon that patients' benefit from receiving surgery within 24 to 48 hours [83-86]. On the other hand, there is also evidence of that patients with depraving medical conditions can benefit from delayed surgery due to preoperative stabilization [87]. According to national recommendations in Sweden a goal is that 80% of all patients with hip fracture should have received surgery within 24 hours after arriving at a healthcare facility where the currently achieved proportion amounts to 60% [8].

Functional outcome and HGS

Hip fractures are a major cause of disability worldwide and survived patients experience significantly worse functional independence, mobility, quality of life, health, and increased institutionalization than age-matched controls. The most significant recovery occurs within the first six months postoperatively whereas approximately 40-60% of patients never regain their pre-fractural level of function [10]. Thus, functional outcome is a critical subject when it comes to patients with hip fracture and an important indicator of potential developments in healthcare.

Early functional evaluation in hip fracture patients has an important prognostic value and HGS is an objective and easily measured surrogate for whole body- and specifically lower-limb strength [88, 89] in addition to being an important factor in assessment of frailty and sarcopenia as mentioned earlier [90, 91]. HGS is measured in kilograms (kg) with a hand dynamometer, easily performed bedside.

Previous studies indicate that HGS as measured both pre- and postoperatively is positively associated with functional outcome in terms of success of rehabilitation, a better performance in activities of daily living (ADL) and independent walking ability within the first year postoperatively [92-95].

Development over time

During the last decades in Sweden as well as in other Nordic countries there has been a development towards an increased use of arthroplasty as opposed to internal fixation in treatment of intracapsular fractures and an increased use of intramedullary devices as opposed to other methods of osteosynthesis in treatment of extracapsular fractures [74, 96, 97]. At the same time LOS has decreased and time to surgery has remained unchanged [3]. However, despite developments in surgery and management, according to longitudinal studies, subsequent functional outcome seems to have remained unaltered, a suggested reason being a concurrent increase in comorbidity burden and potential frailty within the population [3, 74].

1.12 Surgical site infection

Surgical site infection (SSI) after hip fracture surgery is a disastrous complication associated with increased mortality [98, 99]. SSIs are commonly divided into superficial infection of the skin or subcutaneous tissue and deep infection of the fascia, muscle, and prosthetic devices- or implant material [100]. Incidence varies from 1-8%, deep infection representing 1-2% [98, 99, 101-105]. Numerous risk factors have been identified, both related to patient characteristics [103, 104, 106-108], and to surgery [102-104, 109-112]. Association has also been identified for postoperative factors such as increased LOS, readmission [113], and other infections [114, 115].

The source of pathogens is often the endogenous flora of the patient's skin and Staphylococcus aureus (S. aureus) is the most frequently isolated pathogen [98-100]. Therefore, an obvious strategy for SSI prevention is preoperative skin disinfection.

1.13 Preoperative disinfection

Full body disinfection

The Swedish Handbook for Healthcare recommends that patients planned for surgical procedures posing a risk of infection by skin colonizing bacteria go through full-body disinfection (FBD) with 4% chlorhexidine preoperatively [116]. This method is well established and has been recommended for decades [117] based on earlier research presenting evidence of an increased frequency of skin infections in patients colonized with skin pathogens [118], FBD with chlorhexidine causing a significant decrease in skin colonizing bacteria particularly during the first 48 hours after disinfection [119-122], chlorhexidine being superior to ordinary soap in eradicating bacteria [123] and the eradication being amplified after repeated disinfection with chlorhexidine [120]. However, according to more recent studies questioning the method, FBD decreases the amount of skin colonizing bacteria but it is uncertain whether this results in a reduction of SSIs and systematic reviews present that there in fact does not seem to be any clear evidence of benefit in using FBD with 4% chlorhexidine compared to placebo, no wash or regular soap in terms of SSI prevention [124-128]. Due to the notion of this over the past years, the recommendation is carried out by less than 50% of all orthopaedic clinics in Sweden [129].

Patient experiences

Qualitative studies of patients with hip fracture and their experiences of the preoperative phase have described how the pain in conjunction to movement is experienced as the most intense [130] and that specifically the preoperative shower is a cause of pronounced pain [131], in some cases despite having received a femoral block [132]. It is well documented that patients with hip fracture and specifically patients with cognitive impairment are continuously being undertreated with analgesics according to their pain-level [133, 134] which is in turn associated with an increased risk of delirium, prolonged hospitalization, and postoperative pain [133, 135, 136].

2 Aims

This thesis aims to investigate differences in comorbidity, malnutrition, sarcopenia, mortality, surgical characteristics, and functional outcome in patients with hip fracture, ten years apart as well as to compare preoperative FBD with local disinfection (LD) of the surgical site regarding SSI incidence and experiences of nursing personnel. The specific objectives of each study are outlined below.

Study I	To investigate possible differences in morbidity, malnutrition, sarcopenia, and specific drug use in patients with hip fracture from 2008 and 2018 and to analyse the potential association with 1-year mortality.
Study II	To compare patients with hip fracture from 2008 and 2018 regarding surgical characteristics and four-month functional outcome in relation to individual morbidity. A secondary aim is to compare postoperative HGS in relation to walking ability at four months postoperatively.
Study III	To compare preoperative FBD prior to hip fracture surgery with LD of the surgical site regarding incidence of postoperative SSI.
Study IV	To describe the experiences of nursing personnel regarding the performance of preoperative LD on patients prior to hip fracture surgery after having switched from FBD.

3 Materials and methods

3.1 Design

This thesis included patients with hip fracture from 2008 and 2018 (I-II) respectively 2018-2019 (III) and orthopedic nursing personnel (IV). Anthropometric measurements were collected prospectively (I-II) and data from medical records (I-III) and the Swedish hip fracture register (SHR) (II) were collected retrospectively. Focus group discussions (FGDs) were conducted and analyzed by content analysis (IV).

Study I was a prospective cohort study were all patients with hip fracture diagnosed with ICD-10 codes S72.0, S72.1 or S72.2 treated with hip fracture surgery at Örebro University Hospital, Sweden during a five-month period in 2008 and in 2018 respectively, were prospectively invited to participate. Data were obtained from consecutive bedside anthropometric measurements and retrospective review of individual medical records.

Study II was a prospective cohort study based on the same prospectively sampled cohorts as study I, described above. Data were obtained by consecutive bedside measurements of HGS and retrospective review of individual medical records. Data on functional outcome at four months postoperatively were retrospectively extracted from the SHR.

Study III was a retrospective cohort study were all patients diagnosed with ICD-10 codes S72.0, S72.1 or S72.2 who underwent hip fracture surgery at Karlskoga Hospital, Sweden between January 2018, and December 2019, were consecutively included. Patients in 2018 were prepared with FBD preoperatively and patients in 2019 were prepared with LD of the surgical site.

Study IV was a qualitative study where data were collected by FGDs and analysed using inductive content analysis. This study was based on the same change in method of disinfection as study III. Inclusion criteria were working as a nurse or an assistant nurse at the orthopaedic ward.

Table 1. Methodological overview of study I-IV.

		Study			
		I	**II**	**III**	**IV**
Study design	Prospective/retrospective cohort study	Yes	Yes	Yes	No
	Qualitative study	No	No	No	Yes
Source population	Regional, Örebro County	Yes	Yes	Yes	No
	Specific to Karlskoga hospital	No	No	No	Yes
Data sources	Medical records	Yes	Yes	Yes	No
	Physical examination	Yes	Yes	No	No
	The National Quality register for Hip Fractures	No	Yes	No	No
	Focus group discussions	Yes	Yes	Yes	No
Study Population	Patients undergoing hip fracture surgery	Yes	Yes	Yes	No
	Nursing personnel of the orthopaedic ward	No	No	No	Yes
Exclusion criteria	No exclusion criteria	Yes	Yes	Yes	Yes
Time period	Five months in 2008 and 2018, respectively	Yes	Yes	No	No
	2018-2019	No	No	Yes	Yes
Sample, included	$n = 76 + 78$	Yes	Yes	No	No
	$n = 237 + 259$	No	No	Yes	No
	$n = 12$	No	No	No	Yes
Outcomes	1-year mortality	Yes	No	No	No
	Four-month functional outcome	No	Yes	No	No
	SSI and SSI and/or death	No	No	Yes	No

Table explanation: green colour, yes; red colour, no.

3.2 Participants

This thesis included 78+76 (I-II) respectively 237+259 (III) patients with hip fracture and in total 12 participants consisting of nursing personnel working at an orthopaedic ward (IV). The specific dropout of each study is described below.

In study I and II a total of 108 patients in 2008 and 97 in 2018 were invited to participate, consent was not retrieved from 30 respectively 21 eligible patients during each year, leaving 78 patients included in 2008 and 76 in 2018. The major reason for non-consent was impaired ability to give consent due to cognitive state in the acute setting. No cognitive screening tests were performed.

In study III primarily 276 patients were included in 2018 and 297 patients were included in 2019. Due to unavailable medical records, secondary fracture during the study period, and incorrect disinfection, 43 respectively 36 patients were secondarily excluded leaving 237 patients included in 2018 and 259 patients included in 2019.

In study IV participants were purposively sampled from personnel working at the orthopaedic ward five months after the intervention was implemented. At the time of inclusion there were 17 assistant nurses and 13 nurses employed and all had experience of performing both FBD and LD on patients prior to hip fracture surgery. The ambition was to recruit four to six participants per focus group to enhance discussions and to achieve theoretical saturation [137, 138]. In total, three FGDs were conducted for the study where the focus groups included five, four respectively three participants in each group.

3.3 Settings

The studies within this thesis took place at Örebro University Hospital (I-II), an urban hospital, and at Karlskoga hospital (III-IV), a rural hospital that constitute two out of three regional hospitals within the county of Örebro in Sweden. Örebro University Hospital constitutes one out of seven University Hospitals in Sweden.

Patients in study I and study II received surgery, pre- and postoperative care as well as in-hospital physiotherapy according to normal routine. The study setting was not different for patients in 2008 respectively 2018.

In study III and IV, up until 2018, preoperative disinfection was performed as FBD with 4% chlorhexidine meaning patients were showered twice during one occasion taking place on a specific shower-gurney in a specific shower room. In 2019 preoperative disinfection was performed as LD of the planned surgical site with 4% chlorhexidine meaning patients were disinfected once during one occasion in their own hospital bed. During both years, the respective procedures were performed once within 24 hours before surgery. If time to surgery was longer than 24 hours, disinfection was repeated. All preoperative procedures of disinfection were performed by nursing personnel of the orthopaedic ward at Karlskoga hospital. For each patient, a standardized form was completed by nursing personnel addressing how the preoperative disinfection had been performed.

Apart from the preoperative method of disinfection, patients in study III received surgery, pre- and postoperative care as well as in-hospital physiotherapy according to normal routine.

3.4 Data sources

Medical records

Individual medical records were used as a partial data source in study I-III. Study I and II partly included patients admitted in 2008 and during this time at Örebro University Hospital, medical records were not digitalized but written manually and kept in paper form. Medical records of patients included in 2018 and later in this thesis were digital. A standardized review protocol was used when data was collected from medical records and data in study I-III collected this way included: data on patient characteristics, comorbidities, ASA class, medications, surgical characteristics, experience of surgeon, hospitalization characteristics, SSIs, other infections apart from SSIs and mortality.

Physical examination

Study I and II included anthropometric measurements of BMI, CC and HGS performed bedside during hospitalization. Weight is by rule measured on all patients by nursing staff during hospitalization and noted according to date in the medical records. In addition, the patient's height is in most cases also registered in the medical records and from this, BMI was calculated for each patient in study I. Measurements of both CC and HGS were carried out bedside before discharge within the first seven days postoperatively by a few licensed physiotherapists, trained in the methods. CC was obtained by measurement of the widest point of the patient's calf where the widest measurement was evaluated. HGS was measured with a hand dynamometer (Jamar) in kilograms (kg) where the best attempt of three after assessment of both hands was evaluated.

The Swedish Hip Fracture register

The National Quality Register for Hip Fractures in Sweden, RIKSHÖFT is one of the oldest Swedish national quality registers, founded in 1988. Data in the register is contributed by almost all orthopaedic departments in Sweden amounting to an estimated coverage of 80-90% of all hip fractures. The register covers data of patient characteristics, treatment, reoperation, functional outcome, and mortality with the purpose of evaluating potential development in Swedish healthcare, assessing regional differences, and spreading knowledge [8].

To uphold quality of data the registry-software has since 2013 been enforced with automatic logical controls. The registering individual is automatically warned if an unusual combination of for example a specific fracture type or a surgical method is registered or if a non-valid id-number or an un-logical time-sequence is inserted. Furthermore, spot checks of data comparison with corresponding medical records are performed continuously by the register coordinator and registrars.

Provided an adequate ethical approval has been obtained, all data in the SHR is available for researchers. Study II included the following data from the register: patient housing, walking ability, need of walking aids at four months postoperatively and information on potential reoperation.

Focus group discussions

Data in study IV were collected via FGDs, a common method in qualitative research where group interaction is used to generate data. The method is specifically suitable when the purpose is to examine experiences of a group. The group in which the interview is performed should be homogenous in some aspect, for example a group exposed to the same experience. This makes the method specifically suitable when the aim is to investigate how a group has experienced a specific phenomenon, possibly sufficing appropriate means for implementation [137-139].

FGDs require a group of participants and a so-called moderator, acting as a discussion facilitator. Focus groups do not require a specific number of participants although too few could potentially impede discussions and risk that nuances of the experiences are left unspoken [139].

In study IV, all FGDs were conducted within two weeks during May 2019 and took place in a private breakroom at the orthopaedic ward. The timing was considered to ensure that personnel would have enough experience of the new method to discuss their experiences, although still remembering the previous method clearly. The second author of study IV, trained in qualitative research, acted as moderator and the first author acted as co-moderator, observing the FGDs. The FGDs were semi-structured by use of an interview guide ensuring that they included the same content areas. The interview guide included open ended questions based on the principal question: “In light of having performed FBD on patients on a shower gurney prior to hip fracture surgery, what are the experiences of nursing personnel regarding the performance of LD of the patients fractured hip in their own bed?” Exploratory questions were sometimes added to deepen the understanding of participants’ experiences. The interview guide was tested in a pilot FGD, no changes were made after the pilot FGD which was included in the analysis. Audio recordings were made of the FGDs that lasted between 43-50 minutes. All recordings were transcribed verbatim by a professional transcriber. After three FGDs had been performed no new experiences were described and data saturation was deemed reached [138] whereas no further FGDs were conducted.

3.5 Definitions and outcomes

Comorbidity and multimorbidity

In study I and II comorbidities were verified according to registered ICD-10 codes in the medical records where all comorbidities of the ECM were evaluated [140] and multimorbidity was defined as having ≥3 comorbidities.

In study III comorbidities were verified according to registered ICD-10 codes and the CCI was calculated according to the coding system by Ludvigsson et al. for each patient [33]. Cognitive impairment, an important risk factor of SSI [141] and a relevant characterizing factor when it comes to geriatric populations was presented separately in the results, in addition to being included in the CCI calculated for each patient. Cognitive impairment was defined as all patients diagnosed with ICD-10 codes of dementia and delirium (F00-F05). The code E11.9 (uncomplicated type 2 diabetes) is not included in this coding system for CCI and due to that specifically diabetes mellitus is an important risk factor of SSI [107], diabetes mellitus was presented independently in the results and not included in the CCI calculated for each patient.

Polypharmacy, PIMs and FRIDs

In study I, polypharmacy and excessive polypharmacy were defined as 5-9 respectively ≥10 prescribed medications. PIMs were identified from indicator 1.1(“drugs that should be avoided if explicit reasons for prescription do not apply”) of the drug specific indicators compiled by the SNBHW in 2017 [47] and a list (“drugs that should be prescribed restrictively”) compiled by the Drug and Therapeutics Committee of Örebro County in 2018 [142]. Drugs defined as FRIDs were identified from indicator 1.8 (“drugs and specific symptoms;

drugs that increase the risk of falling") by the SNBHW in 2017 [42] and a list ("drugs that can increase the risk of falling") compiled by the Drug and Therapeutics Committee of Örebro County in 2018 [143].

Medications included as PIMs, presented according to their Anatomical Therapeutic Chemical Classification:

- *Hypnotics and sedatives*: long-acting benzodiazepines (N05BA01, N05CD02 and N05CD03), Zolpidem, (N05CF02) and Propiomazine (N05CM06)
- *Analgesics:* Tramadol (N02AX02) and Codeine (N02AJ06, N02AJ09 and R05DA04)
- *Anti-inflammatory drugs:* Non-Steroidal Anti-inflammatory Drugs (M01A) and cox2 inhibitors (M01AH)
- *Glibenklamid* (A10BB01)
- *Anticholinergic drugs*: A03AB, A03BA, A03BB, A04AD, C01BA, G04BD exclusive of G04BD12, M03BC01, M03BC51, N02AG, N04A, N05AA02, N05AB04, N05AF03, N05AH02, N05BB01, N05CF02, N06AA, R06AA02, R06AA04, R06AB, R06AD, R06AE05 and R06AX02

Medication included as FRIDs, presented according to their Anatomical Therapeutic Chemical Classification:

- *Psychotropic drugs:* opioids (N02A), antipsychotics (N05A), hypnotics (N05C), sedatives (N05B), anti-depressives (N06A) and dopaminergic drugs (N04B)
- *Cardiovascular drugs:* C01D, C02-3, C07-9 and G04CA
- *Anticholinergic drugs:* A03AB, A03BA, A03BB, A04AD, C01BA, G04BD exclusive of G04BD12, M03BC01, M03BC51, N02AG, N04A, N05AA02, N05AB04, N05AF03, N05AH02, N05BB01, N06AA, R06AA02, R06AA04, R06AB, R06AD, R06AE05 and R06AX02

Malnutrition and sarcopenia

In study I, malnutrition was diagnosed according to the GLIM criteria: At least one phenotypic criterion (listed below) and one etiologic criterion (decreased food intake or inflammatory condition/disease burden) had to be met for diagnosis. Hip fracture was considered as an etiologic criterion [56]. Phenotypic criteria consisted of:

- Low BMI (kg/m2), cut-off < 20 if < 70 years or < 22 if ≥ 70 years [56].
- Reduced muscle mass, measured as CC, cut-off < 31 cm [61, 144].

Documentation on weight loss was very poor and therefore excluded from possible phenotypic criteria. Patients were thus considered malnourished if they had low BMI or CC under cut-off in addition to hip fracture as the etiologic criteria.

In study I, sarcopenia was diagnosed according to the EWGSOP2-criteria [61], consisting of the following three steps:

- Reduced muscle strength indicating probable sarcopenia. Measured as HGS using a hand dynamometer, the best attempt of three on the best hand was evaluated, cut-off < 27 kg for men and < 16 kg for women [61].
- Reduced muscle mass confirming diagnosis, measured as CC, cut-off < 31 cm [61, 144].

The severity of sarcopenia was not evaluated in study I.

Functional outcome

In study II, functional outcome at four months postoperatively was assessed by three measurements: housing, walking ability and the need of walking aids. This data was extracted from the SHR. The different categories of housing, walking aids and walking ability in the register were recoded to facilitate the analysis and to improve clinical applicability. “Ordinary housing” corresponded to patients living in their own home while “institutionalized housing” corresponded to any service housing, rehabilitation unit/convalescent home, acute hospital or other. “Independent walking ability” corresponded to being able to walk independently both indoors and outdoors while “dependent walking ability” corresponded to needing to be accompanied to walk outdoors and/or indoors. “No need of walking aids” corresponded to not needing any walking aids at all and “walking aids” corresponded to the need of any walking aids except for wheelchair which was considered separately.

Surgical site infection

In study III, SSI was defined as patients diagnosed with ICD-10 codes of superficial infection of the surgical wound or deep infection of prosthetic devices or implant material by a clinician during the follow-up time of six weeks postoperatively. Information on collected microbial cultures and isolated pathogens was also retrieved from medical records.

The primary outcome in study III was incidence of SSI, and the secondary outcome was incidence of SSI and/or death. There were patients who died during the six-week follow-up and therefore the secondary outcome was included due to that the outcome of SSI within follow up could not be ruled out in deceased patients.

3.6 Analytical methods

Statistics

Statistical methods were adapted in study I-III and performed with SPSS, version 22 (IBM Corp., Armonk, NY, USA), and P-values of less than 0.05 were considered statistically significant.

Differences in means were analysed by independent sample *t* test in study I-III. Differences in categorical variables were analysed with the chi-square test in study II-III and also by the method described by Newcombe and Altman [145] in study I. In study I differences in proportions were presented as 95% confidence intervals and the interval was considered statistically significant if it did not include zero.

Unadjusted and adjusted logistic regression was performed for the outcomes of one-year mortality in study I, four-month functional outcome in study II and SSI and SSI and/or death in study III and adjustment was made for confounders. Logistic regression gives odds ratio with 95% confidence intervals as association measures.

In study III adjustment could not be performed for smoking and surgeon experience for the SSI outcome and for smoking for the SSI and/or death outcome due to no outcome events among current smokers and/or patients operated by a less experienced surgeon. Therefore, two adjusted models were performed, the first with no adjustment for the named variables and the second where the adjusted analysis was restricted to the subgroup of non-smoking patients (SSI and/or death-outcome) and non-smoking patients operated by a senior surgeon (SSI-outcome). The restricted analysis for the SSI outcome included 442 of the 496 (89%) patients.

Table 2. Statistical methods adapted in this thesis.

	Statistical method	**Study**			
		I	**II**	**III**	**IV**
Comparing means	Independent sample t test				
Comparing medians	Mann-Whitney U test				
Comparing proportions	Method described by Newcombe and Altman [145]				
	Chi-square test				
Regression analysis	Logistic regression analysis				

Table explanation: green colour, yes; red colour, no.

Content analysis

In study IV, data were analysed by content analysis as described by Elo & Kyngäs [146]. The audio recordings from the FGDs were listened to, and transcripts were read through several times for immersion with the data. Meaning units responding to the aim and relating to the same central meaning were highlighted in the text. All meaning units were then condensed and labelled with a code. Categories were generated freely and then grouped into sub- and generic categories via abstraction. The analysis involved going back and forth between re-reading the transcripts and meaning units, recoding and recategorizing. To ensure trustworthiness, the analysis was simultaneously evaluated in several sessions and finalized by the research group constituting of the authors NP, KB and ÅA. Since only two authors (NP and KB) had conducted the FGDs, the research group included different perspectives. In addition, the last author (ÅA) who had not attended the FGDs also performed a retrospective review of a sample of the analysis and approved the coding and abstraction. Quotations were selected to enunciate the results and to increase trustworthiness. For examples of the analysis process see Figure 4.

Meaning unit	Code	Subcategory	Category
"It's like you said, then you have almost washed them already, and they can maybe lift their body a bit themselves, just to be able to say, that I don't have to leave the bed, I can stay in my bed, and I will go down to surgery in it."	Patients feel safe enough to lift their body themselves today	Increased physical participation of patients	Involving the patients in the procedure
"But it is a stressful event, affecting, I am going into a shower when I am in this much pain, already there it becomes a stop for the patient."	It was stressful for patients	Decreased signs of fear, stress, and anxiety among patients	Sparing patients psychological distress
"Many lie there all tense. I have not experienced that now actually"	Patients are not as tense		
"No, they are more relaxed too"	Patients are more relaxed		
"...that it does not become such a big thing anymore."	Not such a big thing anymore	A less traumatic experience for patients	

Figure 4. Example of the analysis process in study IV.

