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Michael Blauth, Stephen L Kates, Joseph A Nicholas

Osteoporotic Fracture Care

Medical and Surgical Management

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More than 1,000 high-quality x-rays, clinical photographs, and illustrations

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Foreword

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When Dr Kates asked me if I was interested in writing a foreword for the *Osteoporotic Fracture Care* book, I could not refuse. Having worked with Dr Kates on issues involving insufficiency fracture care as both a colleague and friend, I understand the passion and commitment that has been brought to this textbook.

The care of the young male high-energy trauma patient often dominates the focus of trauma education. The care of the older adult with osteoporotic fractures often seems to be of less interest in both trauma education and research. This AO book entitled *Osteoporotic Fracture Care* provides an important reminder of why this area is of key importance in healthcare today for all of us. A recent report found the burden of hospitalization of women over age 55 in the US for osteoporotic fractures is greater than the hospitalization burden for myocardial infarction, stroke, or breast cancer [1].

1. **Singer A, Exuzides A, Spangler L, et al.** Burden of illness for osteoporotic fractures compared with other serious diseases among postmenopausal women in the United States. *Mayo Clin Proc.* 2015 Jan;90(1):53–62.

Multiple important topics are covered in this textbook including societal impact of the clinical problem of osteoporotic fractures as well as important current perspectives in all aspects of patient care.

The outline of the book spans the entire scope of care including basic pathophysiology, clinical assessment, patient-specific considerations in determining treatment, and specific recommendations for pre-, intra-, and postoperative care; it also covers templated order sets to facilitate the care of the osteoporotic fracture patient and strategies for secondary osteoporotic fracture prevention. This is a thorough and well-written reference work for all musculoskeletal care providers who treat patients with osteoporotic fractures. I hope you find this textbook a useful reference.

Durham, November 2017

Preface

The inspiration for this textbook comes from the vibrant AOTrauma Care of the Geriatric Fracture Patient courses held across the world, as orthogeriatric care education has been pushed to the forefront for orthopedic surgeons, medical physicians, and other care teams involved in care of the fragility fracture patient. These innovative and interactive courses were launched in Rochester, NY, USA, in 2006 under the leadership of Dr Stephen Kates and Dr Daniel Mendelson and introduced into the AO Courses in Davos in December 2007 by Drs Michael Blauth, Stephen Kates, and Daniel Mendelson as the first truly interdisciplinary course in AO followed by a worldwide rollout. They continue to provide the best in evidence-based medicine, geriatric principles, and clinical experience to promote better care for older adults undergoing orthopedic surgery. From an academic standpoint, these courses bring together some of the most prominent orthopedic and geriatric medicine faculty in this emerging field. From an educational and clinical standpoint, these courses are inspirational and invigorating, designed for clinicians to share current experiences, learn new fracture reduction and fixation techniques, consider the unique physiology of geriatric patients, and begin to design systems of care that dramatically improve patient outcomes and reduce system costs. The content of these courses inevitably changes the way the faculty and the attendees practice. This textbook aims to capture the essential evidence and clinical principles so well identified during these courses.

In order to develop innovative teaching methods for these truly interdisciplinary courses, AO launched an Orthogeriatric Task Force that is still active. Another product that came out of this task force is an Orthogeriatric App about the management of osteoporosis, delirium, pain, and anticoagulation that can be downloaded free of charge.

Optimal outcomes for fragility fracture patients depend on excellent surgical care of osteoporotic bone, incorporation of geriatric medicine into the routine care pathways, and construction of new systems of care. To address these areas, this book is organized into three sections:

The *Principles* section outlines the unique medical, surgical, and anesthesia needs of fragility fracture patients; these chapters focus on practical approaches to the most common and important clinical issues facing the geriatric fracture patient. We aim to create a basic understanding of why older adult patients benefit significantly from an adapted management and environment compared to younger adult patients, analogous to the approach to pediatric patients.

In the section *Improving the system of care*, physicians and administrators present chapters with local, regional, and national health delivery changes that are necessary to optimize patient outcomes.

The majority of the textbook is devoted to *Fracture management*; this section is focused on expert and specific surgical management of the wide array of fragility fractures as they present to most physicians and hospitals worldwide.

The impact of the dramatic demographic shift of the world's population and the explosion in fragility fractures demands that health systems and physicians be willing to update their clinical approaches, improve their understanding of the needs of older adults, and develop interprofessional and interdisciplinary systems to manage complex and frail patients safely and efficiently.

We hope this textbook will support the necessary revolution in care for orthogeriatric patients, their families, and the clinicians caring for them.

Michael Blauth, MD
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Joseph A Nicholas, MD

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It would not have been possible to produce and publish the *Osteoporotic Fracture Care* textbook without the dedication and support of an extensive list of contributors. From hard-working AO surgeons donating their time and expertise, to colleagues volunteering case notes and images, to our staff within our own medical institutions, and to the teams at AOTrauma and AO Education Institute, we thank you for assisting us in developing this publication.