4 Ethics

All studies in this thesis were performed in accordance with the declaration of Helsinki [147].

Study I and study II were approved by the Ethics Review Authority, Uppsala, Sweden DNR 2008/243, DNR 2017/490 and DNR 2022 01682-02. All included patients (and involved relatives) received both oral and written information about the studies and potential participation. A written consent signed primarily by the patient or, if possible, secondarily by next of kin was acquired for all included participants. Study I and study II both have an observational design based on retrospectively collected data from medical records as well as prospectively collected anthropometric measurements. Included patients received surgical, pre-, and postoperative care according to normal routine. The anthropometric measurements CC (study I) and HGS (study I-II) that were performed on included patients are normally not performed in routine care, although simple and non-invasive measurements inferring little burden on the individual patient. Although, if a patient's general health was deemed too ill to contribute, measurements were not taken, diminishing the potential risk of hampering with patient recovery. Since the studies did not infer any major changes in treatment or rehabilitation, benefits were estimated to outweigh risks.

Study III was approved by the Ethics Review Authority, Uppsala, Sweden DNR 2017/466. Due to little evidence in SSI prevention the change in method of preoperative disinfection from FBD to LD was planned previously to study III and therefore initially unrelated to the study. Therefore, study III did not infer any additional risks for patients and was purely observational. Apart from the intervention, included patients received surgical, pre-, and postoperative care according to normal routine. Informed consent was not needed for inclusion of participants in this study due to that the intervention was planned regardless of the study as approved by the Ethics Review Authority, Uppsala, Sweden.

Study IV was approved by the Ethics Review Authority, Uppsala, Sweden DNR 2017/466. The study has a qualitative design, based on FGDs with nursing personnel. Specific risks with the study are related to confidentiality among participants since they work at the same clinic and specific opinions expressed could potentially risk harming them in relation to co-workers. However, this specific method and constellation was necessary to answer the research question and the subject itself was not considered specifically sensitive. Therefore, even for this study, benefits were deemed to outweigh risks.

5 Results

Study I

Patients of cohort 2008 and 2018 were alike in baseline characteristics, there were no significant differences in mean age, gender distribution, pre-fractural housing, or use of walking aids. In total among patients, there were 85 comorbidities in 2008 and 133 in 2018. Cohort 2018 presented significantly higher figures of comorbidity, multimorbidity, and ASA class III-IV. Significant differences were seen for the individual comorbidities of uncomplicated hypertension and renal failure among all comorbidities of the ECM [140], more prevalent in 2018, see table 3.

Polypharmacy was significantly more prevalent in 2018. Results indicated a decrease in PIM-exposure while exposure to FRIDs remained high, see table 3.

Table 3. A summary of the statistically significant differences in morbidity, individual comorbidities, and polypharmacy between cohort 2008 and 2018 found in study 1 in addition to differences in PIM and FRID exposure.

	Cohort 2008 n=78	**Cohort 2018** n=76	**[p]/ (95% CI)**
Multimorbidity, *n* (%)	10 (13)	21 (28)	(-27; -2) *
ASA class III-IV, *n* (%)	27/75 (36)	46 (61)	(-39; -9) *
Comorbidity, mean (SD)	1 (1)	2 (1)	[0.002] *
Hypertension, *n* (%)	20 (26)	42 (55)	(-43; -14) *
Renal failure, *n* (%)	1 (1)	7 (9)	(-17; -1) *
Polypharmacy, *n* (%)	40/77 (52)	52/75 (69)	(-32; -2) *
Exposed to at least one PIM, *n* (%)	15/77 (29)	11/75 (15)	(-7; 17)
Exposed to at least one FRID, *n* (%)	63/77 (82)	62/75 (83)	(-13; 12)

Abbreviations: CI, confidence interval; SD, standard deviation; ASA, American Society of Anaesthesiologists; PIM, potentially inappropriate medication; FRID, fall-risk increasing drug. *, significant.

Prevalence of malnutrition and sarcopenia was significantly higher in 2008, coinciding with more patients having a HGS and CC under cut-off. In line with this, cohort 2018 presented significantly higher values of mean CC and HGS than cohort 2008, see figure 5 A-B.

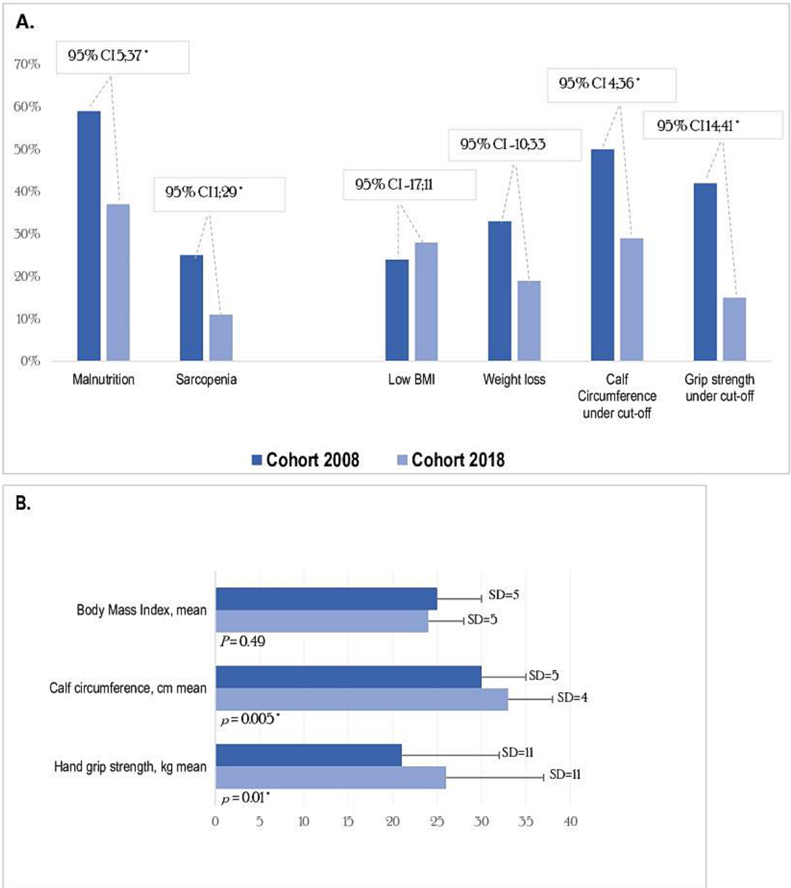

Figure 5 A-B. A. Differences in prevalence of malnutrition, sarcopenia, low BMI, weight loss, CC under cut-off and HGS under cut-off. **B.** Differences in mean values of BMI, CC and HGS. Abbreviations: CI, confidence interval; BMI, body mass index; SD, standard deviation. [a], kg/m2, <20 if <70 years or <22 if >70 years; [b], During the last 3 months; [c], <31 cm; d, measured with a hand dynamometer, <27 kg for men and <16 kg for women; *, significant.

One-year mortality remained unaltered with a rate of 23 % in 2008 and 22% in 2018 (95%CI -13;14). A logistic regression analysis of associations between variables and one-year mortality was performed where all odds ratios were adjusted for age. Malnutrition and sarcopenia did not present any significant associations with one-year mortality. For patients with ASA classification III-IV, there was a significant association with one-year mortality in 2008 (95%CI 1.1;11.6), see figure 6 A-B.

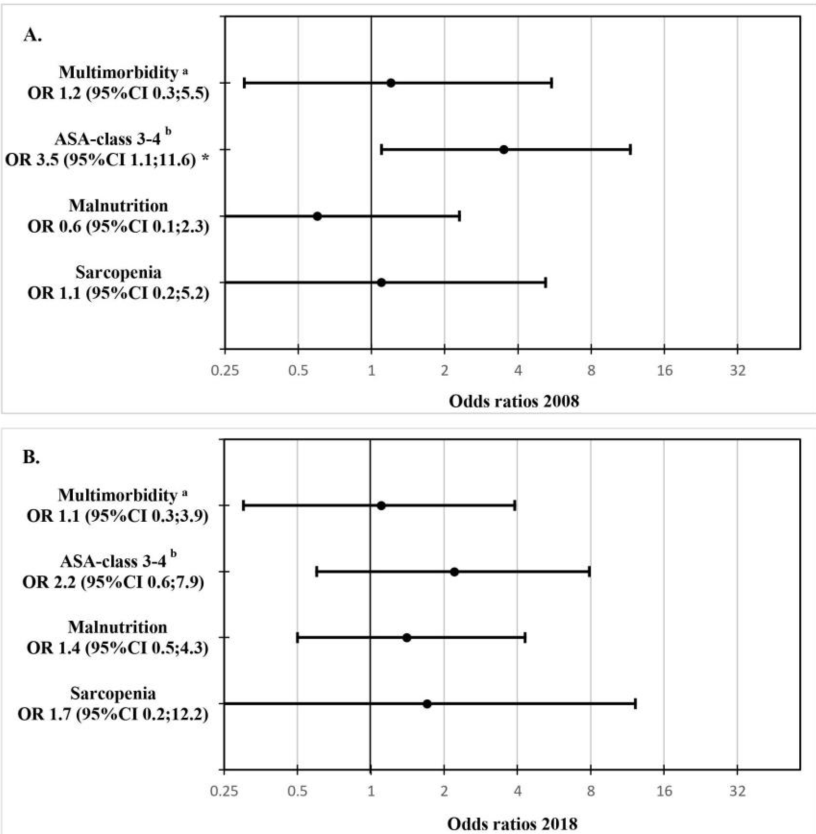

Figure 6 A-B. A. Possible associations of variables with one-year mortality post hip fracture surgery in 2008 adjusted for age. **B.** Possible associations of variables with one-year mortality post hip fracture surgery in 2018, adjusted for age. Abbreviations: OR, odds ratio; CI, confidence interval; ASA class, American Society of Anesthesiologists. *, significant. [a], ≥3 comorbidities of the Elixhauser comorbidity measure. [b], ranging from 1-6, no patients were assessed with an ASA class >4.

Study II

There were significant differences in adapted surgical methods and postoperative HGS between cohort 2008 and 2018 in study II. In 2018, arthroplasty and intramedullary nailing was more common as opposed to other methods of osteosynthesis and patients had a higher mean HGS as well as less cases of HGS under the cut-off limit for sarcopenia according to the EWGSOP2 criteria [61], see Table 4.

Table 4. Surgical characteristics and postoperative HGS of cohort 2008 and 2018.

Fracture and surgery		2008 *n*=78	2018 *n*=76	P
Coplanar-fall-related fracture, *n* (%)		76(97)	71(93)	0.23
Type of fracture, *n* (%)	S72.0	41(53)	37(49)	
	S72.1	31(40)	31(41)	0.79
	S72.2	6(8)	8(11)	
Surgery within 24h, *n* (%)		39(50)	32(42)	0.33
Surgical method, *n* (%)	Osteosynthesis with pins, nails, screws, and plates	60(77)	42(55)	
	Intramedullary nail	3(4)	13(17)	0.01*
	Hemi-arthroplasty	13(17)	14(18)	
	Total arthroplasty	2(3)	6(8)	
	Flail joint	0(0)	2(3)	
Length of stay, mean (SD), days		10(5)	9(4)	0.70
Postoperative HGS		*n* = 69	*n* = 57	
HGS, mean (SD), kg		21(11)	26(11)	0.01*
HGS under cut-off [a]		33(48)	11(19)	<0.01*

Abbreviations: SD, standard deviation; HGS, hand grip strength. *, significant. [a], <27 kg for men and <16 kg for women.

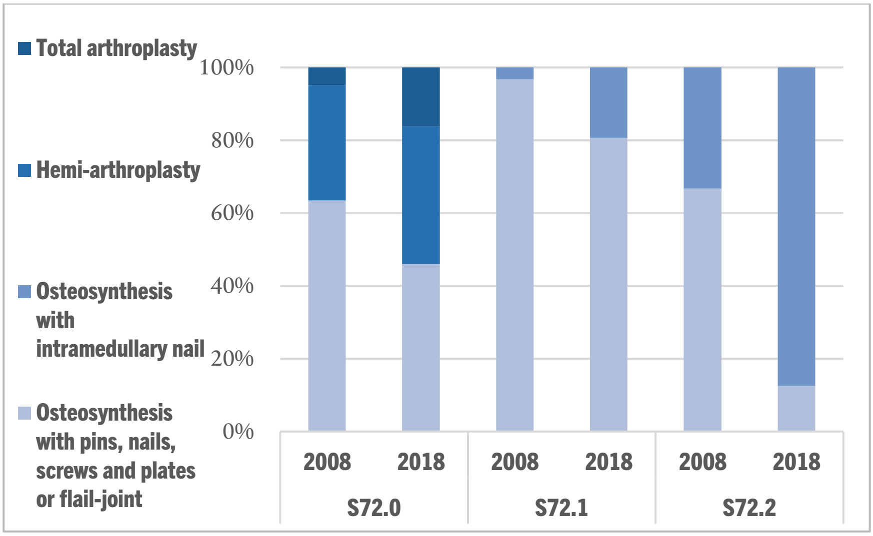

Figure 7. Surgical methods in relation to fracture-type in 2008 and 2018.

There were no significant differences in the three different measures of functional outcome of housing, walking ability and the use of walking aids between cohort 2008 and cohort 2018 at the four-month follow-up. A multiple logistic regression analysis was performed for the three functional outcomes at four months postoperatively, see table 5. The unadjusted analysis revealed a significant association between cohort 2018 and independent walking ability, remaining significant in the adjusted analysis. The adjusted analysis also revealed a significant association between cohort 2018 and the outcome of not needing any walking aids at the four-month follow-up.

Table 5. Unadjusted and adjusted logistic regression for the functional outcomes at the four-month follow-up.

	Unadjusted *n*=124		**Adjusted** *n*=124	
	OR (95%CI)	**P**	**OR (95%CI)**	**P**
Ordinary housing at follow-up				
Cohort 2018	2.5 (0.9-7.1)	0.08	2.1 (0.6-7.4) [a]	0.30
Cohort 2008	reference		reference	
Independent walking ability at follow-up				
Cohort 2018	2.2 (1.1-4.5)	0.03*	5.7 (1.9-17.2) [b]	<0.01*
Cohort 2008	reference		reference	
No need of walking aids at follow-up				
Cohort 2018	1.7 (0.7-4.3)	0.30	5.1 (1.0-26.4) [c]	0.05*
Cohort 2008	reference		reference	

[a] Adjusted for housing before fracture, gender, age, multimorbidity, ASA class ⩾III and surgical method (arthroplasty or osteosynthesis).
[b] Adjusted for walking ability before fracture, gender, age, multimorbidity, ASA class ⩾III and surgical method (arthroplasty or osteosynthesis).
[c] Adjusted for walking aid before fracture, gender, age, multimorbidity, ASA class ⩾III and surgical method (arthroplasty or osteosynthesis). *, significant.

The comparison of postoperative HGS and functional outcome at follow-up included 102 patients (58 patients in 2008 and 44 patients in 2018). When comparing postoperative HGS according to the cut-off values of EWGSOP2 [61] with walking ability at the four-month follow-up there were more independent walkers among the patients who had a HGS over cut-off in both cohorts, see Figure 8.

A potential association between postoperative HGS and an independent walking ability at the four-month follow-up was analyzed in a logistic regression analysis adjusted for age and gender revealing a significant odds ratio of 5.8 (CI1.7-17.4, P=<0.01).

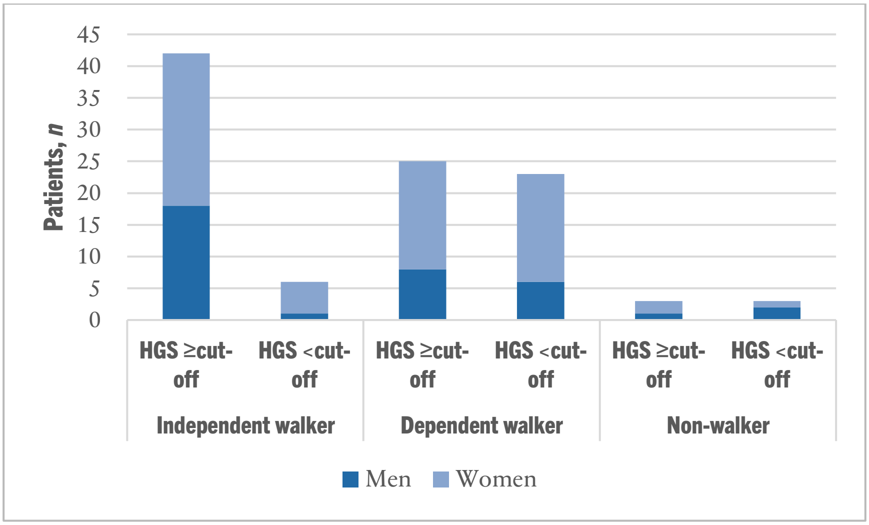

Figure 8. HGS measured postoperatively before discharge, presented in relation to reported walking ability at four months postoperatively. Cut-off: < 27 kg for men and < 16 kg for women. Abbreviations: HSG, hand grip strength

Study III

There were 16 (6.8%) cases of SSI in in 2018 and 8 (3.1%) cases of SSI in in 2019 (table 6) with an unadjusted odds ratio of 2.3 (95% CI 0.9-5.4, P=0.06) and an adjusted odds ratio of 1.9 (95% CI 0.8-4.9, P=0.16) in the model with no adjustment for smoking and surgeon experience, respectively 2.0 (0.8-5.1, P=0.14) in the population restricted to non-smokers operated by a senior surgeon.

In addition, 40 (16.9%) patients in 2018 and 29 (11.2%) patients in 2019 had the combined outcome of SSI and/or death (table 7), with an unadjusted odds ratio of 1.6 (95 CI 0.9-2.7, P=0.07) and an adjusted odds ratio of 1.6 (95% CI 0.9-2.8, P=0.08) in the model with no adjustment for smoking, respectively 1.7 (0.8-2.9, P=0.06) in the restricted non-smoking population.

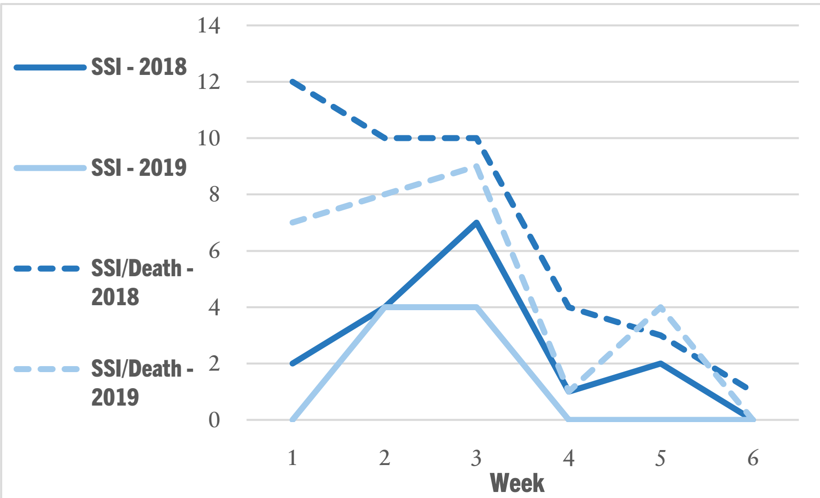

Figure 9. Time of SSI and SSI and/or death during the follow-up time of six weeks postoperatively in 2018 and 2019. *Abbreviations: SSI, surgical site infection*

Table 6. Unadjusted and adjusted logistic regression for the SSI outcome.

	SSI	Unadjusted (*n*=496)		Adjusted 1[a] (*n*=496)		Adjusted 2[b] (*n*=442)	
	n (%)	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
FBD, 2018	16 (6.8%)	2.3 (0.9-5.4)	0.064	1.9 (0.8-4.9)	0.16	2.0 (0.8-5.1)	0.14
LD, 2019	8 (3.1%)	Reference		Reference		Reference	

[a] Study population was all patients with adjustment for the following variables: age≥80, female gender, CCI, ASA class >III, diabetes mellitus, anticoagulant therapy, corticosteroid therapy, surgery within 24 hours, surgical length≥120 min, reoperation, and arthroplasty.
[b] Study population restricted to non-smokers and patients operated by a senior surgeon with adjustment for the same variables as included in Adjusted 1.
Abbreviations: SSI, surgical site infection; OR, Odds ratio; CI, confidence interval; CCI, Charlson Comorbidity Index; ASA, American Society of Anesthesiologists' Classification system; DM, Diabetes Mellitus

Table 7. Unadjusted and adjusted logistic regression for the SSI and/or death outcome.

	SSI and/or death	Unadjusted (*n*=496)		Adjusted 1[a] (*n*=496)		Adjusted 2[b] (*n*=475)	
	n (%)	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
FBD, 2018	40 (16.9%)	1.6 (0.9-2.7)	0.07	1.6 (0.9-2.8)	0.08	1.7 (0.9-2.9)	0.06
LD, 2019	29 (11.2%)	Reference		Reference		Reference	

[a] Study population was all patients with adjustment for the following variables: age≥80, female gender, CCI, ASA class >III, diabetes mellitus, anticoagulant therapy, corticosteroid therapy, surgery within 24 hours, surgical length≥120 min, experience of surgeon, reoperation, and arthroplasty.
[b] Study population restricted to non-smokers with adjustment for the same variables as included in Adjusted 1.
Abbreviations: SSI, surgical site infection; OR, Odds ratio; CI, confidence interval; CCI, Charlson Comorbidity Index; ASA, American Society of Anesthesiologists' Classification system; DM, Diabetes Mellitus

Study IV

All participants experienced significant differences after the change in method of disinfection and considered LD as a favourable method. However, concerns regarding the reliability of LD in cleanliness and prevention of SSI's were expressed during all FGDs. Six categories were identified describing the experiences of personnel regarding the performance of preoperative LD on patients prior to hip fracture surgery after having switched from FBD: sparing the patients' physical harm, sparing the patients' psychological distress, involving the patient in the procedure, improving the working environment for personnel, preventing unethical situations and a more adequate utilization of resources, see Figure 10.

Subcategories	Categories
Reduced pain and physical suffering for patients	Sparing patients' physical harm
Reduced physical side-effects of medication	
Reduced physical discomfort for patients	
Decreased signs of fear, stress, and anxiety among patients	Sparing patients' psychological distress
Increased feelings of safety among patients	
A less traumatic experience for patients	
Fewer induced states of confusion and sedation	Involving the patients in the procedure
Increased physical participation of patients	
Better communication with patients	
Reduced stress for personnel	Improving the work environment for personnel
Reduced physical burden for personnel	
A simpler process for personnel	
Harming patients physically	Preventing unethical situations
Forcing patients	
Exposing patients naked	
Reduced use of medication	A more adequate utilization of resources
Less need of personnel	
Less time-consuming	
Reduced cost	

Figure 10. Summary of sub-categories and categories in study IV.

6 Discussion

6.1 A potential evolution of the hip fracture population

The older population and patients with hip fracture

In Sweden, the general older population is growing with longevity and due to the developments in healthcare and society the population is also changing in its characteristics. Studies of the older population in Sweden present that at the age of 70, later born cohorts perform better in tests of physical performance, are more independent in ADL, have better hearing and enjoy more active lifestyles than earlier born cohorts [148]. However, there is an obvious concern and reality to that an increasing life expectancy subsequently also increases the prevalence of chronic conditions and ultimately the risk of hip fracture [9]. On the other hand, recent epidemiologic studies present that hip fracture incidence has been declining during the last decades in Sweden in all age-groups, regardless of comorbidity-level [14]; a decline that is also seen in other Nordic countries [12, 15]. Proposed reasons for the general decline in hip fracture incidence are increased osteoporotic diagnosis and treatment, improved use of walking aids, increased prevalence of over-weight (causing increased bone mineral density), reduced smoking and alcohol consumption and the better functional status of later-born cohorts [12, 14, 15]. This in turn highlighting the potential evolution of the population that succumbs to hip fracture and the importance of continuous research to optimize healthcare according to knowledge of this patient group at present.

Morbidity

When studying a potential development in morbidity over a 10-year period our results (Study I) presented a significantly higher mean comorbidity-count, prevalence of multimorbidity and polypharmacy in patients admitted in 2018 compared to 2008, suggesting an increase. A few previous studies had also compared the population and its morbidity over time and results of a general increase in comorbidity-burden coincided with ours [19, 21, 22, 48, 49]. Our results suggested that the prevalence of multimorbidity increased significantly from 13 to 28%, comparable with the increase from 33.9 to 43.4% found by Bekersi et al. in their large longitudinal (2000-2016) American study, using the same definition of multi- and comorbidity [22]. Significant differences regarding individual comorbidities could only be seen for hypertension and renal failure in our study (I), suggesting an increase. These results are aligned with those reported by Bekeris et al, however, they found the largest increases in sleep apnea, not reported on in our study as well as in drug abuse, weight loss and obesity, not prevalent in our results [22]. These differences are possibly attributable to study-sample and design as well as differences in healthcare and lifestyle between countries. Some comorbidities of the Elixhauser comorbidity measure were not prevalent at all in our results, possibly also attributable to our small sample-size. Trevisan et al. preformed similarly to us a smaller study comparing a cohort from 2000 with a cohort from 2015 in Italy and found significant increases in renal disease in addition to Alzheimers disease, chronic obstructive pulmonary disease, and valvulopathy [19]. Significant increases in renal disease and cardiovascular disease have also been reported in the larger longitudinal studies by Jantzen et al. (1999-2012) in Denmark [21], Baker et al. (2000-2012) in England [48] and Brauer et al. (1986-2005) in USA [49].

Evidently there seems to have been a shift towards increased comorbidity over time. What cannot be disregarded though is the possible influence of increased screening, awareness and diagnosis affecting these respective measures of morbidity. On the other hand, this shift is also reflected in our concurrent 25% significant increase in patients classified with an ASA class >III (study I) corresponding to severe systemic disease preoperatively, resembling the increase of 20% found in a larger Swedish longitudinal study (1999-2017) by Turesson et al. from 2019 studying the care process, ASA class, time to surgery, mortality and functional outcome in patients with hip fracture based on data from the SHR [3]. There are however limitations to ASA class: the scoring scheme for estimation was revised in 2014, with a re-introduction of case-vignettes [34], possibly affecting assessment. In addition, the subjective assessment of ASA class is also a limiting factor. Interestingly though, since the publication of Study I, Miralles-Muñoz et al. also conducted a similar study to ours comparing patients from 2010 to 2012 with patients from 2018 to 2020 also presenting an increase in comorbidity according to the CCI and an ASA class >III, thus further supporting our results [149].

Although not significant, results of study I also indicated increased awareness regarding PIMs, resembling decreases seen within the general older population in Sweden [150]. The use of FRIDs remained high potentially testifying to a lesser awareness, a theory supported by a Swedish study reporting of increased prescribing of FRIDs after hip fracture [46].

Malnutrition and sarcopenia

Since comorbidity is a contributing factor to frailty [50] the main expectation would be that an increase among patients with hip fracture would in turn entail contemporary increases of conditions interrelating within the frailty concept such as malnutrition and sarcopenia [52, 53]. Our results (study I) however proposed the opposite. Results presented significantly higher mean values of HGS and CC in 2018 and patients were less likely to have values under the cut-off limits for diagnosis of malnutrition and sarcopenia. BMI did not differ, possibly explained by increased knowledge and treatment regarding nutrition, preserving BMI levels in patients otherwise at risk of malnutrition and weight loss due to disease and subsequent loss of appetite. The documentation of weight loss was very poor, especially for cohort 2018, only reported on in 21 of 76 patients. Therefore, the diagnosis of malnutrition was only based on CC or BMI under cut-off as phenotypic criteria. The prevalence of malnutrition was significantly lower in 2018 than in 2008 although possibly underestimated in either cohort since weight loss was not included. Furthermore, potential effects of oedema and hereditary traits on CC-value cannot be disregarded, possibly causing an overestimation. Due to the GLIM criteria being new when study I was conducted, to our knowledge there were no direct comparable studies. The prevalence of malnutrition among patients with hip fracture in other studies previous to study I varied greatly from <20% to >80% and commonly used criteria were low albumin, vitamin D deficiency, BMI<22kg/m2, weight loss and Mini Nutritional Assessment scores [151, 152]. A few studies on malnutrition according to the GLIM criteria in patients with hip fracture have been conducted and published after the publication of study I, presenting a prevalence varying between 35 and 84% [53, 153-155].

Sarcopenia also differed significantly with a prevalence of 25% in cohort 2008 and 11% in 2018 (study I), resembling the prevalence of 17% found in a Spanish study from 2016 using the EWGSOP criteria prior to the latest revision [66] and coinciding with the general indication of a decreasing frailty over time. An explanation for a decrease in sarcopenia and malnutrition could be increased screening, awareness, and treatment of comorbidities, otherwise commonly overlapping with these conditions and ultimately frailty [52]. Increased awareness as to the importance of physical activity and nutrition are also possible contributors.

Mortality

Comorbidity is also a predictor of mortality after hip fracture [24] and therefore it is somewhat surprising that the four-month mortality (study II) and one-year mortality (study I) remained unaltered with the rates of 14% respectively 23 % in 2008 compared to14% respectively 22% in 2018. These results are however also in line with results of earlier mentioned studies that, in addition to reporting of an increase in morbidity over time, also found unaltered or in some cases decreasing mortality rates, suggesting improvements in healthcare either related to rehabilitation or possibly an improved physical status of patients [3, 19, 21, 49, 149] as suggested in study I. This theory is also supported by a study from 2021 that found increasing comorbidity among patients with hip fracture between 2000-2009 although at the same time decreasing rates of the postoperative complications of in-hospital death, cardiac events, pneumonia, and respiratory failure [156]. Surprisingly though, study I presented no significant association between malnutrition or sarcopenia and one-year mortality. Several previous studies have presented that sarcopenia and malnutrition infer a significant increased risk of one-year mortality after a hip fracture although not using the GLIM or EWGSOP2 criteria [64, 157-159]. However, a recent study by Sánchez-Torralvo et al. compared the GLIM criteria with two other assessment tools (the Global Subjective Assessment and the Mini Nutritional Assessment Short Form) for malnutrition in their predictive value of mortality post hip fracture and found the GLIM criteria to be inferior to the other measures, specifically emphasizing the risk of overestimating HGS under cut-off in these patients [154]. In addition, Bermejo-Bescós et al. also recently presented that baseline sarcopenia according to EWGSOP2 did not predict one-year mortality in patients with hip fracture [160].

In 2008, there was a significant association between ASA class III-IV and one-year mortality although there was no significant association in 2018 potentially attributable to increased individualization of healthcare over time, a conclusion also discussed by other authors in studies presenting similar results [19, 20, 49].

Surgical methods and hospitalization

Our results suggested an increased use of intramedullary nailing in trochanteric fractures and arthroplasty in femoral neck fractures between 2008 and 2018 (study II). The same shift was presented by an additional Swedish longitudinal (1988-201) study by Turesson et al. in 2018 analysing treatment and functional outcome in patients with hip fracture, based on data from the SHR, and a similar development was recorded in a Norwegian longitudinal (2005-2014) study by Gjertsen et al. [74, 97]. Concomitantly, the rate of surgeries performed within 24 hours seems to have remained unchanged as presented in our results, supported by Turesson et al. [3] and potentially related to the concomitant increase in morbidity where preoperatively unstable medical conditions are a known contributor to prolonged time to surgery [161]. Our cohorts did not differ significantly regarding LOS, although results indicated a decrease which was reported by Turesson et al. presenting a significant decrease from an average of 12 days in 1999 to 8.3 days in 2017 ($P<0.001$) [3].

Functional outcome and HGS

In study II there were no significant differences between cohort 2008 and cohort 2018 regarding the three measures of four-month functional outcome. Results reported by Turesson et al. in 2018 coincided with ours in suggesting no improvement over time regarding patients housing and independency in walking at a four-month follow-up postoperatively [74]. This study thus aligns with ours in recording development in surgical care over time but no subsequent significant improvements in functional outcome and the authors emphasize the potential effect of a potentially concomitant increase in morbidity within the population [74].

Although interestingly, results of the logistic regression analysis for the three functional outcome measures revealed that after adjustment for preoperative functional status, age, gender, surgical method, and morbidity in terms of ASA class and multimorbidity the odds of being an independent walker and not needing any walking aids at the four-month follow-up were significantly higher in 2018 than in 2008. These results do suggest that the increased morbidity in cohort 2018 seems to be affecting the patients' recovery negatively and, potentially highlighting that the developments made over time regarding surgery and management of patients with hip fracture in Sweden has in some aspects been successful despite not being directly apparent in figures of functional outcome in previous studies, lacking data on individual comorbidity-burden [3, 74]. However, evidently study II did not considered all potential confounders, obvious to consider when interpreting results.

In study II a multiple logistic regression analysis revealed that patients who had a HGS over cut-off at discharge had significantly 5.8 times higher odds of being independent walkers at the four-month follow-up after adjustment for age and gender than patients who had a HGS under cut-off. Previous studies support these results although differing in their follow-up time and measurement of functional outcome [92-95]. Savino et al. found that a higher preoperative HGS was significantly correlated with a higher probability of independent walking recovery withing the first year postoperatively [93]. Milman et al. found that HGS as a continuous variable, as well as dichotomized according to the cut-off values by EWSOP2, significantly predicted the success of rehabilitation in patients with hip fracture [94]. Di Monaco et al. and Selakovic et al. found significant correlations between postoperative HGS and better performance in ADL up to six months postoperatively [92, 95] where Selakovic et al. also defined hand grip weakness according to the definition by EWGSOP2. Considering this, results of study II contribute to and further underline the prognostic value of HGS, a quick and easily measured surrogate for whole body strength, not limited to patients with walking ability in the immediate postoperative phase [88, 89].

6.2 Surgical site infection and preoperative disinfection

FBD compared to LD in terms of SSI incidence

The found incidence rate of SSI in 2018 and 2019 (study III) within the follow-up time of six weeks postoperatively and the timing of detection as presented in figure 9 resembled what other studies had reported before us [98, 99, 162].

When studying the potential difference in incidence of SSI depending on method of preoperative skin disinfection in patients with hip fracture, our results (study III) suggested that the change in method from traditional FBD to LD did not cause a significant difference in SSI incidence and these results were in general supported by others. Bonnevialle et al. compared patients prepared with an antiseptic shower (polyvidone-iodine) twice before elective hip-replacement with emergency patients not prepared at all and found no cases of SSI in either cohort [127]. Rotter et al. compared FBD with chlorhexidine before clean surgery with a detergent not containing chlorhexidine and found that the relative risk of wound infection in the chlorhexidine group was 1.11% (CI 0.69-1.82) in comparison to the non-chlorhexidine group [125]. Systematic reviews by Webster et al. [124] including all kinds of surgery in addition to Jivegård et al. [128] and Franco et al. [126] addressing all kinds of clean surgery found no evidence of benefit in preoperative FBD with 4% chlorhexidine compared to placebo, soap, and no washing in terms of SSI incidence. In contradiction however, Wihlborg et al. conducted a study in 1987 similar to ours but reported of a significantly lower rate of SSI in patients preoperatively prepared with 4% chlorhexidine FBD (1.7%) compared to LD of the surgical area (4.1%), RR 0.4 (CI 0.19-0.85), although studying patients who went through biliary tract, inguinal hernia or breast surgery [163].

According to results of study III the role of both chlorhexidine and FBD in SSI prevention seems to be unclear. Although, it remained surprising that even after adjustment for confounders, the cohort prepared with FBD had an odds ratio of 2.0 compared to LD in terms of association with SSI risk. This association has not been recorded to the same extent or not at all in other studies resembling ours, however these studies were not directly comparable due to differences such as included surgeries, type of antiseptic used and diagnostic criteria of SSI etc. Interestingly, it has been reported by others that disinfection with chlorhexidine prior to hip and knee arthroplasty as well as cardiac surgery does not seem to eradicate bacteria but decreases bacterial diversity [164], and in some cases increases presence of Gram-negative bacteria in turn possibly reducing colonization resistance [165]. These findings could potentially explain our results although this is purely speculative. Anyhow, LD does not seem to be inferior to traditional FBD in terms of SSI prevention and if chlorhexidine does in fact have a role in this, LD is a more humane alternative for all patients considering the pain caused by FBD (study IV), especially when it comes to frail and potentially cognitively impaired patients, overrepresented within this patient category (study I and II).

Experiences of FBD compared to LD of the surgical site

In relation to the discussion of FBD potentially harming patients in study III, study IV aimed to describe the experiences of nursing personnel regarding the performance of preoperative LD on patients prior to hip fracture surgery after having switched from FBD. All participants in study IV clearly considered LD as a favourable method but also discussed the reliability of LD in cleanliness and prevention of SSI as investigated in study III.

A large part of the results from the content analysis in study IV, concerning multiple categories, was how participants experienced that the change in method decreased the preoperative pain for patients. The most significant contributor to this seemed to be the lesser movement required during LD which aligns with findings of other studies exploring patients' experiences of the preoperative phase. Studies describe how the pain in conjunction to movement is experienced as the most intense [130] and that specifically the preoperative shower is a cause of pronounced pain [131], in some cases even despite patients having received a femoral block [132].

FBD was also associated with issues related to pain management such as inadequate effect of morphine, no possibility of evaluating the administered analgesics, feeling like analgesics were given by routine and adverse drug events. To the contrary LD was associated with a lesser need of sedatives and analgesics, subsequently causing less drug-related issues. Interestingly, in addition to the lesser movement required, these results are also supported by other studies concluding that interaction between personnel and patients is important in achieving well managed pain [132] which also seemed to have improved considering the categories of LD enabling better involvement of patients in the procedure. Furthermore, patients have been reported to feel more satisfied when staff create a secure feeling and show interest and empathy towards them [130]. This suggests that other aspects of development after the switch from FBD to LD such as improved communication with patients, a safer environment and reduced time-pressure as experienced by participants could also be contributing to a lesser need of medications and reducing pain, potentially by enabling pain management that is more than purely medical.

Patients with cognitive impairment, overrepresented within this patient category, have been reported to experience higher levels of pain preoperatively [166]. Furthermore, it is well documented that patients with hip fracture and specifically patients with cognitive impairment are continuously being undertreated with analgesics according to their pain-level [133, 134]. Undertreated or severe preoperative pain has been reported to increase the risk of delirium, prolonged hospitalization, and postoperative pain for patients [133, 135, 136]. This in turn emphasizing the importance of pain-management and continuously addressing causes of pain.

It is portrayed by others how movement and nursing actions can be a cause of anxiety and feelings of suffering in patients with hip fracture due to the associated pain [132, 167]. It was specifically expressed by participants that the circumstances during FBD hindered communicative and physical involvement of patients. The change in method of disinfection from FBD to LD was interpreted to reduce psychological distress in patients along with involving them better in the procedure. In line with this, a study of suffering in hip fracture patients concluded that nursing staff's presence, the opportunity for patients to have a dialogue with orthopedic staff and adequate information to patients is important in alleviating suffering preoperatively [167].

The results of study IV highlight the importance of involving patients in their care. Although the routine of informing and involving patients before and during the procedure did not differ between FBD and LD, the switch from FBD to LD was experienced to promote better involvement of the patients in the procedure due to factors related to patients medical and cognitive state and LD enabling better communication and physical participation of patients as described earlier. In addition, for the most part only one person was required to perform LD which was experienced to enable a more personalized way of care, personnel not having to work "over the patients". Supporting this, earlier studies emphasize the importance of carrying out routines that facilitate and safeguard a way of care that enables seeing the individual behind the patient, in turn incorporating patients as active partners in their care [168].

Lastly, the results of study IV documented how personnel perceived LD as less time consuming than FBD and that time to surgery was shortened. Studies of patient experiences portray how waiting for surgery in the ward is specifically stressful for patients, emphasizing the importance of investigating and addressing causes of delay [130]. Furthermore, a prolonged time to surgery has been found to increase the risk of intraoperative medical complications and postoperative mortality [84]. However, there was no significant difference regarding surgery withing 24 hours when the methods of FBD and LD were compared in study III. Nonetheless as highlighted in study IV, any time gained before surgery, weather minutes or hours, could potentially spare patients from suffering.

7 Limitations

This thesis has several limiting factors.

- The dropout of eligible participants in study I and II was relatively large with 30 respectively 21 patients unable to participate in 2008 and 2018.
- The sample-sizes in both study I-II (78+76) and study III (237+259) were relatively small in relation to the measurements and outcomes studied.
- A principal part of data in study I-II and III were retrospectively collected from medical records were risk of error in documentation cannot be disregarded and the observational design is a limiting factor.
- In study I, due to that documentation of weight loss was very poor, the diagnosis of malnutrition was only based on CC or BMI under cut-off as phenotypic criteria potentially risking an underestimation of malnutrition in either cohort.
- In study II, data on functional outcome at follow-up was collected from the SHR where follow-up data is initially collected via phone conversations with patients or close relatives risking outcome misclassification.
- In study II, 28 patients were not included in the measurement of postoperative HGS which could have affected results.
- Study II lacked information on individually performed in-hospital or post-discharge physiotherapy which could have interfered with results.
- In study III, patients were not randomized to receive either method of disinfection or compared during the same year.
- A clear limitation in study IV was that the perspectives were not from the patients' views but from personnel, possibly affecting credibility.
- There is a risk of selection bias in study IV with the risk of that participants who volunteered where the ones who were most positive to the intervention.

8 Conclusions

This thesis studying patients with hip fracture has several different conclusions, although the respective studies all point towards the characterizing heterogeneity of the population, a known problematizing factor in research. This heterogeneity is extensively related to the typically high age and multimorbidity of the patients and, in line with many studies, emphasizes the importance of individualization in care and management.

Summary of the main findings from this thesis:

Study I	This study, in line with others, suggests an increase in morbidity over time within the population with hip fracture. Concomitantly, results suggested a decrease in malnutrition and sarcopenia while one-year mortality remained unaltered, suggesting a decrease in frailty within the population.
Study II	This study supports the since previously reported developments in hip fracture surgery in Sweden while also presenting that functional outcome seems to have improved despite the concomitant increase in morbidity. Results suggest an improvement in postoperative HGS, significantly associated with walking ability at four months postoperatively.
Study III	When comparing traditional FBD with 4% chlorhexidine prior to hip fracture surgery with LD of the surgical site in terms of SSI incidence, results presented a non-significant increased risk of SSI in 2018 (FBD) compared to in 2019 (LD), suggesting that LD is not inferior to FBD regarding SSI prevention.
Study IV	All participants considered LD of the surgical site as a favorable method to FBD, witnessing of an increased wellbeing in patients and the method facilitating a better involvement of patients in the procedure.

9 Future perspectives

As discussed in this thesis, older generations today are not the same as they were a couple of decades ago which is also true for the specific subgroup that succumbs to hip fracture. Examples of this kind of evolution has been presented and discussed in this thesis (study I and II) contributing to the larger picture of where we stand at present and expected demands on healthcare. However, the studies in this thesis have a cross-sectional, observational design and can therefore merely suggest potential trends, emphasizing the need of larger longitudinal studies. There are currently relatively few studies of this population and its potential change in characteristics of morbidity and frailty over time, emphasizing the need of further and continuous research. What has also been highlighted in this thesis is that comorbidity and frailty overlap but are not equal, important to consider when describing the population.

Due to a generally high age and multimorbidity this population is characterized by a heterogeneity and therefore there is no way of treating patients according to one single algorithm or plan. It is clear from research that individualized care is key and therefore predictors of outcome, such as HGS potentially predicting functional outcome as presented in study II, are of great value in trying to treat patients as correctly as possible from the start.

Study III and IV support the hypothesis of that there does not seem to be any evidence of benefit in using FBD with 4% chlorhexidine compared to LD of the surgical site regarding SSI prevention. In addition, if chlorhexidine does in fact have a role in this, which remains unclear, LD is a more humane alternative for all patients considering the pain caused by FBD. Randomized controls are still needed, however despite this, several clinics in Sweden have and are already wavering from the national recommendations of preoperative FBD. Our plan is to contact relevant national authorities and inform them of our studies regarding preoperative disinfection, hopefully contributing to a review of the national recommendations and sparing future patients from any unnecessary pain.

10 Summary in Swedish

Höftfrakturer är ett globalt hälsoproblem med hög dödlighet som främst drabbar den äldre befolkningen. Under de senaste decennierna verkar dock incidensen ha minskat trots en ökande livslängd bland människor. Däremot har dödligheten förblivit oförändrad vilket möjligen vittnar om en förändring vad gäller sjuklighet inom patientgruppen. En höftfraktur kräver i regel kirurgi och nationella riktlinjer i Sverige rekommenderar fortfarande preoperativ helkroppsdesinficering i preventivt syfte mot postoperativ sårinfektion trots svaga evidens i studier. En metod som är mycket smärtsam för patienterna. Denna avhandling hade flera syften. Ett syfte var att jämföra två kohorter av patienter med höftfraktur med tio års mellanrum avseende sjuklighet, sarkopeni, malnutrition och dödlighet (studie I) samt operationsmetoder och funktionellt status vid uppföljning (studie II). Ett andra syfte var att jämföra preoperativ helkroppsdesinficering med lokal desinficering av den brutna höften avseende incidens av postoperativa sårinfektioner (studie III) och upplevelser hos vårdpersonal som utför de preoperativa tvättarna (studie IV). Patienter med höftfraktur från 2008 och 2018 (studie I och II), från 2018–2019 (studie III) och vårdpersonal på den ortopediska klinik där skiftet i desinficeringsmetod genomfördes (studie IV) inkluderades. Data i form av fysiska patientmått insamlades prospektivt (Studie I och II) medan data från journaler (studie I-III) och kvalitetsregistret RIKSHÖFT (studie II) insamlades retrospektivt. Intervjuer i fokusgrupper utfördes och analyserades med innehållsanalys (studie IV). Resultaten från studie I indikerar en ökad sjuklighet bland patienterna över tid men en samtida minskning av sarkopeni och malnutrition vilket skulle kunna förklara den oförändrade dödligheten som också sågs. Studie II presenterade en samtida förändring av val av operationsmetod vilket skulle kunna ha bidragit till den förbättring i funktionellt status som sågs hos patienterna i kohort 2018 vid den postoperativa uppföljningen efter korrigering för sjuklighet. I studie III sågs ingen signifikant skillnad i frekvens av postoperativa sårinfektioner mellan patienterna som genomgått de olika desinficeringsmetoderna och studie IV vittnade om ett förbättrat mående hos patienterna efter bytet till lokal desinficering. Denna avhandling innehåller flera slutsatser men de respektive studierna framhäver alla den heterogenitet som karakteriserar patienter med höftfraktur vilket är en känd komplicerande faktor inom forskning av gruppen. Denna heterogenitet är starkt relaterad till den typiskt höga åldern och multisjukligheten bland patienterna och som i linje med andra studier, understryker vikten av individualiserad vård och behandling. Utöver detta förändras populationen kontinuerligt över tid och är uppenbarligen inte samma som den var för tio år sedan, vilket i sin tur också understryker vikten av en samtida anpassning och utveckling av vården som ska ta emot patienterna.