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Abbreviations

AAOS	American Academy of Orthopaedic Surgeons
ABCDE	airway, breathing, circulation, disability, exposure/examination
ACC	American College of Cardiology
ACCP	American College of Chest Physicians
ACE	angiotensin-converting enzyme
ACEI	angiotensin-converting enzyme inhibitors
ACL	anterior cruciate ligament
ADL	activity of daily living
AF	ankle fracture (chapter 3.17 Ankle)
AF	atrial fibrillation
AFF	atypical femoral fracture
AFN	antegrade femoral nail
AGS	American Geriatrics Society
AHA	American Heart Association
ANZHFR	Australian and New Zealand Hip Fracture Registry
AO	Arbeitsgemeinschaft für Osteosynthesefragen
AOCID	AO Clinical Investigation and Documentation
AP	anteroposterior
APL	abductor pollicis longus
aPTT	activated partial thromboplastin time
ARIF	arthroscopy-assisted reduction and internal fixation
ARB	angiotensin receptor blockers
ASA	American Society of Anesthesiologists
ASBMR	American Society for Bone and Mineral Research
ASIS	anterior superior iliac spine
ASLS	angular stable locking system
ATE	arterial thromboembolism
ATLS	advanced trauma life support
AVN	avascular necrosis
BGS	British Geriatrics Society
BIPAP	biphasic positive airway pressure
BMD	bone mineral density
BMI	body mass index
BOA	British Orthopaedic Association
BP	bisphosphonate
BPF	best practice framework
BPT	Best Practice Tariff
CAD	coronary artery disease
CAM	Confusion Assessment Method
CCD	caput-collum-diaphyseal (angle)
CCI	Charlson Comorbidity Index
C-clamp	compression clamp (for pelvis)
CGA	comprehensive geriatric assessment
CGC	clinical practice guidelines
CHF	congestive heart failure
CI	confidence interval
COPD	chronic obstructive pulmonary disease
CPG	clinical practice guidelines
CPM	continuous passive motion
CRP	cardiopulmonary resuscitation
CRPS	complex regional pain syndrome
CSF	cerebrospinal fluid
CT	computed tomography
CVA	cerebrovascular accident
CVD	cardiovascular disease
DASH	Disabilities of the Arm, Shoulder and Hand
DECT	dual-energy computed tomography
DEXA	dual energy x-ray absorptiometry
DFF	distal forearm fracture (chapter 3.6 Distal forearm)
DFF	distal femoral fracture (chapter 3.12 Distal femur)
DFR	distal femoral replacement
DHF	distal humeral fracture
DFN	distal femoral nail
DHS	dynamic hip screw
DM	diabetes mellitus
DOSS	Delirium Observation Screening Scale
DRF	distal radial fracture
DRG	diagnosis-related group
DRUJ	distal radioulnar joint
DSM-V	Diagnostic and Statistical Manual of Mental Disorders
DUF	distal ulnar fracture
DVT	deep vein thrombosis
EF	external fixator
EFD	elbow fracture dislocation
EPL	extensor pollicis longus
FAITH	Fixation using Alternative Implants for the Treatment of Hip fractures
FCR	flexor carpi radialis
FCU	flexor carpi ulnaris
FDA	Food and Drug Administration
FFN	Fragility Fracture Network
FFP	fragility fracture patient (all chapters except 3.7 Pelvic ring)
FFP	fragility fracture of the pelvic ring (only in chapter 3.7 Pelvic ring)

FLS	fracture liaison service
FRAX	Fracture Risk Assessment
FSF	femoral shaft fracture
FWB	full weight bearing
FWBAT	full weight bearing as tolerated
GA	general anesthesia
GAF	geriatric acetabular fracture
GI	gastrointestinal
GCS	Glasgow Coma Scale
GORU	geriatric orthopedic rehabilitation unit
GP	general practitioner
GT	greater tuberosity (chapter 3.1 Proximal humerus)
GT	greater trochanter (chapter 3.13 Periprosthetic fractures around the hip)
HBR	home-based rehabilitation
HO	heterotopic ossification
HRQoL	health-related quality of life
HSA	head-shaft angle
HTN	hypertension
HU	Hounsfield Unit
IADL	instrumental activity of daily living
ICD	implantable cardioverter defibrillator
ICU	intensive care unit
IGF	insulin-like growth factor
IKS	International Knee Score
IL	interleukin
IM	intramedullary
INR	international normalized ratio
IOF	International Osteoporosis Foundation
IPCD	intermittent pneumatic compression devices
IQR	interquartile range
IR	internal rotation
IRF	inpatient rehabilitation facility
ISP	Infraspinatus (muscle/tendon)
ISS	Injury Severity Score
IU	International units
IV	intravenous
IVC	inferior vena cava
K-wire	Kirschner wire
KSS	Knee Society Score
LAP	locking attachment plate
LBD	local bone density
LBQ	local bone quality
LC-DCP	limited-contact dynamic compression plate
LCP-DF	reversed distal femoral locking compression plate
LCL	lateral collateral ligament
LCP	locking compression plate
LHB	long head of the biceps
LHS	locking head screw
LISS	less invasive stabilization system
LMWH	low-molecular-weight heparin
LOS	length of hospital stay
LP	locked plating
LT	lesser tuberosity (chapter 3.1 Proximal humerus)
LT	lesser trochanter (chapters 3.13 Periprosthetic fractures around the hip, 3.14 Periprosthetic fractures around the knee)
MCD	minimum common dataset
MCL	medial collateral ligament
MET	metabolic equivalent
MGF	mechano growth factor
MI	myocardial infarction
MIPO	minimally invasive plate osteosynthesis
MIPPO	minimally invasive percutaneous extraperiostally plate osteosynthesis
MIS	minimally invasive surgery
MNA	Mini-Nutritional Assessment
MRI	magnetic resonance imaging
MVA	motor vehicle accident
NA	neuraxial
NHFD	National Hip Fracture Database
NHFS	Nottingham Hip Fracture Score
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
NMS	New Mobility Score
NOAC	new oral anticoagulant
NPWT	negative-pressure wound therapy, also called vacuum-assisted wound closure (VAC)
NRS	numerical rating scale
NSAIDs	nonsteroidal antiinflammatory drugs
NOF	National Osteoporosis Foundation
OGU	Orthogeriatric unit
ONJ	osteonecrosis of the jaw
ONS	oral nutrition supplements
ORIF	open reduction and internal fixation
OTA	Orthopaedic Trauma Association
PACU	postanesthesia care unit
PADL	personal activity of daily living
PCA	patient-controlled analgesia
PCC	prothrombin complex concentrate