11 Acknowledgements

I want to express my deepest gratitude to all who have helped me on this journey, in science as well as in life. I would be nothing without the people around me and completing this thesis would certainly not have been possible.

Åsa Andersson
My supervisor. Eight years ago, you introduced me to research. I will never regret choosing you as a supervisor for my first scientific essay as a medical student. Thank you for your unconditional guidance, enthusiasm, and for always believing in me. In retrospect, I apologize for all the questionably late and numerous phone calls (which you always answered as optimistic as ever). This journey has undeniably been hard at times, but I would still turn back time if I could and do it all again.

Karin Blomberg
My main supervisor, it has been a privilege getting to know you during my time as a doctoral student. One of my favorite parts of this journey was working literally side by side with you on study IV and getting to learn from your expertise. You have been a tremendous support and I am so grateful.

Elisa Kosamo
Thank you for your guidance during this time. I could never have kept track of everything that goes with completing a doctoral thesis without your help.

The staff at the Geriatric department at Örebro University Hospital
Thank you for all your hard work and help in the data collection for study I and II.

The staff at the Orthopedic department at Karlskoga hospital
Thank you for all your hard work, help and investment in the data collection for study III and IV.

CKF, Region Värmland
Thank you for financing my doctoral studies during my years in Region Värmland.

My colleagues at the radiology department in Karlstad
Thank you for introducing me into the world of radiology and for being the best colleagues. I appreciate working with you all.

Louise Larmark
My dear friend, I want to thank you for all the years we have had together and for all those that are to come. You have a special place in my heart.

My friends
Thank you for supporting me and making me think of other things than research during these years. I am lucky to have you in my life.

My parents Ullrika and Magnus
Thank you for all your unconditional support. I would not be where I am today if not for you. I love you, and I will always keep appreciating our phone calls and the times that we meet.

My brother Linus and family
Thank you for all the dinners, bike rides, and fun games. Spending time with you always makes me happy.

My brother Dominic
I thank the universe every day for giving me a twin brother. A best friend from birth. Thank you for all your support.

Tobias
My love and best friend. You are my eternal optimist and supporter. I cannot imagine life without you.

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J Nutr Health Aging. 2020;24(8):870-877

A COMPARISON OF PATIENTS WITH HIP FRACTURE, TEN YEARS APART: MORBIDITY, MALNUTRITION AND SARCOPENIA

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Abstract: *Objectives:* To investigate possible differences in morbidity, malnutrition, sarcopenia and specific drug use in patients with hip fracture, ten years apart. To analyse 1-year mortality and possible associations with variables. *Design:* A prospective, observational study. *Setting:* Örebro University Hospital, Sweden. *Participants:* Two cohorts of patients with hip fracture, included in 2008 (n=78) and 2018 (n=76). *Measurements:* Presence of comorbidity according to the Elixhauser comorbidity measure, multimorbidity defined as ≥3 comorbidities, preoperative American Society of Anaesthesiologists Classification (ASA-class), malnutrition according to the definition by the Global Leadership Initiative on Malnutrition (GLIM), sarcopenia according to the most recently revised definition by the European Working Group on Sarcopenia in Older People (EWGSOP), polypharmacy defined as ≥5 prescribed medications, use of Potentially Inappropriate Medications (PIM) and Fall-Risk-Increasing-Drugs (FRID) and postoperative 1-year mortality. *Results:* When comparing the cohorts, significant increases over time was seen for mean comorbidity-count (Difference -1; p=0.002), multimorbidity (Difference -15%; 95%CI -27;-2), ASA-class 3-4 (Difference -25%; 95%CI -39;-9) and polypharmacy (Difference -17%; 95%CI -32;-2). Prevalence of malnutrition and sarcopenia coherently decreased with 22% (95%CI 5;37) and 14% (95%CI 1;29) respectively. One-year mortality remained unchanged and a significant association was found for a higher ASA-class in 2008 (OR 3.5, 95%CI 1.1;11.6) when adjusted for age. Results on PIM exposure suggest a decrease while exposure to FRID remained high. *Conclusion:* Our findings support an increasing morbidity within the population over time. However, also presented is a coherent decrease in malnutrition and sarcopenia, suggesting a decrease in frailty as a possible explanation for the observed unaltered mortality, in turn suggesting advances in treatment of comorbidities.

Key words: Hip fracture, comorbidity, malnutrition, sarcopenia, mortality.

Introduction

Hip fracture primarily affects older people and low-energy trauma is the most common cause due to osteoporosis and an increased risk of falling. According to Swedish national data the mean age at time of fracture is 82 years and 67% of the patients are of female gender (1). Sweden represents one of the highest incidences worldwide with close to 17.000 cases annually (1, 2). The incidence of hip fracture is estimated to escalate as people live longer (3), a major concern due to the following economic burden, poor outcome and excess mortality (4–6), 1-year mortality-rate amounting to >25% in Sweden (7).

Patients typically suffer from a high premorbid frailty, multimorbidity and polypharmacy, factors found to increase risk of hip fracture (8–10). Malnutrition, sarcopenia and comorbidity, overlapping with- and contributing to frailty, being a multifactorial clinical condition (11, 12), are factors associated with an increased mortality post fracture (13–15). Consensus has recently been reached regarding a definition of malnutrition by the Global Leadership Initiative on Malnutrition (GLIM) (16). Recommendations on defining sarcopenia have also latterly been revised by the European Working Group on Sarcopenia in Older People (EWGSOP) (17). Two major categories of drugs are frequently mentioned in studies. Older people and particularly patients with hip fracture have a vulnerability to Potentially Inappropriate Medications (PIM), associated with increased mortality post-fracture (18). Fall-Risk-Increasing-Drugs (FRID), prevalent within the population, increase hip fracture risk and are also associated with an increased mortality (19, 20). Due to their observed adverse events in older people, several international lists of PIM and FRID have been established in order to increase awareness.

Contradictory to earlier estimates, hip fracture incidence is declining and Swedish data suggests that coherent survival rates have remained unaltered (21), possibly explained by a potential change in morbidity of the population. A few previous studies have examined the development of the population and its morbidity over time and present homogenous results of an increased comorbidity-burden and polypharmacy while mortality has decreased or remained unchanged, possibly portraying advances in treatment of comorbidities, hip fracture and individualized care (22–27). In light of this there is a value in studying how a possible increase in morbidity may reflect possible changes in malnutrition and sarcopenia as well as specific drug use, to our knowledge not yet studied.

Received March 23, 2020
Accepted for publication April 8, 2020

Published online June 11, 2020, http://10.1007/s12603-020-1408-2

Aim

The primary aim was to investigate possible differences in morbidity, malnutrition, sarcopenia and specific drug use in patients with hip fracture, ten years apart. Our secondary aim was to analyse 1-year mortality and possible associations with variables.

Methods

Study design and population

In this prospective, observational cohort study all patients undergoing surgery at Örebro University Hospital due to hip fracture diagnosed with ICD-10 codes S72.0, S72.1 or S72.2 during 5 months in 2008 and in 2018 respectively, were consecutively invited to participate. No exclusion criteria existed.

Morbidity and drugs

Data on diseases, ASA-class (28) and medications was obtained from individual medical records. Diseases were verified according to ICD-10, all Elixhauser comorbidities were evaluated (29, 30). Multimorbidity was defined as ≥3 comorbidities. Polypharmacy and excessive polypharmacy was defined as 5-9 and ≥10 prescribed medications respectively.

PIM were identified from indicator 1.1 (drugs that should be avoided if explicit reasons for prescription do not apply) of the drug specific indicators compiled by the Swedish National Board of Health and Welfare (SNBHW) (31) and a list (drugs that should be prescribed restrictively) compiled by the Drug and Therapeutics Committee of Örebro County (32). Drugs defined as FRID were identified from indicator 1.8 (drugs and specific symptoms; drugs that increase the risk of falling) by the SNBHW (31) and a list (drugs that can increase the risk of falling) compiled by the Drug and Therapeutics Committee of Örebro County (32). Included drugs can be viewed in Supplementary Dataset S1.

Malnutrition and sarcopenia

Anthropometric measurements were obtained through clinical bedside examinations.

Malnutrition was diagnosed according to GLIM-criteria (16): At least one phenotypic (listed below) and one etiologic (decreased food intake or inflammatory condition/disease burden) criterion has to be met for diagnosis. Hip fracture was considered an etiologic criterion (16). Phenotypic criteria consist of:

- Low BMI (kg/m2), cut-off < 20 if < 70 years or < 22 if > 70 years (16).
- Reduced muscle mass, measured as calf circumference (CC), cut-off < 31 cm (33).
- Non-volitional weight loss the last three months, measured by the screening-tool Mini Nutritional Assessment (34).

Documentation on weight loss was very poor and therefore excluded from possible phenotypic criteria. Patients were thus considered malnourished if they had low BMI or CC under cut-off in addition to hip fracture as the etiologic criteria.

Sarcopenia was diagnosed according to EWGSOP2-criteria (17), consisting of the following three steps:

- Reduced muscle strength indicating probable sarcopenia. Measured as hand-grip strength using a hand dynamometer, the best attempt of three on the best hand was evaluated, cut-off < 27 kg for men and < 16 kg for women (35).
- Reduced muscle mass confirming diagnosis, measured as CC, cut-off < 31 cm (17).
- Impaired physical performance determining severity; not evaluated in this study.

Statistics

Differences in mean age, length of stay, comorbidity, BMI, CC and hand grip strength was analysed by independent sample t-test. Differences in gender was analysed by chi-squared test. Level of statistical significance was set at $p < 0.05$. Differences in proportions for dichotomized variables were calculated with the method described by Newcombe & Altman (36). Differences in proportions are presented as 95% confidence intervals, the interval will be significant if it does not include zero.

Odds ratios adjusted for age were calculated by logistic regression analysis, the 95% confidence interval will be significant if it does not include one.

The t-test, chi-squared test and calculation of odds ratios were performed in SPSS Statistics 25. Differences in proportions were calculated with the software program Confidence Interval Analysis.

Results

Participants

In total, 108 patients in 2008 and 97 in 2018 were invited to participate where 30 and 21 patients were unable to, respectively, leaving 78 patients included in 2008 and 76 in 2018. The major reason for non-inclusion was impaired ability to give consent due to cognitive state.

When comparing dropout groups with participants there was no significant difference in gender, in 2008 ($p=0.96$) or 2018 ($p=0.70$). In 2008 there was no significant difference in mean age ($p=0.26$), the drop-out group presenting a mean age of 84 years compared to 81 among participants, whereas in 2018, the dropout group presented a significantly higher mean age of 87 compared to 80 among participants ($p=0.007$).

Baseline characteristics

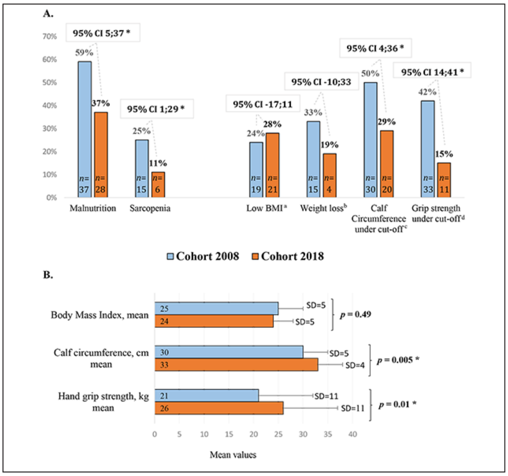
Patients were similar regarding baseline characteristics (table 1), there were no significant differences in mean age or gender distribution. Pre-fractural housing and prevalence of walking aids was similar.

Table 1
Baseline characteristics of the two cohorts of patients with hip fracture

	Cohort 2008 n = 78	Cohort 2018 n = 76	Difference, [p-value] / (95% CI)
Age, mean (SD)	81 (11)	80 (12)	-1 year
Min-max	35-98	41-103	[0.55]
Female, n (%)	49 (63)	47 (62)	-1 (-14;16)
Ordinary housing, n (%)	69 of 77 (90)	69 (91)	-1 (-11;9)
Living alone before fracture, n (%)	45 (58)	48 (63)	-5 (-20;10)
Walking aid before fracture, n (%)	33 of 76 (43)	36 (47)	-4 (-19;12)
Length of stay, mean (SD)	10 (5)	9 (4)	1 [0.58]
Coplanar fall-related fracture, n (%)	76 (97)	71 (93)	4 (-3;12)
Fall indoors, n (%)	57 of 71 (80)	53 of 73 (73)	7 (-6;21)
Type of fracture, n (%):			
S 72.0 [a]	41 (53)	37 (49)	4 (-12;19)
S 72.1 [b]	31 (40)	31 (41)	-1 (-16;14)
S 72.2 [c]	6 (8)	8 (11)	-3(-13;7)

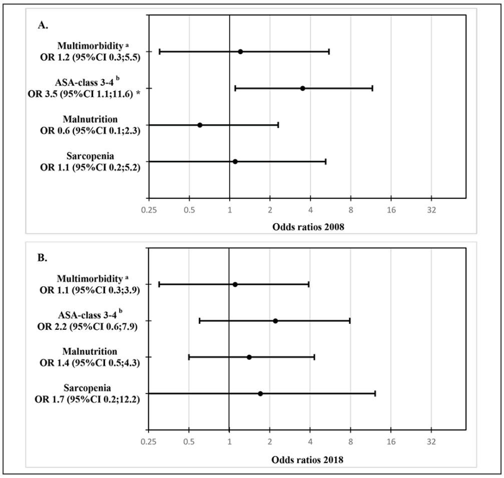
Abbreviations: CI, confidence interval; SD, standard deviation; a. Femoral neck fracture; b. Subtrochanteric femoral fracture; c. Pertrochanteric femoral fracture.

Figure 1 A-B
A. Differences in prevalence of malnutrition, sarcopenia, low BMI, weight loss, calf circumference under cut-off and grip strength under cut-off comparing the two cohorts of patients with hip fracture. B. Differences in mean values of body mass index, calf circumference and grip strength comparing the two cohorts of patients with hip fracture



Abbreviations: CI, confidence interval; BMI, body mass index; SD, standard deviation; a, kg/m2, <20 if <70 years or <22 if >70 years; b, During the last 3 months; c, <31 cm; d, measured with a hand dynamometer, <27 kg for men and <16 kg for women; *, significant.

Figure 2 A-B
A. Possible associations of variables with 1-year mortality post hip fracture surgery in 2008, presented in a forest plot as odds ratios and 95% confidence intervals adjusted for age. B. Possible associations of variables with 1-year mortality post hip fracture surgery in 2018, presented in a forest plot as odds ratios and 95% confidence intervals adjusted for age



Abbreviations: OR, odds ratio; CI, confidence interval; ASA-class, American Society of Anaesthesiologists classification. a, Multimorbidity defined as having ≥3 comorbidities of the Elixhauser comorbidity measure. b, Ranging from 1-6, no patients were assessed with an ASA-class >4; *, significant.

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Table 2
Differences in morbidity, polypharmacy and exposure to PIM and FRID between the two cohorts of patients with hip fracture

	Cohort 2008, n=78	Cohort 2018, n=76	Difference, [p- value]/ (95% CI)
Multimorbidity[a], n (%)	10 (13)	21 (28)	-15 (-27; -2) *
ASA-class 3 and 4, n (%)	27of 75 (36)	46 (61)	-25 (-39; -9) *
Comorbidity, mean (SD)	1 (1)	2 (1)	-1 [0.002] *
Congestive heart failure	10 (13)	11 (15)	-2 (-13;9)
Cardiac arrythmia	13 (17)	18 (24)	-7 (-20;6)
Valvular disease	3 (4)	5 (7)	-3 (-11;5)
Peripheral vascular disorders	0 (0)	3 (4)	-4 (-11;1)
Hypertension, uncomplicated	20 (26)	42 (55)	-29 (-43; -14) *
Neurological disorder	6 (8)	4 (5)	3 (-6;11)
Paralysis	1 (1)	1 (1)	0 (-6;6)
Chronic pulmonary disease	9 (12)	8 (11)	1 (-9;11)
Diabetes, uncomplicated	6 (8)	7 (9)	-1 (-11;8)
Diabetes, complicated	0 (0)	4 (5)	-5 (-13;0)
Hypothyroidism	4 (5)	6 (8)	-3 (-12;6)
Renal failure	1 (1)	7 (9)	-8 (-17; -1) *
Liver disease	0 (0)	3 (4)	-4 (-11;1)
Tumour	6 (8)	6 (8)	-0 (-9;9)
Lymphoma	1 (1)	0 (0)	1 (-4;7)
Metastatic cancer	1 (1)	1 (1)	0 (-6;6)
Rheumatoid arthritis	3 (4)	2 (3)	1 (-6;8)
Coagulopathy	1 (1)	0 (0)	1 (-4;7)
Alcohol abuse	0 (0)	2 (3)	-3 (-9;2)
Depression	0 (0)	2 (3)	-3 (-9;2)
Polypharmacy, ≥5 drugs, n (%)	40 of 77 (52)	52 of 75 (69)	-17 (-32; -2) *
Excessive polypharmacy, ≥10 drugs, n (%)	11 of 77 (14)	16 of 75 (21)	-7 (-19;5)
Number of patients exposed to at least one PIM, n (%)	15 of 77 (20)	11 of 75 (15)	5 (-7;17)
Number of patients exposed to at least one FRID, n (%)	63 of 77 (82)	62 of 75 (83)	-1 (-13;12)

a. Multimorbidity defined as having ≥3 comorbidities of the Elixhauser comorbidity measure; Abbreviations: CI, confidence interval; ASA-class, American Society of Anaesthesiologists Classification; SD, standard deviation; PIM, Potentially Inappropriate Medications; FRID, Fall-Risk-Increasing-Drugs; *, significant.

Morbidity, malnutrition, sarcopenia and drug use

In total, there were 85 comorbidities in 2008 and 133 in 2018. Cohort 2018 presented significantly higher figures of comorbidity, multimorbidity, and ASA-class 3-4. No patients were assessed with an ASA-class higher than 4. Significant differences were seen for the individual comorbidities of uncomplicated hypertension and renal failure, more prevalent in 2018. Pulmonary circulation disorders, complicated hypertension, peptic ulcer disease, AIDS/HIV, blood loss anaemia, fluid and electrolyte disorders, weight loss, obesity, psychoses and drug abuse were not prevalent at all and thus not included in table 2.

Polypharmacy was significantly more prevalent in 2018. Results indicate a decrease in PIM-exposure while exposure to FRID remained high. In both cohorts, the most common PIM-categories were hypnotics and sedatives followed by anticholinergics and the most common FRID-categories were cardiovascular FRID followed by psychotropics. Zolpidem was the most frequently prescribed PIM, 10 patients exposed in 2008 and 5 in 2018. In 2008 3 patients were prescribed the PIM Tramadol, not prevalent in 2018. The most common FRID were: Furosemide, Metoprolol, and Zolpidem in 2008 and Furosemide, Metoprolol and Amlodipine in 2018.

Prevalence of malnutrition and sarcopenia was significantly

Table 3
One-year mortality post-surgery for hip fracture of the two cohorts and possible associations with variables. Odds ratios and 95% confidence intervals adjusted for age

	Cohort 2008 n=78					Cohort 2018 n=76				
	Diseased, n =18	**n**	**Alive, n =60**	**n**	**OR (95% CI)**	**Diseased, n =17**	**n**	**Alive, n =59**	**n**	**OR (95% CI)**
Multimorbidity [a]	3	18	7	60	1,2 (0.3;5.5)	5	7	6	59	1,1 (0.3;3.9)
ASA-class 3-4 [b]	10	16	17	59	3,5 (1.1;11.6) *	13	17	33	59	2,2 (0.6;7.9)
Malnutrition	6	11	31	52	0,6 (0.1;2.3)	8	17	20	58	1,4 (0.5;4.3)
Sarcopenia	4	11	11	48	1,1 (0.2;5.2)	2	13	4	44	0,9 (0.2;12.2)

Abbreviations: OR, Odds ratio; CI, confidence interval; ASA-class, American Society of Anaesthesiologists Classification; a. Multimorbidity defined as having ≥3 comorbidities of the Elixhauser comorbidity measure; b. Ranging from 1-6, no patients were assessed with an ASA-class >4. *, significant.

higher in 2008, coinciding with more patients having a grip strength and CC under cut-off (figure 1A). In line with this, cohort 2018 presented significantly higher values of mean CC and grip strength than cohort 2008 (figure 1B). BMI and weight-loss did not differ significantly.

Mortality

One-year mortality remained unaltered with a rate of 23 % in 2008 and 22% in 2018 (95%CI -13;14). A logistic regression analysis of associations between variables and 1-year mortality was performed (Table 3 and figure 2A-B.), all odds ratios were adjusted for age. Malnutrition and sarcopenia did not present any significant associations with 1-year mortality. For patients with ASA classification 3-4, there was a significant association with 1-year mortality in 2008 (95%CI 1.1;11.6) but not in 2018.

Discussion

Main findings

When comparing two cohorts of patients with hip fracture from 2008 and 2018, we found a significant increase in morbidity in terms of comorbidity, preoperative ASA-class and polypharmacy. To the contrary, 1-year mortality remained subsequently unaltered and prevalence of malnutrition and sarcopenia significantly decreased.

Comorbidity and drug use

In consensus with others, patients were of higher age and to a greater extent of female gender. Cohort 2018 presented a significantly higher morbidity in terms of mean comorbidity-count, multimorbidity and preoperative ASA-class. A few previous studies have also compared the population over time and results of a general increase in comorbidity-burden coincide with ours (22, 24–27). Multimorbidity increased from 13 to 28% (95%CI -27;-2), comparable with the increase of 33.9 to 43.3% found in a large observational study between 2000 and 2016 in USA by Bekeris et al, using the same definition of multi- and comorbidity (25). Significant differences regarding individual comorbidities could only be seen for hypertension and renal failure in this study, suggesting an increase. Although, the potential increase of complicated diabetes mellitus was close to significant (Difference -5%; 95%CI -13;0). These results are supported by Bekeris et al, however, this author found the largest increases in sleep apnea, not reported on in our study as well as in drug abuse, weight loss and obesity, not prevalent in our results (25). This could be attributable to differences in study-sample and design as well as in healthcare and lifestyle between USA and Sweden. Some comorbidities of the Elixhauser comorbidity measure were not prevalent at all in our results, possibly also attributable to small sample-size. Trevisan et al. preformed similarly to us a smaller study comparing a cohort from 2000 with a cohort from 2015 in Italy and also found significant increases in renal disease in addition to alzheimers, COPD, and valvulopathy (26). Significant increases in renal disease, cardiovascular disease and diabetes have also been reported in the larger longitudinal studies by Jantzen et al. from 1999-2012 in Denmark (24), Baker et al. from 2000-2012 in England (27) and Brauer et al from 1986-2005 in USA (22).

Evidently there seems to have been a shift towards increased comorbidity over time. However, there is no way of disregarding possible influences of increased screening, awareness and diagnosis. Also supporting our results though is the coherent increase of ASA-class 3-4 of 25% (95%CI -39; -9), corresponding to preoperative severe systemic disease (28). These findings resemble the increase of 20% found in a population-based study by Turesson et al., observing patients between 1999-2017 in Sweden (37). There are however limitations to ASA-class, the scoring scheme for estimation was revised in 2014, with a re-introduction of case-vignettes (28), possibly affecting assessment. Additionally, the subjective assessment of ASA-class is also a limiting factor, we have tried to diminish this by grouping the ASA-scores of 1-2 and 3-4.

A potential reason for increasing comorbidity could be increasing age of the patients (38). This study presented no significant difference regarding this and results of other studies are inconclusive, Trevisan et al. and Brauer et al. found significant increases in age over 90 and 85 respectively while other studies support our findings (24, 25, 27). Numerous individual diseases have been associated with increased risk of hip fracture (10), therefore a coherent increase in incidence could be expected due to current results on comorbidity. To the contrary, incidence in western countries is constant or declining (39). Causes of this are unclear, the coinciding rise of anti-osteoporotic treatment is a known and debated factor but does not seem to solely explain the situation (40).

Thus, comorbidity seems to be increasing within a decreasing population. A potential explanation could be increasing preventative measures causing the population to exclusively consist of a high-risk profile population, in terms of a higher morbidity. This coincides with the observed increase in polypharmacy (≥5 medications) of 17% (95%CI-32;-2), also being a risk factor (9). Baker et al. found a similar increase of 20%, although defining polypharmacy as ≥4 regular medications. However, studies of the general older population in Sweden have also reported of an increase accordingly and findings in our study could just be reflecting this (41).

Although not significant, results indicate a decrease in PIM-exposure. This resembles decreases seen within the older population in Sweden (42), perhaps bearing witness of increased awareness. Exposure to FRID remained high but psychotropic drugs such as Zolpidem were not as pronounced in 2018 as in 2008, possibly attributable to increased awareness of PIM since these drugs are commonly categorized as both PIM and FRID. Nonetheless, results suggest a lesser awareness regarding FRID, a theory supported by studies reporting of increased prescribing after hip fracture (43).

Malnutrition and sarcopenia

Since comorbidity has been found a risk factor of frailty and postoperative mortality (11, 13) the main expectation would be that an increase would in turn entail concomitant increases of these conditions/outcomes. Our results however propose the opposite. Frailty, a multidimensional clinical condition increasing with age is predictive of falls, disability, hospitalization and death, thus a major issue concerning the population with hip fracture. Fried et al. came up with a definition of frailty in 2001, since then widely used, including weight loss, exhaustion, weakness, slow walking speed and low physical activity (11). Malnutrition, sarcopenia and weight-loss, also widespread syndromes among older people, interrelate with frailty (12) and can therefore grossly serve as indicators. Interestingly, our results presented significantly higher mean values of hand grip strength and CC in 2018 and patients were less likely to have values under cut-off limits for diagnosis of malnutrition and sarcopenia. BMI did not differ, possibly explained by increased knowledge and treatment regarding nutrition, preserving BMI levels in patients otherwise at risk of malnutrition and weight loss due to disease and concomitant loss of appetite. The documentation of weight loss was very poor, especially for cohort 2018, only reported on in 21 of 76 patients, therefore the diagnosis of malnutrition was only based on CC or BMI under cut-off as phenotypic criteria. Results present a significant decrease in malnutrition of 22% (95%CI 5;37), although possibly underestimated in either cohort since weight loss was not included. Additionally, potential effects of oedema and hereditary traits on CC-value cannot be disregarded, possibly causing overestimation. Due to the GLIM-criteria being new there are to our knowledge no direct comparable studies. The prevalence of malnutrition among patients with hip fracture in other studies varies greatly from <20% to >80%, commonly used criteria are low albumin, vitamin D deficiency, BMI<22kg/m2, weight loss and Mini Nutritional Assessment (44, 45).

Sarcopenia also differed significantly with a prevalence of 25% in cohort 2008 and 11% in 2018 (95%CI 1;29), resembling the prevalence of 17% found in a Spanish study from 2016 using EWGSOP criteria prior to the latest revision (46) and coinciding with the general indication of a decreasing frailty over time. An explanation for a decrease in sarcopenia, malnutrition and possibly frailty could be increased screening, awareness and treatment of the different comorbidities, preventing imminent frailty in older people. Increased awareness as to the importance of physical activity and nutrition is also a possible contributor.

Mortality

One-year mortality remained unaltered with the rates of 23 % in 2008 compared to 22% in 2018 (95%CI -13;14), in line with results of both Jantzen et al reporting of 9.7% in 1999 compared to 10.3% in 2012 (P=0.9) and Trevisan et al reporting of 25.3% in 2000 compared to 22.2% in 2015 (p=>0.05). In 2008, there was a significant association between ASA-class 3-4 and 1-year mortality (OR 3.5, 95%CI 1.1;11.6) although the association was not significant for Cohort 2018. This could be attributable to increased individualization of healthcare over time, prioritizing those with greatest need. Coinciding with this, Trevisan et al. found significantly worse Charlson comorbidity index scores (a measure of comorbidity) in survived patients 30 days post-surgery in 2015 compared to in 2000. In addition Brauer et al. and a Danish study comparing patients between 1980-2014 (23) found decreases in short- and long-term mortality irrespective of comorbidity-level, suggesting advances in treatment and rehabilitation of hip fracture.

When adjusted for age, we did not find any statistically significant association between 1-year mortality and malnutrition or sarcopenia in this study. Our relatively small cohort size is a limitation, evident when observing results of previous larger studies. For example, a study including 324 patients with hip fracture found that individuals with sarcopenia had a 1.8 times higher 1-year mortality rate than nonsarcopenic (15). Another larger study on 322 patients with hip fracture, showed that malnutrition was an independent predictor of 1-year mortality (OR 2.4) (14). Despite not being able to show it in this study, malnutrition and sarcopenia most likely have a negative impact on survival and the presented decrease in prevalence could be a major factor contributing to the surprisingly unaltered or even decreasing mortality within a population burdened by increasing morbidity.

Limitations and strengths

A limitation of this study is the small sample-size, decreasing generalizability. Additionally, data regarding comorbidities and drugs were collected from documentation of ICD-10 codes and drugs in medical records that might have caused an over- or underestimation.

The fact that no exclusion criteria existed is also a limitation since pathological and high-energy-trauma caused hip fractures were included as well, however as seen in table 1, 97% versus 93% (95%CI -3;12) had a fracture caused by a coplanar fall.

The dropout group in 2018 had a significantly higher age than the included cohort. Comorbidity is associated with increased age (38), thus results on multimorbidity and medications might have been underestimated in 2018.

The strength of this study is the individually collected data from medical records in combination with individual physical examinations of each patient contributing to a complete evaluation of the population regarding morbidity and frailty in a theoretical as well as a physical sense.

Conclusions

By comparing two cohorts of patients with hip fracture, a decade apart, our study in line with others suggests an increase in morbidity in terms of increased comorbidity-burden and preoperative ASA-class as well as an increase in polypharmacy. One-year mortality rate remained unaltered and results indicated a subsequent decrease in frailty in terms of malnutrition and sarcopenia.

Acknowledgements: The corresponding author, Probert, affirms that she has listed everyone who contributed significantly to the work and has obtained written consent from all contributors who are not authors, named in this section. The study was supported by grants from the Research Committee of Region Örebro, Sweden. Appreciation is expressed to all personnel at the geriatric and orthopaedic wards at Örebro University Hospital who assisted with the collection of data and to Anders Magnuson, Clinical Epidemiology and Biostatistics, Örebro University, for statistical advice.

Author contributions: - Study concept and design: Probert, Akner, Wretenberg, Andersson; - Acquisition of data: Andersson, Probert, Lööw, Johnsson; - Analysis and interpretation of data: Probert, Lööw, Andersson; - Preparation of manuscript: Probert, Lööw, Akner, Wretenberg, Andersson

Ethics declaration: Both projects were approved by the Regional Research and Ethics committee in Uppsala, Sweden, DNR 2008/243 and DNR 2017/490. All included patients were informed about the purpose of the study and signed an informed consent.

Conflict of interest: All authors have no conflicts of interest in this work.

Financial disclosure: All authors have no financial disclosure.

Funding Information: Open access funding provided by Örebro University

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Probert and Andersson *BMC Geriatrics* (2023) 23:686
https://doi.org/10.1186/s12877-023-04398-9

BMC Geriatrics

PAPER II

RESEARCH **Open Access**

Functional outcome in patients with hip fracture from 2008 to 2018, and the significance of hand-grip strength – a cross-sectional comparative study

Noelle Probert[1,2*] and Åsa G. Andersson[1,3]

Abstract

Background Incidence of hip fracture is estimated to rise, increasing demands on healthcare. Our objective was to compare patients with hip fracture, a decade apart, regarding surgical characteristics and functional outcome in relation to morbidity. A secondary aim was to analyse postoperative hand-grip strength (HGS) in relation to walking ability 4 months postoperatively.

Methods This is a cross-sectional comparative study of patients with hip fracture, included in 2008 (n = 78) and 2018 (n = 76) at Örebro University Hospital. Patient-data (age, gender, morbidity, fall-circumstances, fracture, surgical characteristics, and length of stay) were collected from medical records. HGS was measured postoperatively. Data on functional outcome in terms of housing, walking ability and need of walking aids at 4 months postoperatively was collected from the Swedish Hip Fracture Register RIKSHÖFT. Statistical analyses adapted were hypothesis tests and regression analysis.

Results Patients in 2018 presented a significantly higher morbidity than patients in 2008 and there were significant differences in adapted surgical methods. Functional outcome at 4-months postoperatively was analysed by logistic regression where Cohort 2018 was associated with higher odds of independent walking ability (OR 5.7; 95%CI 1.9–17.2) and not needing any walking aids (OR 5.1; 95%CI 1.9–17.2). Postoperative HGS was higher among patients in 2018 and a multiple regression analysis revealed a significant association between HGS and walking ability at 4 months postoperatively.

Conclusions This study supports the since previously reported development in hip fracture surgery in Sweden while also presenting that functional outcome seems to have improved despite a concomitant increase in morbidity. Results suggest an improvement in postoperative HGS, predicting walking ability at 4 months postoperatively.

Keywords Hip fracture, Comorbidity, Surgical method, Development, Functional outcome, Hand-grip strength

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Introduction

Hip fracture is a devastating condition causing excess mortality in older people [1]. Sweden represents one of the highest incidences worldwide with approximately 16 000 registered hip fractures annually and a lifetime risk of approximately 20% in women and 10% in men [2–4]. Incidence is expected to rise with longevity, increasing the demands on healthcare in treatment and patient management [5].

Hip fractures are grossly classified as those of the femoral neck or trochanteric fractures and the major surgical methods used are arthroplasty or osteosynthesis [6]. Arthroplasty is associated with a longer surgical duration and length of stay (LOS) but potentially also a better functional outcome postoperatively [6, 7]. It is unclear whether the methods differ regarding postoperative mortality, but a higher failure rate has been seen for osteosynthesis, requiring further surgery [7]. Delayed surgery is associated with increased medical complications, mortality and functional outcome [8–11] and Swedish national guidelines recommend that 80% of patients are operated within 24 h after arrival at a healthcare facility [2].

During the last decades in Sweden there has been a development towards arthroplasty from osteosynthesis in treatment of femoral neck fractures and an increase of intramedullary nailing regarding methods of osteosynthesis [6, 9, 12]. At the same time, LOS has decreased and time to surgery has remained unchanged with approximately 60% of patients operated within 24 h [13]. However, despite this potential development, according to longitudinal studies, subsequent functional outcome at 4 months postoperatively seems to have remained unaltered [6, 13]. A suggested reason for this is a concomitant increase in individual comorbidity-burden and potential frailty within the population [6, 13, 14]. Internationally, a few studies do present an association between individual comorbidities and functional outcome in patients with hip fracture although differing in follow-up time and measurement of outcome [15–18]. Furthermore, increased age (>85) is associated with worser functional outcome and increased frailty in previous studies and has also been presented as an independent risk factor of mortality post hip fracture despite level of frailty and comorbidity [19].

Early functional evaluation in hip fracture patients has an important prognostic value and hand-grip strength (HGS) is an objective and easily measured surrogate for whole body- and specifically lower-limb strength [20, 21] in addition to being an important factor in assessment of frailty [22] and sarcopenia [23]. The European Working Group on Sarcopenia in Older People (EWGSOP) revised the criteria for sarcopenia in 2019, providing validated cut-off values for hand-grip weakness in older people [23]. HGS has been positively associated with functional outcome in hip fracture patients by a few studies [24–26] although to our knowledge not in a Swedish population and none have evaluated a possible association with walking ability at 4 months postoperatively using the EWGSOP2-criteria [23].

This study sought to compare patients with hip fracture from 2008 to 2018 regarding surgical characteristics and 4-month postoperative functional outcome in relation to individual morbidity. A secondary aim was to compare postoperative HGS in relation to walking ability at 4 months postoperatively.

Methods

Study design and population

This was a prospective cross-sectional comparative study where all patients going through surgery due to acute hip fracture diagnosed with ICD-10 codes S72.0 (femoral neck fracture), S72.1 (pertrochanteric fracture) or S72.2 (subtrochanteric fracture) during the periods of Oct 2008 to Feb 2009 and Feb 2018 to Jun 2018 at Örebro University Hospital, were consecutively invited to participate. A written consent signed firstly by the patient or, if possible, secondarily by next of kin was acquired for all included participants. No exclusion criteria existed.

Data collection, variables, and measurements

Individual patient data (age, gender, fall-circumstances, fracture-type, measures of morbidity, time to surgery, surgical-method, LOS, and mortality) were collected from individual medical records using a standardized review protocol.

Age was calculated from year of birth. Gender was male or female. Morbidity was assessed by: preoperative American Society of Anaesthesiologist Classification (ASA-class) [27], individual comorbidities (verified in the medical records according to ICD-10 codes where all Elixhauser comorbidities were evaluated [28]), and multimorbidity, defined as having ≥ 3 comorbidities. Time to surgery was defined as hours from radiology statement of hip fracture to time of surgery. Surgical methods were verified in the medical records according to the Swedish translation of the collective Nordic operational codes: NOMESCO classification of surgical procedures (NCSP69).

HGS was measured with a hand dynamometer (Jamar) in kilograms (kg). The best attempt of three after assessment of both hands was evaluated, cut-off < 27 kg for men and < 16 kg for women according to the EWGSOP2-criteria [23]. All measurements of HGS were carried out bedside before discharge within the first seven days postoperatively by a few licensed physiotherapists, trained in the method. Measurements were conducted in everyday clinical life and included patients received healthcare as well as in-hospital physiotherapy according to normal routines.

Functional outcome

Functional outcome at 4 months postoperatively was assessed by three measurements: housing, walking ability and the need of walking aids. This data (both pre-fracture and at 4 months postoperatively) in addition to data on reoperation was extracted from the Swedish Hip Fracture Register RIKSHÖFT (SHR), a national, clinical, quality register with an estimated coverage of >80% of all hip fractures in Sweden [2]. The different categories of housing, walking aids and walking ability registered were recoded to facilitate the analysis and to improve clinical applicability. "Ordinary housing" corresponded to patients living in their own home while "institutionalized housing" corresponded to any service-housing, rehabilitation-unit/convalescent home, acute hospital or other. "Independent walking ability" corresponded to being able to walk independently both indoors and outdoors while "dependent walking ability" corresponded to needing to be accompanied to walk outdoors and/or indoors. "No need of walking aids" corresponded to not needing any walking aids at all and "walking aids" corresponded to the need of any walking aids except for wheelchair which was considered and presented separately.

Statistical analysis

Differences in age, surgical length and LOS were analysed by independent sample *t* test, differences in comorbidity-count were analysed by the Mann-Whitney *U* test and differences in categorical variables with the chi-square test.

Unadjusted and adjusted logistic regression were performed for the three different functional outcomes in terms of housing, walking aids and walking ability to compare the two cohorts. Adjustment was made for confounders as presented in Table 1. All variables were evaluated on categorical scale. Logistic regression gives odds ratio (OR) with 95% confidence intervals (CI) as association measures. A P-value lower than 0.05 was considered statistically significant and all analyses were performed in IBM SPSS (Armonk, NY, USA) version 25.

Results

Participants

A total of 108 and 97 patients met the inclusion criteria in 2008 and 2018, respectively. In 2008, 30 patients did not give their consent for inclusion and in 2018 the corresponding number was 21, leaving 78 patients included in 2018 and 76 patients in 2018, see Fig. 1. Impaired ability to give consent due to cognitive state in the acute setting was the most common reason for non-inclusion in both cohorts. No cognitive screening tests were performed. There was no significant difference in gender, comorbidity or time to surgery when comparing the included cohorts with the non-included groups in 2008 and 2018. The mean age of the included cohort in 2008 was 81 years compared to 84 years in the non-included group, presenting no significant difference (P=0.26). To the contrary, the non-included group in 2018 presented a significantly higher mean age of 87 compared to the mean age of 80 in the included cohort (P=0.007).

Baseline characteristics

As presented in Table 1, the cohorts where alike in terms of age and gender. There were no significant differences in pre-fracture housing, walking-aids, or walking ability.

The cohorts differed significantly in preoperative morbidity in terms of median comorbidity-count, multimorbidity and ASA-class of 3–4, where Cohort 2018 presented significantly higher values. No patients were assessed with a preoperative ASA-class higher than 4. In addition, there were significant differences regarding surgical method where arthroplasty and osteosynthesis with an intramedullary nail was more common in 2018 than 2008, also further presented according to fracture-type in Fig. 2. Surgery within 24 h and LOS remained unaltered.

Postoperative HGS was assessed in 69 patients in Cohort 2008 with a loss of nine (three due to patient-related conditions, one discontinued participation, one early death and four unspecified) and in 57 patients in Cohort 2018 with a loss of 19 (eight due to patient-related conditions, one declined participation, six occasions due to lack of resources and three unspecified). When the total fallout group of 28 patients was compared with the group of 126 patients where HGS was measured there were no significant differences in gender (P=0.41), mean age (P=0.19) or mean number of comorbidities (P=0.35). In 2008 the average time between surgery and measurement of HGS was 6 days (SD 2) and in 2018 the average time was also 6 days (SD 4), (p=0.15). The mean HGS was significantly higher in Cohort 2018 and there were significantly more patients with a HGS under cut-off in Cohort 2008, see Table 2.

As presented in Fig. 1, 11(14%) patients in Cohort 2008 and 11(14%) patients in Cohort 2018 died before the follow-up at 4 months postoperatively, P=0.95. In addition, for three (4%) patients in Cohort 2008 and five (7%) patients in 2018 no follow-up was completed, P=0.45. The most common reason for no follow-up was that the patient could not be reached via telephone.

There were no significant differences in the three different measures of functional outcome of housing, walking ability and the use of walking aids between Cohort 2008 and Cohort 2018 at the 4-month follow-up, see Table 3. In addition, four (5%) patients in 2008 and one (1%) patient in 2018 were re-operated within follow-up

Table 1 Patient characteristics, surgical characteristics and postoperative HGS of Cohort 2008 and 2018

		Cohort 2008 *n* = 78	Cohort 2018 *n* = 76	P
Patient characteristics – pre-fracture				
Age, mean (SD), years		81(11)	80(12)	0.68
	Age ≥ 80, *n (%)*	50(64)	45(59)	0.53
Gender, female, *n* (%)		49(63)	45(59)	0.65
Comorbidity-count, median (IQR)		1(1)	2(1)	< 0.01
	Multimorbidity [a], *n* (%)	10(13)	21(31)	0.02
ASA-class, *n* (%)	1	10(13)	5(7)	
	2	37(47)	25(33)	< 0.01
	3	29(37)	34(45)	
	4	2(3)	12(16)	
Housing, *n* (%)	Ordinary	65(83)	70(92)	0.10
	Institutionalized	13(17)	6(8)	
Walking ability, *n* (%)	Independent	51(65)	53(70)	
	Dependent	22(28)	20(26)	0.74
	Could not walk	5(6)	3(4)	
Walking aids, *n* (%)	None	32(41)	38(51)	
	Walking aid	41(53)	35(47)	0.33
	Wheelchair	5(6)	2(3)	
Fracture and surgery				
Coplanar-fall-related fracture, *n* (%)		76(97)	71(93)	0.23
Type of fracture, *n* (%)	S72.0	41(53)	37(49)	
	S72.1	31(40)	31(41)	0.79
	S72.2	6(8)	8(11)	
Surgery within 24 h, *n* (%)		39(50)	32(42)	0.33
Surgical method, *n* (%)	Osteosynthesis with pins, nails, screws, and plates	60(77)	42(55)	
	Intramedullary nail	3(4)	13(17)	0.01
	Hemi-arthroplasty	13(17)	14(18)	
	Total arthroplasty	2(3)	6(8)	
	Flail joint	0(0)	2(3)	
Length of stay, mean (SD), days		10(5)	9(4)	0.70
Postoperative HGS		***n* = 69**	***n* = 57**	
HGS, mean (SD), kg		21(11)	26(11)	0.01
HGS under cut-off [b]		33(48)	11(19)	< 0.01

[a], ≥3 comorbidities; [b], <27 kg for men and <16 kg for women; Abbreviations: SD: standard deviation; IQR: Inter Quartile Range; ASA: American Society of Anaesthesiologists; HGS: hand-grip strength

(P=0.18). All the re-operated patients in 2008 had been primarily treated with osteosynthesis with pins or screws due to femoral neck fractures where three patients (two fracture-dislocations and one pseudoarthrosis) were re-operated with a hemiarthroplasty and one patient received a total arthroplasty due to caput necrosis. The single re-operated patient in 2018 was primarily treated by osteosynthesis with a twin-hook due to a per-trochanteric fracture and was re-operated due to a peri-implant fracture with re-osteosynthesis.

A multiple logistic regression analysis was performed for the three functional outcomes at 4 months postoperatively, see Table 3. The unadjusted analysis revealed a significant association between Cohort 2018 and independent walking ability, remaining significant in the adjusted analysis. The adjusted analysis also revealed a significant association between Cohort 2018 and the outcome of not needing any walking aids.

The comparison of postoperative HGS and functional outcome at follow-up included 102 patients (58 patients in 2008 and 44 patients in 2018) due to reasons as described earlier. When comparing postoperative HGS according to the cut-off values of EWGSOP2 with walking ability at the 4-month follow-up there were more independent walkers among the patients who had a HGS over cut-off in both cohorts, further described in Fig. 3. A potential association between postoperative HGS and an independent walking ability at the 4-month follow-up was analysed in a logistic regression analysis adjusted for age and gender revealing a significant OR of 5.8 (CI1.7-17.4, P=<0.01), see Table 4.

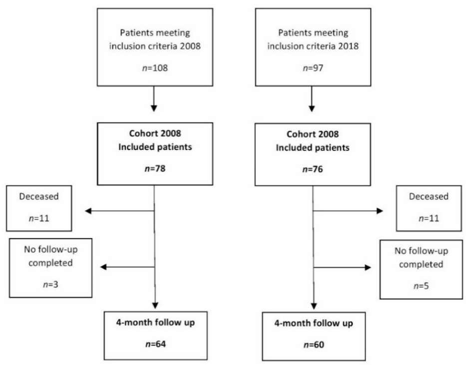

Fig. 1 Patients included at baseline and in the follow-up at 4 months postoperatively

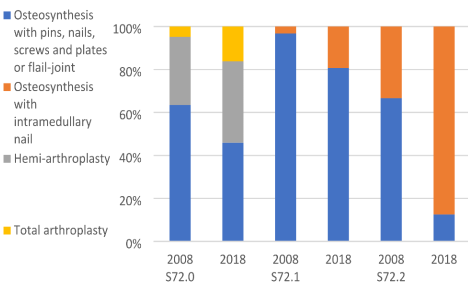

Fig. 2 Surgical methods in relation to fracture-type in Cohort 2008 and Cohort 2018. S72.0, femoral neck fracture; S72.1, pertrochanteric fracture; S72.2, subtrochanteric fracture

Table 2 Functional outcome at the 4-month follow-up

		Cohort 2008 *n* = 64	Cohort 2018 *n* = 60	P
Housing, *n* (%)	Ordinary	50(78)	54(90)	0.07
	Institutionalized	14(22)	6(10)	
Walking ability, *n* (%)	Independent	36(56)	25(42)	
	Dependent	5(8)	2(3)	0.09
	No walking ability	23(34)	33(55)	
Walking aid, *n* (%)	None	9(14)	13(22)	
	Walking aid	49(77)	45(75)	0.25
	Wheelchair	6(9)	2(3)	

Discussion

Results of this cross-sectional comparative study present that the 4-month postoperative functional outcome in hip fracture patients potentially has improved during the last decade in Sweden despite a concomitant increase in morbidity and that postoperative HGS is associated with walking ability at 4 months postoperatively. The study is limited by its small sample-size and observational design although still contributing to knowledge-gaps of the Swedish hip fracture population and further highlighting the potential prognostic value of postoperative HGS.

A majority of the patients in this study were women with a mean age of 80–81 years which is in line with other studies and national data [6, 12]. Patients in 2018 presented a higher morbidity-level in terms of an increased comorbidity-burden, multimorbidity and preoperative ASA-class compared to patients in 2008 which has also been reported by previous studies both nationally and internationally [13, 29]. Our results are also in line with previous studies in reporting a shift in choice of surgical methods during the last decades in Sweden as well as in other countries. The shift being an increased use of intramedullary nailing in trochanteric fractures and arthroplasty in femoral neck fractures [6, 12]. In addition, our study presented no statistically significant difference regarding surgeries performed within 24 h, a trend also supported by larger Swedish longitudinal studies [13]. This is potentially related to the concomitant increase in morbidity where preoperatively unstable medical conditions is a known contributor to prolonged time to surgery [30]. The cohorts did not differ significantly regarding LOS, although our results do indicate a decrease which is also what other studies have reported over time in Sweden [13]. The 4-month mortality-rate was 14% in 2008 respectively 14% in 2018 ($P = 0.95$) which is similar to but slightly higher than what has been reported in other Swedish studies [13, 31]. An age over 85 years has been presented as an independent risk factor for 1-year mortality in patients with hip fracture by previous studies [19] although, in line with this, age did not differ significantly between the cohorts in this study.

There were no significant differences between Cohort 2008 and Cohort 2018 regarding the three measures of functional outcome, see Table 3, also supported by national data [6, 13]. However interestingly, the results of the logistic regression analysis for the three functional outcome measures in this study (see Table 3) revealed that after adjustment for preoperative functional status, age, gender, surgical method, and morbidity in terms of ASA-class and multimorbidity, the odds of being an independent walker and not needing any walking aids at the 4-month follow-up were 5.7 (95%CI 1.9–17.2) respectively 5.1 (95%CI 1.0-26.4) times significantly higher in 2018 than in 2008. The unadjusted analysis also presented a significant association between independent walking ability and patients in Cohort 2018 with an unadjusted OR of 2.2 (95%CI 1.1–4.5), although the level of significance and the odds ratio increased after adjustment. These results do suggest that the increased morbidity in Cohort 2018 seems to be affecting the patients' recovery

Table 3 Unadjusted and adjusted logistic regression for the functional outcomes at the 4-month follow-up

	n (%)	Unadjusted *n* = 124		Adjusted *n* = 124	
		OR (95%CI)	**P**	**OR (95%CI)**	**P**
Ordinary housing at follow-up					
Cohort 2018		2.5 (0.9–7.1)	0.08	2.1 (0.6–7.4) [a]	0.30
Cohort 2008		reference		reference	
Independent walking ability at follow-up					
Cohort 2018		2.2 (1.1–4.5)	0.03	5.7 (1.9–17.2) [b]	< 0.01
Cohort 2008		reference		reference	
No need of walking aids at follow-up					
Cohort 2018		1.7 (0.7–4.3)	0.30	5.1 (1.0-26.4) [c]	0.05
Cohort 2008		reference		reference	

[a] Adjusted for housing before fracture, gender, age, multimorbidity (≥3 comorbidities), ASA-class ≥ 3 and surgical method (arthroplasty or osteosynthesis)

[b] Adjusted for walking ability before fracture, gender, age, multimorbidity (≥3 comorbidities), ASA-class ≥ 3 and surgical method (arthroplasty or osteosynthesis)

[c] Adjusted for walking aid before fracture, gender, age, multimorbidity (≥3 comorbidities), ASA-class ≥ 3 and surgical method (arthroplasty or osteosynthesis)

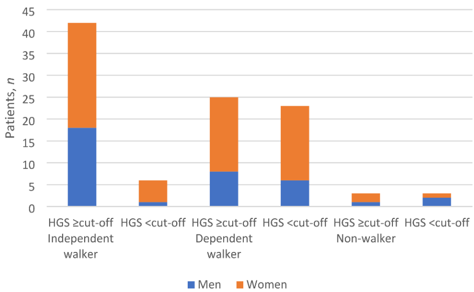

Fig. 3 HGS measured postoperatively before discharge, presented in relation to reported walking ability 4 months postoperatively. Cut-off: < 27 kg for men and < 16 kg for women. Abbreviations: HSG, hand-grip strength

negatively and, in relation to earlier studies, potentially highlighting that the development over time regarding surgery and management of patients with hip fracture in Sweden has in some aspects been successful despite not being directly apparent in figures of functional outcome in previous studies, lacking data on individual comorbidity-burden [6, 13]. However, evidently this study has not considered all potential confounders.

Patients in Cohort 2018 had a significantly higher postoperative mean HGS and hand-grip weakness was significantly lower than in Cohort 2008 according to the cut-off values of EWGSOP2 [23]. These particular findings are discussed in relation to the increased comorbidity-burden and unaltered mortality in another study based on the same population as this study, published in 2020 [14]. A multiple logistic regression analysis revealed that patients who had a HGS over cut-off at discharge had significantly 5.8 (CI 1.7–17.4) times higher odds of being independent walkers at the 4-month follow-up after adjustment for age and gender, see Table 4. Previous studies support these results although differing in their follow-up time and measurement of functional outcome [24, 25, 32, 33]. Savino et al. found that a higher preoperative HGS was significantly correlated with a higher probability of independent walking recovery withing the first year postoperatively [32]. Milman et al. found that HGS as a continuous variable, as well as dichotomized according to the cut-off values by EWGSOP2, significantly predicted the success of rehabilitation in patients with hip fracture [33]. Di Monaco et al. and Selakovic et al. found significant correlations between postoperative HGS and better performance in activities of daily living up to six months postoperatively [24, 25] where Selakovic et al. also defined hand-grip weakness according to the definition by EWGSOP2 [24]. Considering this, our results contribute to and further underline the prognostic value of HGS, a quick and easily measured surrogate for whole body strength, not limited to patients with walking ability in the immediate postoperative phase [20, 21]. Furthermore, these findings also highlight the importance of physical activity and interventions to maintain muscle strength in the older

Table 4 Unadjusted and adjusted logistic regression for independent walking ability, presented in relation to postoperative HGS

	n (%)	Unadjusted *n* = 102		Adjusted *n* = 102	
		OR (95%CI)	**P**	**OR (95%CI)**	**P**
Independent walking ability at follow-up					
HGS over cut-off [a]		6.5 (2.4–17.8)	< 0.01	5.8 (1.7–17.4) [b]	< 0.01
HGS under cut-off		reference		reference	

[a] Cut-off < 27 kg for men and < 16 kg for women; [b] Adjusted for age and gender. Abbreviations: HGS: hand-grip strength; OR: odds ratio; CI: confidence interval

population, considering the effect on postoperative functional outcome.

Limitations and strengths

Results of this study are limited by the small sample-size and observational design. Most data were collected from medical records where the risk of error in documentation cannot be disregarded. Data on functional outcome at follow-up was collected from the SHR where follow-up data was initially collected via phone-conversations with patients or close relatives by use of a questionnaire and the risk of outcome misclassification cannot be completely ruled out. Furthermore, the non-included patients and fallout of data of this study is a limiting factor. The non-included group in 2018 was significantly older than the included cohort (p=0.007) and inclusion could possibly have affected results. In addition, a total of 28 patients were not included in the measurement of postoperative HGS while three patients in 2008 and five patients in 2018 were not included in the follow-up which could also have affected results on HGS and functional outcome. The follow-up time of 4 months was adapted since it is the official follow-up time used by the SHR, although, also supported by previous studies as a valid time for assessing functional outcome in patients with hip fracture [34]. Furthermore, this study lacks data on individually performed in-hospital and post-discharge physiotherapy which of course could have interfered with results. A strength of this study is that it had no exclusion criteria in turn contributing to correctly portraying clinical reality. In addition, this study assessed patients through both registered data, individual data from medical records and bedside anthropometric measurements such as HGS, not possible in larger register-based studies. To our knowledge, this is the first cross-sectional study in Sweden assessing functional outcome after hip fracture surgery in relation to individual comorbidity-burden as well as assessing the potential predictive value of HGS in functional outcome.

Conclusion

In conclusion, by comparing patients with hip fracture, a decade apart, this study supports the since previously reported developments in hip fracture-surgery and hospitalization in Sweden while also presenting that functional outcome seems to have improved despite a concomitant increase in morbidity. Results suggest an improvement in postoperative HGS, significantly associated with walking ability at 4 months postoperatively.

Abbreviations

LOS	Length of stay
HGS	Hand-grip strength
EWGSOP	European Working Group on Sarcopenia in Older People
ASA–class	American Society of Anaesthesiologist Classification
SHR	Swedish Hip fracture Register

Acknowledgements

Appreciation is expressed to all personnel at Örebro University Hospital who assisted with the collection of data and to Anders Magnuson for statistical advice.

Authors' contributions

Study concept and design was planned by ÅGA in both 2008 and 2018 and NP contributed to concept and design in 2018. Acquisition of data was conducted by both authors. Analysis and interpretation of data was conducted by both authors. Manuscript preparation was conducted by NP with guidance from ÅGA. Both authors read and approved the final manuscript.

Funding

Open access funding was provided by Örebro University. This work was supported by ALF-funding of Region Örebro County. Grant number is not applicable.
Open access funding provided by Örebro University.

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

All experimental protocols for this study were ethically approved by the Regional Research and Ethics committee in Uppsala, Sweden, DNR 2008/243, DNR 2017/490 and DNR 2022-01682-02. Informed consent was obtained from all the participants, primarily by written consent from the participants themselves and secondarily, if possible, from next of kin. All the experiments in this study were conducted in accordance with the relevant guidelines and regulations.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Received: 17 March 2023 / Accepted: 9 October 2023
Published online: 23 October 2023

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PAPER III

European Geriatric Medicine (2022) 13:1089–1097
https://doi.org/10.1007/s41999-022-00640-6

RESEARCH PAPER

Check for updates

Surgical-site infection after hip fracture surgery: preoperative full-body disinfection compared to local disinfection of the surgical site—a population-based observational cohort study

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Received: 23 December 2021 / Accepted: 21 March 2022 / Published online: 7 April 2022

PAPER III

Key summary points

Aim To compare preoperative full-body disinfection (FBD) prior to hip fracture surgery with local disinfection (LD) of the surgical site regarding incidence of postoperative surgical-site infection (SSI), both procedures performed with 4% chlorhexidine.

Findings There were 16 (6.8%) cases of SSI in 2018 when FBD was performed and 8 (3.1%) cases in 2019 when LD was performed. FBD (2018) compared to LD (2019) presented an adjusted OR of 2.0 (95% CI 0.8–5.1) in the logistic regression analysis.

Message Results suggest that LD is not inferior to FBD regarding SSI prevention, meaning patients could potentially be spared significant levels of pain caused by FBD.

Abstract

Purpose Swedish national guidelines recommend full-body disinfection (FBD) with 4% chlorhexidine before hip fracture surgery to prevent surgical-site infection (SSI) despite little evidence. Our objective was to compare preoperative FBD with local disinfection (LD) of the surgical site regarding SSI incidence.

Methods All patients with hip fracture, operated at a hospital in Sweden, January 1, 2018 to December 31, 2019 were included. Patients in 2018 ($n=237$) were prepared with FBD and patients in 2019 ($n=259$) with LD. Primary outcome was SSI and secondary outcome was SSI and/or death. We adjusted for potential confounders with logistic regression. The adjusted analysis was performed in two models to enable assessment of variables that lacked either outcome; in the first model, these variables were not adjusted, and the second model was restricted to a sub-population not affected by respective variables.

Results There were 16 (6.8%) cases of SSI in 2018 and 8 (3.1%) cases in 2019. FBD (2018) compared to LD (2019) presented an adjusted OR of 1.9 (95%CI 0.8–4.9, $P=0.16$) respectively 2.0 (95%CI 0.8–5.1, $P=0.14$) in the two models of the logistic regression. In addition, 40 (16.9%) patients in 2018 and 29 (11.2%) patients in 2019 had the combined outcome of SSI and/or death, adjusted OR 1.6 (95% CI 0.9–2.8, $P=0.08$) respectively 1.7 (95% CI 0.9–2.9, $P=0.06$).

Conclusion We found a non-significant increased risk of SSI 2018 compared to 2019 after adjustment. Randomized control trials are needed. Nonetheless, results suggest that LD is not inferior to FBD regarding SSI prevention, meaning patients could potentially be spared substantial pain.

Keywords Hip fracture · Surgical-site infection · Disinfection · Hip fracture surgery

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Introduction

Surgical-site infection (SSI) after hip fracture surgery is a disastrous complication associated with increased mortality [1, 2]. SSIs are commonly divided into superficial infection of the skin or subcutaneous tissue and deep infection of the fascia, muscle and prosthetic devices or implant material [3]. Incidence varies from 1 to 8%, deep infection representing 1–2% [1, 2, 4–8]. Numerous risk factors have been identified, both related to patient characteristics [6, 7, 9–11], and to surgery [4–7, 12–14]. Association has also been identified for postoperative factors, such as increased length of stay (LOS), readmission [15], and other infections [16, 17].

The source of pathogens is often the endogenous flora of the patient's skin and *Staphylococcus aureus (S. aureus)* is the most commonly isolated pathogen [1–3]. Therefore, an obvious strategy for SSI prevention is preoperative skin disinfection. The Swedish Handbook for Healthcare recommends that patients planned for procedures posing a risk of infection by skin-colonizing bacteria go through full-body disinfection (FBD) with 4% chlorhexidine preoperatively. This method is well established and has been recommended for several years due to research presenting evidence [18, 19]. However, according to more recent studies questioning the method, FBD decreases the amount of skin-colonizing bacteria, but it is uncertain whether this results in a reduction of SSIs and systematic reviews present that there in fact does not seem to be any clear evidence of benefit in using FBD with 4% chlorhexidine compared to local disinfection of the surgical site (LD), placebo, no wash or regular soap in terms of SSI prevention [20–24]. Due to the notion of this over the past years, the recommendation is only carried out by approximately 50% of all orthopedic clinics in Sweden [25].

The objective of the study was to compare incidence of SSI between traditional FBD prior to hip fracture surgery with LD of the surgical site, both procedures performed with 4% chlorhexidine.

Patients and methods

Study design, setting and participants

In this retrospective population-based observational cohort study, all hospitalizations of patients with acute hip fracture, classified with International Classification of Disease, tenth revision (ICD-10) codes: S72.0 (cervical hip fracture), S72.1 (pertrochanteric hip fracture) or S72.2 (sub-trochanteric hip fracture) who underwent hip fracture surgery at Karlskoga Hospital in Sweden between January 1, 2018 and December 31, 2019 were consecutively included.

Study intervention

In 2018 preoperative disinfection was performed as FBD with 4% chlorhexidine meaning patients were showered twice during one occasion taking place on a specific shower-gurney. In 2019 preoperative disinfection was performed as LD of the planned surgical site with 4% chlorhexidine meaning patients were disinfected once during one occasion in their own bed. The change in method of disinfection at the orthopedic ward was planned (in line with other orthopedic clinics in Sweden, as mentioned in the introduction) and therefore initially unrelated to this study. During both years, the respective procedures were performed once within 24 h of surgery. If time to surgery was longer than 24 h, disinfection was repeated. All procedures were performed by nursing staff of the orthopedic ward. For each patient, a standardized form was completed addressing how the preoperative washing was performed. If no form was available, information on disinfection was obtained from patient medical records. According to routines of the Orthopedic ward, all patients received antibiotic prophylaxis preoperatively. Patients prepared for arthroplasty received Cloxacillin 2 g×3 at set times preoperatively, patients with penicillin-allergy receiving Clindamycin 600 mg×3. Patients prepared for osteosynthesis obtained Cefuroxime 1.5 g×3, patients with penicillin-allergy receiving Clindamycin 600 mg in a single dose.

Patient characteristics and confounders

Data were obtained through retrospective review of medical records by use of a standardized review protocol. Initially, patients were observed during hospitalization and all medical records regarding in-patient care within time of follow-up were reviewed. After discharge, medical records regarding in-patient or out-patient care were reviewed for the remaining time of follow-up. Follow-up time was until 6 weeks postoperatively [26].

The following patient information was obtained to characterize the two cohorts: fracture type, length of stay (LOS), pre- and perioperative antibiotics, other infections apart from SSI defined as other antibiotic-treated conditions (not including antibiotic-treated *Clostridium difficile* enterocolitis, cholecystitis caused by gallstones and pyelitis caused by kidney stones), SSI, readmission (into in-patient care) and death. In addition, according to published literature, the following factors identified as significantly associated with SSI were recorded and categorized accordingly: sex [11], age (< 80, ≥ 80 [6], comorbidities [9], American Society of Anesthesiologists classification (ASA class) (≤ 3, > 3) [7], current smoking [7, 9], BMI [6, 7, 9, 10], ongoing anticoagulant therapy [9], ongoing corticosteroid therapy [10], time to surgery (from time of X-ray) (< 24 h, ≥ 24 h) [4], surgical length (< 120, ≥ 120 min) [6, 7], experience of surgeon (less-experienced surgeon or senior surgeon according to working title) [5, 12, 13], reoperation (not related to SSI) [12], and operation with arthroplasty (as opposed to internal fixation) [5, 27].

Comorbidities were collected according to registered ICD-10 codes and comorbidities registered in a standardized form in the surgical records. A Charlson Comorbidity Index (CCI) was calculated according to the coding system by Ludvigsson et al. [28]. Cognitive impairment is a risk factor of SSI [29] and a relevant characterizing factor when it comes to geriatric populations and was therefore presented separately in Table 1, in addition to being included in the CCI calculated for each patient. We defined cognitive impairment as all patients diagnosed with ICD-10 codes of dementia and delirium (F00-F05). The code E11.9 (uncomplicated type 2 diabetes) was the most common code for diabetes among patients in this study but is not included in this coding system for CCI. Therefore, due to that specifically, diabetes mellitus has been identified as an important risk factor of SSI [10], diabetes mellitus was presented independently and therefore not included in the CCI calculated for each patient. SSI was defined as patients diagnosed with ICD-10 codes of superficial infection of the surgical wound or deep infection of prosthetic devices or implant material by a clinician during follow-up. Information on collected microbial cultures and isolated pathogens was also retrieved from medical records.

Primary and secondary outcome measures

Our primary outcome was incidence of SSI, and our secondary outcome was incidence of SSI and/or death. There were patients who died during the 6 weeks follow-up and therefore the secondary outcome was included; due to that, the outcome of SSI within follow-up could not be ruled out in deceased patients.

Statistical analyses

Differences in age and CCI between the two cohorts were analyzed by independent sample *t* test, differences in LOS and duration of surgery were analyzed by the Mann–Whitney *U* test and differences in categorical variables with the chi-square test.

Unadjusted and adjusted logistic regressions were performed for the SSI and the SSI and/or death outcome to compare the two cohorts. Adjustment was made for the potential confounders presented above under data collection. All variables were evaluated on categorical scale except for CCI evaluated on continuous scale. However, the adjustment could not be performed for smoking and surgeon experience for the SSI outcome and for smoking for the SSI and/or death outcome due to no outcome events among current smokers and/or patients operated by a less-experienced surgeon. Therefore, two adjusted models were performed, the first with no adjustment for the named variables and the second where the adjusted analysis was restricted to the subgroup of non-smoking patients (SSI and/or death outcome) and non-smoking patients operated by a senior surgeon (SSI outcome). The restricted analysis for the SSI outcome included 442 of the 496 (89%) patients. Logistic regression gives odds

Table 1 Characteristics of patients in cohort 2018 and 2019

Patient characteristics	FBD, 2018 $n = 237$	LD, 2019 $n = 259$	*P*
Age, mean (SD)	81 (10)	83 (10)	0.02
Age > 80, *n* (%)	147 (62)	183 (71)	0.04
Female, *n* (%)	155 (65)	176 (68)	0.55
Type of fracture, *n* (%)			
S72.0—Cervical	133 (56)	115 (44)	0.01
S72.1—Pertrochanteric	86 (36)	117 (45)	0.04
S72.2—Sub-trochanteric	18 (8)	27 (10)	0.27
CCI, mean (SD)	5 (2)	5 (2)	0.39
ASA class ≥ 3	152 (59)	122 (51)	0.11
Cognitive impairment	47 (20)	55 (21)	0.70
Diabetes Mellitus			
All	49 (21)	36 (14)	0.05
Insulin-dependent	23 (10)	16 (6)	0.15
Current smoking	13 (6)	8 (3)	0.19
Anticoagulant therapy	33 (14)	43 (17)	0.41
Corticosteroid therapy	12 (5)	17 (7)	0.48
Hospitalization			
Surgery within 24 h, *n* (%)	155 (65)	186 (72)	0.12
Surgical length, minutes, median (IQR)	70 (51–97)	64 (43–89)	0.02
Less experienced surgeon	17 (7)	19 (7)	0.94
Reoperation (not due to infection)	13 (6)	6 (2)	0.07
Arthroplasty			
All	95 (40)	83 (32)	0.06
Cervical fractures	94 (71)	80 (70)	0.85
Pre-operative antibiotics, *n* (%)	9 (4)	8 (3)	0.67
Peri-operative antibiotics, *n* (%)	215 (91)	237 (92)	0.76
LOS, median (IQR)	6 (4–8)	6 (4–7)	0.42
Readmission	39 (17)	53 (21)	0.25

FBD full-body disinfection, *LD* local disinfection, *SD* standard deviation, *CI* confidence interval, *CCI* Charlson Comorbidity Index, *ASA class* American Society of Anesthesiologists Classification system, *IQR* inter-quartile range, *LOS* length of stay

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ratio (OR) with 95% confidence intervals (CI) as association measures. A P value lower than 0.05 was regarded as statistically significant and all analyses were performed in IBM SPSS (Armonk, NY, USA) version 25. A power analysis was performed in retrospect of our study findings, the SSI risk difference (6.8% and 3.1% in the cohorts) and the sample size of 496 patients (237 and 259 in the cohorts) revealing a power of around 50% with the significance level of 5% by the use of chi-square test as statistical method.

Results

As presented in Fig. 1, 237 and 259 hospitalizations were included for further analysis. Hospitalizations of patients with unattainable medical records, of patients who suffered from a second fracture during inclusion and of patients who did not receive disinfection according to correct routine were secondarily excluded.

As seen in Table 1, patients in 2019 had a slightly higher mean age while cervical fractures were significantly more common, and patients had a significantly higher frequency of surgeries < 120 min in 2018. BMI was only found for 12% respectively 6% of patients in 2018 and 2019 and is not included in Table 1.

There were 16 (6.8%) cases of SSI in in 2018 and 8 (3.1%) cases of SSI in in 2019 (Table 2) with an unadjusted OR of 2.3 (95% CI 0.9–5.4, $P = 0.06$) and an adjusted OR of 1.9 (95% CI 0.8–4.9, $P = 0.16$) in the model with no adjustment for smoking and surgeon experience, respectively 2.0 (0.8–5.1, $P = 0.14$) in the population restricted to non-smokers operated by a senior surgeon. In both adjusted models CCI score, reoperation and arthroplasty were associated with a statistically significant increased risk of SSI.

In addition, 40 (16.9%) patients in 2018 and 29 (11.2%) patients in 2019 had the combined outcome of SSI and/or death (Table 3), with an unadjusted OR of 1.6 (95 CI 0.9–2.7, $P = 0.07$) and adjusted OR of 1.6 (95% CI 0.9–2.8, $P = 0.08$) in the model with no adjustment for smoking, respectively 1.7 (0.9–2.9, $P = 0.06$) in the restricted non-smoking population.

Two cases of SSI in 2018 and one case in 2019 were deep infections of the prosthetic devices or implant material, treated by further surgery. The other cases of SSI were superficial infections of the surgical wound, treated with antibiotics. All SSI diagnoses were based on either clinical symptoms of infection and/or positive microbial culture. Most cases were detected within 3 weeks postoperatively (Fig. 2); 75% and 88% respectively detected after discharge. Re-disinfection due to postponed surgery was performed on 8 (3.4%) patients in 2018 and 4 (1.5%) patients in 2019 ($P = 0.19$), no cases of SSI were detected among these patients.

S. aureus was isolated in four cultures in 2018 and one culture in 2019. Other positive cultures presented CoNS,

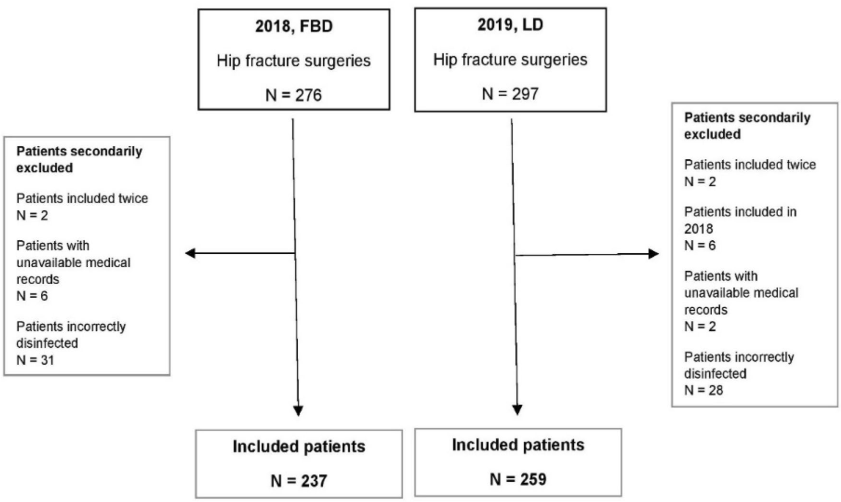

Fig. 1 Study design of included patients who went through hip fracture surgery in 2018 and 2019. Abbreviations: *FBD* full-body disinfection, *LD* Local disinfection

Table 2 Unadjusted and adjusted logistic regression for the SSI outcome

	SSI	Unadjusted ($n=496$)		Adjusted 1[a] ($n=496$)		Adjusted 2[b] ($n=442$)	
	n (%)	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
FBD, 2018	16 (6.8)	2.3 (0.9–5.4)	0.064	1.9 (0.8–4.9)	0.16	2.0 (0.8–5.1)	0.14
LD, 2019	8 (3.1)	Reference		Reference		Reference	
Age < 80 years	7 (4.2)	Reference		Reference		Reference	
Age ≥ 80 years	17 (5.2)	1.2 (0.5–3.0)	0.65	1.0 (0.4–2.7)	0.98	0.8 (0.3–2.1)	0.60
Male	7 (4.2)	Reference		Reference		Reference	
Female	17 (5.1)	1.2 (0.5–3.0)	0.66	1.4 (0.5–3.7)	0.49	1.3 (0.5–3.4)	0.59
CCI, per unit		1.3 (1.0–1.6)	0.03	1.4 (1.1–1.9)	0.01	1.6 (1.1–2.1)	< 0.01
ASA class ≤ 3	11 (5.0)	Reference		Reference		Reference	
ASA class > 3	13 (4.7)	0.9 (0.4–2.2)	0.96	0.6 (0.2–1.6)	0.29	0.5 (0.2–1.5)	0.22
No DM	18 (4.4)	Reference		Reference		Reference	
DM	6 (7.1)	1.6 (0.6–4.3)	0.30	1.1 (0.4–3.2)	0.84	1.1 (0.4–3.1)	0.92
No current smoker	24 (5.1)	Reference					
Current smoker	0 (0.0)	NE[c]					
No anticoagulant therapy	22 (5.2)	Reference		Reference		Reference	
Anticoagulant therapy	2 (2.6)	0.5 (0.1–2.1)	0.49	0.6 (0.1–3.0)	0.55	0.6 (0.1–2.8)	0.49
No corticosteroid therapy	22 (4.7)	Reference		Reference		Reference	
Corticosteroid therapy	2 (6.7)	1.4 (0.3–6.4)	0.63	1.4 (0.3–7.2)	0.67	1.3 (0.2–6.6)	0.76
Surgery after 24 h	6 (3.9)	Reference		Reference		Reference	
Surgery within 24 h	18 (5.3)	1.4 (0.5–3.6)	0.50	1.7 (0.6–4.7)	0.31	1.8 (0.6–4.9)	0.27
Surgical length < 120 min	22 (4.9)	Reference		Reference		Reference	
Surgical length ≥ 120 min	2 (4.7)	1.0 (0.2–4.2)	0.95	1.0 (0.2–4.7)	0.97	1.1 (0.2–5.0)	0.94
Senior surgeon	24 (5.2)	Reference					
Less experienced surgeon	0 (0.0)	NE[c]					
No reoperation	20 (4.2)	Reference		Reference		Reference	
Reoperation	4 (21.1)	6.1 (1.8–20.0)	< 0.01	7.5 (2.0–27.9)	< 0.01	6.9 (1.8–26.0)	< 0.01
No arthroplasty	9 (2.8)	Reference		Reference		Reference	
Arthroplasty	15 (8.4)	3.2 (1.4–7.4)	< 0.01	3.5 (1.4–8.6)	< 0.01	3.3 (1.3–8.2)	0.01

SSI surgical-site infection, *OR* Odds ratio, *CI* confidence interval, *CCI* Charlson Comorbidity Index, *ASA* American Society of Anesthesiologists Classification system, *DM* Diabetes Mellitus

[a]Adjusted 1, Study population was all patients with adjustment for all variables except smoking and patients operated by a less-experienced/senior surgeon due to no SSI outcome

[b]Adjusted 2, Study population restricted to non-smokers and patients operated by a senior surgeon with adjustment for all other variables

[c]NE No estimate due to no SSI outcomes in current smoker and less-experienced surgeon

mono-microbial growth of Gram-negative microorganisms or poly-microbial growth. MRSA was not detected in any cultures. In seven of the SSI cases, no culture was taken, and in one case, the culture was negative.

The cohorts did not differ regarding other infections apart from SSI (divided by origin), presenting the following incidences: urinary tract infections with 34 (14.3%) cases in 2018 and 35 (13.5%) cases in 2019 ($P=0.79$), airway infections with 11 (4.6%) cases in 2018 and 14 (5.4%) cases in 2019 ($P=0.70$), skin infections with 6 (2.5%) cases in 2018 and 6 (2.3%) cases in 2019 ($P=0.88$) and infections of unknown origin with 2 (0.8%) cases in 2018 and 2 (0.8%) cases in 2019 ($P=0.93$).

Discussion

In this retrospective population-based observational cohort study, the results showed a non-significant difference with an adjusted OR of 2.0 when traditional FBD before hip fracture surgery was compared to LD in terms of SSI incidence. Due to few cases of SSI, the study was somewhat underpowered which prevents us from reaching clearer results. Nonetheless, results indicate that the method of LD does not seem to be inferior to traditional FBD in terms of SSI prevention.

Patients were alike in baseline characteristics (Table 1), values also coinciding with national data [25]. There were

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Table 3 Unadjusted and adjusted logistic regression for the SSI and/or death outcome

	SSI and/or Death	Unadjusted ($n = 496$)		Adjusted 1[a] ($n = 496$)		Adjusted 2[b] ($n = 475$)	
	n (%)	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
FBD, 2018	40 (16.9)	1.6 (0.9–2.7)	0.07	1.6 (0.9–2.8)	0.08	1.7 (0.9–2.9)	0.06
LD, 2019	29 (11.2)	Reference		Reference		Reference	
Age < 80 years	15 (9.0)	Reference		Reference		Reference	
Age ≥ 80 years	54 (16.4)	2.0 (1.1–3.6)	0.03	1.3 (0.7–2.6)	0.41	1.1 (0.6–2.2)	0.76
Male	27 (16.4)	Reference		Reference		Reference	
Female	42 (12.7)	0.74 (0.4–1.3)	0.27	0.8 (0.4–1.4)	0.38	0.8 (0.4–1.3)	0.31
CCI, per unit		1.4 (1.2–1.6)	< 0.01	1.3 (1.1–1.6)	< 0.01	1.4 (1.1–1.7)	< 0.01
ASA class ≤ 3	20 (9.0)	Reference		Reference		Reference	
ASA class > 3	49 (17.9)	2.2 (1.3–3.8)	< 0.01	1.4 (0.7–2.7)	0.29	1.4 (0.7–2.6)	0.36
No DM	55 (13.4)	Reference		Reference		Reference	
DM	14 (16.5)	1.3 (0.7–2.4)	0.46	0.9 (0.5–1.8)	0.80	0.9 (0.4–1.7)	0.66
No current smoker	69 (14.5)	Reference					
Current smoker	0 (0.0)	NE[c]					
No anticoagulant therapy	56 (13.3)	Reference		Reference		Reference	
Anticoagulant therapy	13 (17.1)	1.3 (0.7–2.6)	0.38	0.9(0.4–1.9)	0.83	0.9 (0.4–1.9)	0.80
No corticosteroid therapy	64 (13.7)	Reference		Reference		Reference	
Corticosteroid therapy	5 (16.7)	1.3 (0.5–3.4)	0.65	0.8 (0.3–2.4)	0.73	0.8 (0.3–2.3)	0.67
Surgery after 24 h	27 (17.4)	Reference		Reference		Reference	
Surgery within 24 h	42 (12.3)	0.7 (0.4–1.1)	0.13	0.8 (0.4–1.4)	0.38	0.8 (0.5–1.4)	0.44
Surgical length < 120 min	63 (13.9)	Reference		Reference		Reference	
Surgical length ≥ 120 min	6 (14.0)	1.0 (0.4–2.5)	0.99	1.1 (0.4–2.7)	0.88	1.0 (0.4–2.6)	0.96
Senior surgeon	66 (14.3)	Reference		Reference		Reference	
Less experienced surgeon	3 (8.3)	0.5 (0.2–1.8)	0.32	0.6 (0.2–2.1)	0.42	0.7 (0.2–2.4)	0.55
No reoperation	64 (13.4)	Reference		Reference		Reference	
Reoperation	5 (26.3)	2.3 (0.8–6.6)	0.12	2.1 (0.7–6.4)	0.21	2.0 (0.7–6.3)	0.22
No arthroplasty	37 (11.6)	Reference		Reference		Reference	
Arthroplasty	32 (18.0)	1.7 (0.9–2.8)	0.05	1.6 (0.9–2.8)	0.07	1.7 (0.9–2.9)	0.07

SSI surgical-site infection, *OR* Odds ratio, *CI* confidence interval, *CCI* Charlson Comorbidity Index, *ASA* American Society of Anesthesiologists Classification system, *DM* Diabetes Mellitus

[a]Adjusted 1, Study population was all patients with adjustment for all variables except smoking due to no SSI/death outcome

[b]Adjusted 2, Study population restricted to non-smokers with adjustment for all other variables

[c]NE No estimate due to no SSI outcomes in current smoker

significant differences in fracture type between the years although this has not been associated with SSI incidence [1, 5, 7]. Known risk factors of SSI that differed significantly between the cohorts in Table 1 were increased mean age > 80 [6], (although in contradiction patients in 2019 were older) and surgical time of > 120 min [6, 7], higher in 2018. The found incidence of SSI [6, 7], timing of detection (Fig. 2) [30], and isolated pathogens in positive cultures [1, 2, 30], resembles what others have reported.

Our main finding suggesting that the change in method from traditional FBD to LD does not seem to have caused an increased incidence of SSI is in general supported. Bonnevialle et al. compared patients prepared with an antiseptic shower (polyvidone iodine) twice before elective hip replacement with emergency patients not prepared at all and found no cases of SSI in either cohort [23]. Rotter et al. compared FBD with chlorhexidine before clean surgery with a detergent not containing chlorhexidine and found that the relative risk of wound infection in the chlorhexidine group was 1.11% (CI 0.69–1.82) in comparison to the non-chlorhexidine group [21]. Systematic reviews by Webster et al. including all kinds of surgery in addition to Jivegård et al. and Franco et al. addressing all kinds of clean surgery found no evidence of benefit in preoperative FBD with 4% chlorhexidine compared to placebo, soap, and no washing in terms of SSI incidence. However, in contradiction, Wihlborg et al. conducted a study in 1987 similar to ours but reported of a significantly lower rate of SSI in patients preoperatively

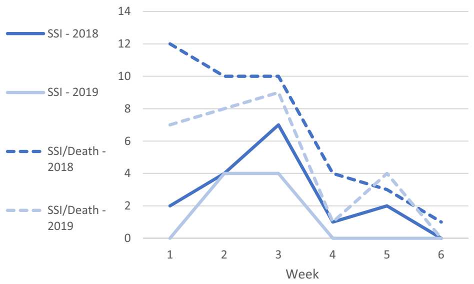

Fig. 2 Time of SSI and SSI and/or death during the follow-up time of 6 weeks postoperatively in 2018 and 2019. Abbreviations: *SSI* surgical-site infection

prepared with 4% chlorhexidine FBD (1.7%) compared to LD of the surgical area (4.1%), RR 0.4 (CI 0.19–0.85), although addressing patients who went through biliary tract, inguinal hernia or breast surgery [31].

The role of chlorhexidine and FBD in SSI prevention seems to be unclear. Although, it remains surprising that even after adjustment for confounders, the cohort prepared with FBD had an odds ratio of 2.0 compared to LD in terms of association with SSI risk. This association has not been recorded to the same extent or not at all in other studies as mentioned above; however, these studies are not directly comparable due to differences, such as included surgeries, type of antiseptic used and diagnostic criteria of SSI, etc. Interestingly, it has been reported by others that disinfection with chlorhexidine prior to hip and knee arthroplasty as well as cardiac surgery does not seem to eradicate bacteria but decreases bacterial diversity [32], and in some cases, increases presence of Gram-negative bacteria, possibly reducing colonization resistance [33]. These findings could potentially explain our results although this is purely speculative. Anyhow, LD does not seem to be inferior to traditional FBD in terms of SSI prevention and if chlorhexidine does in fact have a role in this, LD is a more humane alternative for all patients considering the pain caused by FBD, especially when it comes to frail and potentially cognitively impaired patients, overrepresented within this patient category.

Results of the logistic regression analysis for our primary outcome of SSI compared to the composite outcome of SSI and/or death were similar and we found that increased CCI, reoperation and arthroplasty were significantly associated with SSI risk, in line with others [5, 9, 12, 27]. The two respective models of the adjusted analysis also presented similar results and it is strengthening that the restricted analysis regarding the outcome of SSI does in fact include almost the entire study sample (442 of 496, 89%).

Limitations and strengths

This study is limited by its retrospective design and that patients were not randomized to receive either method of disinfection. In addition, due to that the cohorts were not compared during the same year, the interventions were not compared during the same time period and the lack of information regarding potential confounders, such as seasonal variability, variances in personnel, etc. is a limitation. The study is also limited by a power of 50% to detect a significant difference which must be considered when interpreting the results. SSIs are multifactorial and while we assessed the potential confounding of the majority of known preoperative risk factors, the risk factors: preoperative serum albumin [6, 7], fasting blood glucose [7], hemoglobin [10], and CRP [14], postoperative use of wound drainage [6], long-term catheterization [34], postoperative hematoma [12], and details regarding method of fracture fixation [5, 11], could not be assessed. BMI (specifically BMI > 28) is an important, independent risk factor of SSI [6, 7, 9, 10], unfortunately BMI was only found for 12% respectively 6% of patients in this study and therefore could not be further assessed. This study is based on medical records, also a limitation due to the risk of inconsistency and error in registration, potentially affecting data and reliability of adjustment for confounders. This limitation is specifically relevant for smoking which was low in our study and potentially underestimated. Finally, our follow-up time of 6 weeks risks missing cases of late chronic wound infection, however, since we wanted to capture SSIs potentially associated with factors of surgery such as preoperative disinfection, a longer follow-up time was considered inaccurate. In addition, other studies have found that the majority of SSIs after hip surgery occur within 4 weeks postoperatively [26]. In terms of strengths, our study is population-based and in line with clinical reality in that almost all eligible patients were included. Contributing factors to this were that written consent was not needed for inclusion, there were no exclusion criteria, and consecutive exclusion was low, this in turn increasing generalizability. In addition, a majority of previously known confounders have been taken into consideration and adjusted for. To our knowledge, this is the first study of its kind in Sweden, addressing a matter potentially causing unnecessary pain for patients. Sweden does represent one of the highest incidences of hip fracture worldwide [35], highlighting the importance of research within the field.

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Conclusion

In conclusion, when comparing traditional FBD with 4% chlorhexidine prior to hip fracture surgery with LD of the surgical site in terms of SSI incidence, we found a non-significant increased risk of SSI in 2018 (FBD) compared to in 2019 (LD) after adjustment. The study has limitations and randomized control trials are needed. Nonetheless, results suggest that LD is not inferior to FBD regarding SSI prevention, meaning patients could potentially be spared significant levels of pain.

Acknowledgements The corresponding author, Probert, affirms that everyone who contributed significantly to the work has been listed. Appreciation is expressed to all personnel at the orthopedic clinic where the study was performed who assisted with the collection of data. Appreciation is also expressed to Professor Bo Söderquist for help and valuable comments during completion of this manuscript. This work was supported by ALF funding of Region Örebro County. Grant number is not applicable.

Author contributions Study concept and design: PW, AGA. Acquisition of data: AGA, NP, EK. Analysis and interpretation of data: NP, AM, AGA, EK. Preparation of manuscript: NP, AGA, AM, PW, EK.

Funding Open access funding provided by Örebro University. This work was supported by ALF funding of Region Örebro County. Grant number is not applicable.

Data availability Data are available upon reasonable request. The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical approval The study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Regional Research and Ethics Committee in Uppsala, Sweden, 2017/466.

Informed consent Informed consent was not needed for inclusion of participants in the study due to the observational design as approved by the Regional Research and Ethics Committee in Uppsala, Sweden, 2017/466.

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International Journal of Orthopaedic and Trauma Nursing 49 (2023) 101002

Contents lists available at ScienceDirect

International Journal of Orthopaedic and Trauma Nursing

journal homepage: www.elsevier.com/locate/ijotn

PAPER IV

Traditional compared to modified method of disinfection before hip fracture surgery - Experiences of nursing personnel

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ARTICLE INFO

Handling Editor: C Jensen

ABSTRACT

Background: National guidelines in Sweden recommend preoperative full-body disinfection (FBD) with 4% chlorhexidine to prevent surgical-site infection (SSI) after hip fracture surgery, a method causing patients' severe pain. Although, due to little evidence in research, orthopedic clinics in Sweden are wavering in favor of simpler methods such as local disinfection (LD) of the surgical site.
Purpose: The aim of this study was to describe the experiences of nursing personnel regarding the performance of preoperative LD on patients prior to hip fracture surgery after having switched from FBD.
Methods: This study has a qualitative design where data were collected via focus-group discussions (FGDs) including in total 12 participants and analysed using content analysis.
Results: Six categories were identified describing the aim: sparing the patients' physical harm, sparing the patients' psychological distress, involving the patients in the procedure, improving the working environment for personnel, preventing unethical situations and a more adequate utilization of resources.
Conclusions: All participants considered LD of the surgical site as a favorable method to FBD, witnessing of an increased wellbeing in patients and the method facilitating a better involvement of patients in the procedure, findings that are supported by other studies promoting person-centered care.

1. Introduction

Hip fractures require surgical treatment and are considered the most severe fragility fractures. Studies report a 1-year mortality-rate of 30%, reflecting typical characteristics of the cohort in terms of an increased age and a high prevalence of multimorbidity (Copanitsanou et al., 2012; Meyer et al., 2021; Probert et al., 2020). Consequently, the cohort is specifically vulnerable to adverse events (Cruz et al., 2010; Gunningberg et al., 2001). An important complication being pre- and postoperative delirium which in addition to the high prevalence of cognitive impairment causes significant challenges in communication and care (Juliebø et al., 2009; Seitz et al., 2011).

One of the most catastrophic complications after hip fracture surgery is surgical site infection (SSI), associated with an increased mortality (Duckworth et al., 2012; Edwards et al., 2008). The patient's endogenous skin-flora is often the source of pathogens and therefore, an obvious strategy in preventing SSI is preoperative skin-disinfection (Duckworth et al., 2012; Edwards et al., 2008). Swedish national guidelines recommend that patients planned for hip fracture surgery go through full-body disinfection (FBD) with 4% chlorhexidine preoperatively. Due to earlier evidence, this method has been well-established for years (Kapadia et al., 2013; Vårdhandboken, 2020). However, according to more recent studies it is uncertain whether FBD reduces SSIs and systematic reviews question the evidence in using FBD with 4% chlorhexidine compared to placebo, no wash or ordinary soap (Webster and Osborne, 2015). Due to the notion of this, the recommendation is carried out by less than 50% of the orthopedic clinics in Sweden. (Rikshöft, 2021). Accordingly, the method of disinfection prior to hip fracture surgery was changed from FBD to local disinfection (LD) of the surgical site at a hospital in Sweden in 2019 where the coherently performed study, published in April 2022, presented no significant difference in SSIs with 16 (6.8%) cases of SSI in 2018 when FBD was performed and 8

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https://doi.org/10.1016/j.ijotn.2023.101002
Received 17 December 2022; Received in revised form 26 January 2023; Accepted 9 February 2023
Available online 11 February 2023

(3.1%) cases of SSI in 2019 when LD was performed (Probert et al., 2022).

Studies of patients with hip fracture and their experiences of the preoperative phase report how specifically the preoperative shower is a cause of severe pain (Ivarsson et al., 2018; Unneby et al., 2022). Reducing pain is crucial considering these patients, otherwise risking complications such as delirium and prolonged hospitalization (Morrison et al., 2003). To the best of our knowledge there are no studies specifically focusing on experiences of the preoperative disinfection and potential differences after a change in method. Due to known complications such as memory loss (Olsson et al., 2007; Unneby et al., 2022) and cognitive impairment (Juliebø et al., 2009; Seitz et al., 2011) causing difficulties in interviewing patients, in addition to not being able to compare two methods, we sought to study the experiences of the caregivers performing the disinfections. Therefore, our aim was to describe the experiences of nursing personnel regarding the performance of preoperative LD on patients prior to hip fracture surgery after having switched from FBD.

2. Methods

2.1. Design

This study has a qualitative design where data were collected by focus group discussions (FGDs) and analysed using content analysis (Elo and Kyngäs, 2008). This study is based on the same change in method of disinfection as the quantitative study mentioned in the introduction (Probert et al., 2022).

2.2. Setting

In accordance with the recommendations of the Swedish Handbook for Healthcare (Vårdhandboken, 2020), patients planned for hip fracture surgery, were prepared preoperatively with FBD up until the entire year of 2018 at the orthopedic clinic in Sweden where this study took place. This entailed that, patients were showered twice during one occasion with 4% chlorhexidine on a specific shower-gurney in a shower room located in the ward. In 2019 the method of disinfection was changed to LD of the surgical site. This entailed that the patient's hip was washed once locally during one occasion with 4% chlorhexidine in their own hospital bed. Both FBD and LD were performed within 24 h of surgery by personnel working in the ward. If time to surgery was longer than 24 h, disinfection was repeated.

2.3. Sampling

Participants were purposively sampled from personnel working at the orthopedic ward five months after the intervention was implemented. The timing was considered to ensure that personnel would have enough experience of the new method to discuss their experiences, although still remembering the previous method clearly. Inclusion criteria were working as a nurse or an assistant nurse at the orthopedic ward. At the time of inclusion there were 17 assistant nurses and 13 nurses employed and all had experience of performing both FBD and LD on patients prior to hip fracture surgery. The ambition was to recruit four-six participants per focus group in order to enhance discussions (Morgan, 2012) and to achieve theoretical saturation (Breen, 2006). There were no exclusion criteria.

2.4. Data collection

All personnel received information of the study. Participants reported themselves for participation by voluntarily signing up for the FGDs scheduled during work hours. In total, three FGDs were conducted for the study where the focus groups included five, four respectively three participants in each group. No new experiences were described thereafter, data saturation was deemed reached (Breen, 2006) and no further FGDs were conducted. All FGDs were conducted within two weeks during May 2019 and took place in a private breakroom at the orthopedic ward.

The second author (KB), trained in qualitative research, performed the FGDs as first moderator. The first author (NP) acted as co-moderator, observing the FGDs. The FGDs were semi-structured by use of an interview guide ensuring that they included the same content areas. The interview guide was compiled by the second and last author (KB and ÅGA) containing open ended questions based on the principal question: "In light of having performed FBD on patients on a shower gurney prior to hip fracture surgery, what are the experiences of nursing personnel regarding the performance of LD of the patients fractured hip in their own bed?" In addition, exploratory questions were sometimes added to deepen the understanding of participants' experiences. The interview guide was tested in a pilot FGD, no changes were made after the pilot FGD which was included in the analysis. Audio-recordings were made of the FGDs lasting between 43 and 50 min. All recordings were transcribed verbatim by a professional transcriber.

2.5. Data analysis

Data were analysed by content analysis as described by Elo and Kyngäs (2008). The audio recordings were listened to, and transcripts were read through several times for immersion with the data. Meaning units responding to the aim and relating to the same central meaning were highlighted in the text. All meaning units were then condensed and labeled with a code. Categories were generated freely and then grouped into sub- and generic categories via abstraction. The analysis was conducted by the first author (NP) involving going back and forth between re-reading the transcripts and meaning units, recoding and recategorizing. To ensure trustworthiness, the analysis was simultaneously evaluated in several sessions and finalized by the research group (NP, KB and ÅA). Since only two authors (NP and KB) had conducted the FGDs, the research group included different perspectives. In addition, the last author (ÅA) who had not attended the FGDs also performed a retrospective review of a sample of the analysis and approved the coding and abstraction. Quotations were selected to enunciate the results and to increase trustworthiness. For examples of the analysis process please see Fig. 1.

3. Results

Twelve participants were included in the study. Characteristics of the participants are presented in Table 1.

All participants experienced significant differences after the change in method of disinfection and considered LD as a favorable method. However, concerns regarding the reliability of LD in cleanliness and prevention of SSI's were expressed during all FGDs. Six categories were identified describing the experiences of personnel regarding the performance of preoperative LD on patients prior to hip fracture surgery after having switched from FBD: sparing the patients' physical harm, sparing the patients' psychological distress, involving the patients in the procedure, improving the working environment for personnel, preventing unethical situations and a more adequate utilization of resources, see Table 2.

3.1. Sparing the patients' physical harm

During all FGDs participants expressed that the method of FBD was a cause of pain and physical suffering for the patients. Patients were perceived to express being in pain by verbal expression, screaming and physical resistance. Experiences were described of how it was impossible to relieve patients of the pain caused by the required movements and that morphine did not seem to help.

Meaning unit →	Code →	Subcategory →	Category
"It's like you said, then you have almost washed them already, and they can maybe lift their body a bit themselves, just to be able to say, that I don't have to leave the bed, I can stay in my bed, and I will go down to surgery in it."	Patients feel safe enough to lift their body themselves today	Increased physical participation of patients	Involving the patients in the procedure
"But it is a stressful event, affecting, I am going into a shower when I am in this much pain, already there it becomes a stop for the patient."	It was stressful for patients	Decreased signs of fear, stress, and anxiety among patients	Sparing patients psychological distress
"Many lie there all tense. I have not experienced that now actually"	Patients are not as tense		
"No, they are more relaxed too"	Patients are more relaxed		
"…that it does not become such a big thing anymore."	Not such a big thing anymore	A less traumatic experience for patients	

Fig. 1. Example of the analysis process.

Table 1
Participant characteristics.

Participant	Age	Sex	Working title	Working experience[a]
#1	28	female	Nurse	1 year
#2	21	Female	Assistant Nurse	1 year
#3	29	Male	Assistant Nurse	6 months
#4	34	female	Assistant nurse	6 months
#5	62	Male	Nurse	18 years
#6	20	Female	Assistant nurse	9 months
#7	54	Female	Assistant nurse	7 months
#8	20	Female	Assistant nurse	9 months
#9	23	Female	Nurse	5 months
#10	41	Female	Nurse	5 months
#11	28	Female	Assistant nurse	7 years
#12	28	Female	Nurse	5 years

[a] At the orthopedic ward where the study took place. Several of the participants had a longer working experience at the ward but as assistant nurses or as students prior to their current working title.

"… we are going to go in and shower this person. Can you bring the morphine and sedatives?" "Yes" … and you administered and still you would hear those screams."

Furthermore, another part of this category were descriptions of that morphine and sedatives were necessary in being able to perform FBD although caused patients physical side effects such as nausea and vomiting. Participants described situations where patients due to medically induced unconsciousness needed monitoring after the showers and sometimes substitution with oxygen. The shower-gurney was described as hard and uncomfortable, causing pressure on the patients broken hip. Participants sometimes noticed persisting red marks on the patients' skin from the shower-gurney. It was also lifted that patients had to be naked during the whole procedure and that it was difficult to keep the patients warm.

"They lie there freezing, you try to shower them with warm water but it's just not possible to get them warm."

The change in method meant that patients could stay in their own bed and that less movement was required. LD was experienced as a gentler method and that patients seemed to suffer less.

Table 2
Summary of subcategories and categories.

Subcategories	Categories
Reduced pain and physical suffering for patients (10)	Sparing patients' physical harm (33)
Reduced physical side-effects of medication (17)	
Reduced physical discomfort for patients (6)	
Decreased signs of fear, stress, and anxiety among patients (21)	Sparing patients' psychological distress (34)
Increased feelings of safety among patients (2)	
A less traumatic experience for patients (11)	
Fewer induced states of confusion and sedation (7)	Involving the patients in the procedure (17)
Increased physical participation of patients (5)	
Better communication with patients (5)	
Reduced stress for personnel (16)	Improving the work environment for personnel (49)
Reduced physical burden for personnel (23)	
A simpler process for personnel (10)	
Harming patients physically (5)	Preventing unethical situations (19)
Forcing patients (4)	
Exposing patients naked (10)	
Reduced use of medication (12)	A more adequate utilization of resources (39)
Less need of personnel (9)	
Less time-consuming (16)	
Reduced cost (2)	

3.2. *Sparing the patients' psychological distress*

Participants described how patients seemed overwhelmed by the thought of going through the showering process with a broken hip, needing time to comprehend. However, since the process was in many ways difficult but also mandatory before surgery there was no time for personnel to wait for patients to prepare and understand. Participants described how they finally just had to start by lifting the patient even though the patient had not obviously accepted what was going to happen, causing psychological distress.

Patients were described to signal feelings of fear and anxiety by mental and physical tension, worrying, having a lot of questions about the process and in some cases becoming hysterical. FBD was in general seen as a significant experience, described as a terrifying, terrible or a traumatic event, earmarking the entire hospitalization.

Participants experienced that after the switch to LD patients were generally calmer and more physically relaxed as signs of less psychological distress. LD was perceived as a less significant experience, not differing much from normal care.

> "… we have had one who has done both, the shower as we did before and the wash as we do now, and when you broke your hip the second time then the big fear was to shower, she said, it was worse than breaking your hip, so this she thought, to be washed, was very good."

Being able to remain in their own bed and territory was suggested as a significant factor in increasing the feeling of safety for the patients during LD.

3.3. Involving the patients in the procedure

Participants discussed how stressors associated with FBD led to states of confusion for the patients. Participants described patients becoming offensive, disoriented, and worried, distancing patients from personnel. Furthermore, there were descriptions of how medical sedation was sometimes necessary and in other cases an unwanted side-effect of morphine.

> "Because I think that the sedatives in this shower-situation was mostly because they didn't want to, they didn't even want to try, so then they get to relax in some way, so that we have a chance of being able to move them."

Participants also described how factors such as many personnel involved simultaneously, the chaotic environment, and time-pressure made it difficult to communicate with the patients during FBD regardless of their cognitive state. Participants described how they had to talk over the patients', and it was expressed that this must have been confusing for the patients.

LD was experienced to induce less stressors on patients who were described as more aware and also less affected by medically induced sedation. Furthermore, the process of LD was said to be simpler, and it was easier to get patients on board. In addition, a participant stated that it was more natural to just stand and talk to the patient simultaneously during LD which was nicer than working "over" the patient. Patients participated more physically during LD and one participant perceived that this could be because they felt safer.

> "… if you do it calmly when you aren't very stressed they can help out a lot and then they themselves are involved and can decide or yeah control their pain according to how much they can take."

3.4. Improving the working environment for personnel

Participants associated FBD with time-pressure and stress.

> "… sometimes the anesthesia staff call when you're showering, yes they wanted the patient down five minutes ago. And we just: "Yes, we have hardly begun and we have to do the shower."

FBD would often become chaotic with several individuals involved simultaneously. In addition, participants felt stressed by the fact that the showers consumed personnel, leaving the rest of the ward unseen. Participants who were nurses described feelings of stress related to administering the right amounts of analgesics during FBD with no time to evaluate, fearing giving too little or too much.

> "… to stand there and feel ashamed when you look in the list of administered drugs, "how much have they given?" … and some anesthesiologist calls, and "Have you really given this?" "Yes" … then, you feel bad about that too."

LD was described as less chaotic and less stressful. Nurses expressed that they had more time to individually evaluate analgesics. Patients were perceived to be in less pain during LD which was also a factor claimed to diminish stress.

FBD was a cause of physical burden and strain on personnel. It took up to eight times of lifting and turning the patients to get them to the shower gurney.

> "… maybe the patient starts jerking and pulling away and then it becomes a little like this, no but maybe wearing on the body, arms, your back."

The method of LD included less movement of the patients. The procedure was less physically straining and less painful for personnel who consequently also witnessed of a better psychological wellbeing.

3.5. Preventing unethical situations

Participants described how FBD could feel ethically difficult since they felt like they inflicted pain on their patients. One participant described that it was hard to imagine anything worse than lying there.

> "… when you were in the shower and you had them on the shower gurney you felt time-pressure to, get them into bed because they were lying there in pain and freezing."

In addition, nurses discussed the ethical dilemma with having to administer morphine and sedatives just to be able to perform the mandatory showers although also knowing that this was potentially harming the patients.

The participants felt unease in forcing patients to go through the procedure and the word abuse was expressed several times. They described experiences of patients clearly not understanding what was going on, holding onto their bed, screaming in reluctance and personnel having to administer sedatives so that the patients would stop struggling. However, it was also highlighted how it in such situations was often impossible to get the patient on board and that personnel just had to proceed anyway.

Participants also described the aspect of that patients had to lie naked in front of several personnel during the showers.

> "It felt like, they felt very uncovered and frightened and simply exposed when they were lying in the shower naked with people over them in a big clinical room."

Patients could be covered during LD and no longer had to lie naked in a spotlight as described by participants.

3.6. A more adequate utilization of resources

Due to the associated time-pressure with FBD, participants described how medication was almost given by routine to all patients before commencing, without much possibility of individualizing doses. Participants experienced that less medication was used after the switch to LD and that there was more time to evaluate the need of pain management.

> "Now, it is not sure you have to give anything at all. Because mostly they are a bit pain relieved when they come from the emergency room and so on, but not in the way that we have to give before to every patient."

At least three personnel were needed during FBD and in contrast, LD could be performed by one person with occasional help when the patient needed to be moved.

The methods also differed in time-consumption. Participants described scenarios where the showering would take so long that patients would miss their surgical slot and FBD would have to be re-performed. Factors described to contribute to the time-consumption where: waiting for a nurse who could administer medication and gathering the amount of personnel needed. Participants described that LD was less time-consuming.

> "… when the anesthesia staff are standing waiting down in surgery … we can get the patient down quicker today than before too, sure, it can be done in 20 minutes instead of 45 minutes …"

One participant discussed that it was better to perform the preoperative disinfection shortly before surgery to avoid having to repeat the procedure which was possible with LD but not with FBD.

Participants also discussed how the change in method must be better in an economical aspect due to a lesser use of resources.

4. Discussion

Our aim was to describe the experiences of nursing personnel regarding the performance of preoperative LD on patients prior to hip fracture surgery after having switched from FBD. All participants clearly considered LD as a favorable method but also discussed the reliability of LD in cleanliness and prevention of SSI. The quantitative study performed partly simultaneously with this study, based on the same implementation, published in April 2022, presented no significant difference in the incidence of SSIs or other infections (Probert et al., 2022).

A significant aspect of our results, concerning multiple categories, was how participants experienced that the change in method decreased the preoperative pain for patients. Results presented that the most significant contributor to this was the lesser movement required during LD. This understanding coheres with findings of earlier studies exploring patients experiences of the preoperative phase, describing how the pain in conjunction to movement was experienced as the most intense (Hommel et al., 2012) and that specifically the preoperative shower was a cause of pronounced pain (Ivarsson et al., 2018), in some cases even despite patients having received a femoral block (Unneby et al., 2022).

Related to this, participants associated FBD with issues related to pain management such as inadequate effect of morphine, no possibility of evaluating the administered analgesics, feeling like analgesics were given by routine and adverse drug events. Our results suggest that patients were in a lesser need of sedatives and analgesics during LD, coherently causing less drug-related issues. Interestingly, in addition to the lesser movement required, other studies also support these findings in relation to our other results concluding that interaction between personnel and patients is important in achieving well managed pain and that patients tend to feel safer and calmer if personnel are present and responsive (Unneby et al., 2022). Furthermore, patients have been reported to feel more satisfied when staff create a secure feeling and show interest and empathy towards them (Hommel et al., 2012). Thus, this suggests that other aspects of development as documented in our results such as improved communication with patients, a safer environment and reduced time-pressure as experienced by participants could also be contributing to a lesser need of medications and reducing pain, potentially by enabling pain management that is more than purely medical. Patients with cognitive impairment, overrepresented within this patient category, have been reported to experience higher levels of pain preoperatively (Daniels et al., 2014). Furthermore, it is well documented that patients with hip fracture and specifically patients with cognitive impairment are continuously being undertreated with analgesics according to their pain-level (Morrison and Siu, 2000; Vassiliadis et al., 2002). Undertreated or severe preoperative pain has been reported to increase the risk of delirium, prolonged hospitalization, and postoperative pain for patients (Beloeil and Sulpice, 2016; Morrison et al., 2003; Morrison and Siu, 2000). This in turn underlining the importance of pain-management and continuously addressing causes of pain.

Closely related to pain and suffering is psychological distress. In line with this, it is also portrayed by others how movement and nursing actions can be a cause of anxiety and feelings of suffering in patients with hip fracture due to the associated pain (Hestdal and Skorpen, 2020; Unneby et al., 2022). It was specifically expressed by participants that the circumstances during FBD hindered communication and involvement of patients. The change in method of disinfection from FBD to LD was interpreted to reduce psychological distress in patients along with involving them better in the procedure. Cohering with this, a study of suffering in hip fracture patients concluded that nursing staff's presence, the opportunity for patients to have a dialogue with orthopedic staff and adequate information to patients was important in alleviating suffering preoperatively (Hestdal and Skorpen, 2020).

What has been discussed highlights the importance of involving patients in their care. Although the routine of informing and involving patients before and during the procedure did not differ between FBD and LD, the switch from FBD to LD was experienced to promote better involvement of the patients in the procedure due to factors related to patients medical and cognitive state and LD enabling better communication and physical participation of patients as described earlier in this paper. In addition, for the most part only one person was required to perform LD which was experienced to enable a more personalized way of care, personnel not having to work "over the patients". Supporting this, Ekman et al. emphasize the importance of carrying out routines that facilitate and safe-guard a way of care that enables seeing the individual behind the patient, in turn incorporating patients as active partners in their care (Ekman et al., 2011). Furthermore, involving patients has been found to increase satisfaction and reduce feelings of anxiety and stress (Sahlsten et al., 2008) as well as shorten the time of hospitalization (Olsson et al., 2014).

Lastly, our results document how personnel perceived LD as less time consuming than FBD and that time to surgery was shortened. Studies of patient experiences portray how waiting for surgery in the ward is specifically stressful for patients, emphasizing the importance of investigating and addressing causes of delay (Hommel et al., 2012). Furthermore, a prolonged time to surgery has been found to increase the risk of intraoperative medical complications and postoperative mortality (Leer-Salvesen et al., 2019). However, there was no significant difference regarding surgery withing 24 h when the methods of FBD and LD were compared in the quantitative study related to this study (Probert et al., 2022). Nonetheless as highlighted, any time gained before surgery, weather minutes or hours, could potentially spare patients from suffering.

4.1. Strengths and limitations of the study

The concepts of credibility, confirmability, dependability, and transferability have been used to assess the quality in qualitative research (Lincoln and Guba, 1985). In increasing credibility participants were sampled so that the FGDs included both nurses and assistant nurses with varying perspectives of the preoperative work. In addition, participants varied in age, gender, and experience. A clear limitation to this study and potentially its credibility was that the perspectives were not from the patient's view. However, as stated earlier, cognitive impairment and preoperative delirium is high within this cohort (Juliebø et al., 2009; Seitz et al., 2011) making it difficult to interview patients. In addition, as portrayed by others, despite being cognitively intact, patients often have a hard time remembering the preoperative phase (Olsson et al., 2007; Unneby et al., 2022) and, personnel have the advantage of being able to compare two methods. There was a continuous dialogue within the research group to ensure credibility and confirmability during the analysis (Elo and Kyngäs, 2008). In increasing dependability, a semi-structured interview-guide was used during all FGDs, and no alterations were made after the pilot FGD. Furthermore, all FGDs were conducted within two weeks-time by the same moderators.

5. Conclusion

FBD prior to hip fracture surgery is still recommended in Sweden despite little evidence in research, a method causing patients' severe pain. All participants in our study considered LD of the surgical site as a favorable method compared to FBD, witnessing of an increased

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wellbeing in patients as well as the method facilitating a better involvement of patients in the procedure. It is crucial to reduce levels of preoperative pain in patients with hip fracture and as emphasized by others, steps should continuously be taken towards a more person-centered care.

Ethical statement

This study was carried out in accordance with The Code of Ethics of the World Medical Association (2013) and approved by the Regional Ethical Review Board in Uppsala, Sweden (Dnr, 2017/490). Participants were informed that participation was voluntary and that they could withdraw at any time. An informed consent was obtained from all participants.

Funding

Open access funding was provided by Örebro University. This work was supported by ALF-funding of Region Örebro County. Grant number is not applicable.

Declaration of competing interest

The authors have no conflicts of interest related to this study.

Acknowledgements

The authors would like to thank all participants in the study for sharing their experiences.

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