PCM	perioperative cardiac morbidity
PDCA	plan-do-check-act
PDPH	postdural puncture headache
PE	pulmonary embolism
PET-CT	positron emission tomography combined with computerized tomography
PFN	proximal femoral nail
PFNA	proximal femoral nail antirotation
PHF	proximal humeral fracture
PHILOS	proximal humerus internal locked system
PMMA	polymethylmethacrylate
POMA	performance-oriented mobility assessment
PROM	patient-reported outcome measure
PPHF	periprosthetic hip fracture
PPI	proton pump inhibitors
PPKF	periprosthetic fractures around the knee
PPS	prospective payment system
PROM	patient-reported outcome measures
PRWE	Patient-Rated Wrist Evaluation
PSIS	posterior superior iliac spine
PTF	proximal tibial fracture
PTH	parathyroid hormone
PTS	postthrombotic syndrome
PWB	partial weight bearing
PWBAT	partial weight bearing as tolerated
QALY	quality-adjusted life year
RA	regional anesthesia
RCRI	Revised Cardiac Risk Index
RCT	randomized controlled trial
ROI	region of interest
ROM	range of motion
RSA	reverse shoulder arthroplasty
SAHFE	Standardized Audit of Hip Fracture in Europe
SD	standard deviation
SERM	estrogens, selective estrogen receptor modulator
SHA	shoulder hemiarthroplasty
SNF	skilled nursing facility
SPPB	short physical performance battery
SQ	subcutaneous
SSC	subscapularis
SSP	supraspinatus (muscle/tendon)
TAD	tip-apex distance
Tc	technetium
TEA	total elbow arthroplasty
TENS	transcutaneous electrical nerve stimulation
TFCC	triangular fibrocartilaginous complex
TFN	trochanteric femoral nail
THA	total hip arthroplasty
TIA	transient cerebral ischemia attack
TKA	total knee arthroplasty
TNF-α	tumor necrosis factor α
TSF	tibial shaft fracture
TSH	thyroid-stimulating hormone
TUG	Timed Up and Go test
UCS	Unified Classification System
UFH	unfractionated heparin
UTI	urinary tract infection
VAS	Visual Analog Scale
VDS	Verbal Descriptor Scale
VTE	venous thromboembolism
WBAT	weight bearing as tolerated
WHO	World Health Organization

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Table of Contents

Section 1
Principles

Section 1
Principles

1.1 Principles of orthogeriatric medical care

Joseph A Nicholas

1 Introduction

Despite the large amount of surgical care delivered to older adults [1], perioperative practice remains inappropriately anchored to the surgical experience of more robust and less comorbid patients. At best, many common and accepted approaches to specific illnesses are ineffective in older adults, and at worst, these practices contribute to serious morbidity and mortality [2, 3]. The negative impact of usual medical and surgical care is most pronounced in frail and medically complicated patients [4, 5].

The typical fragility fracture patient (FFP) is emblematic of patients for whom usual medical care is often the wrong care. To those who treat and research this population, it is not surprising that superior postoperative outcomes have been found through unique clinical and systems approaches to the geriatric patient [6, 7], strategies that often diverge from the types of medical investigations and treatments used in most care settings.

Fortunately, there is growing evidence that improved clinical outcomes can be obtained in frail older adults with osteoporotic fractures through the incorporation of a relatively small number of standard approaches and clinical pathways [8]. The major barriers to implementing these approaches are not technological or financial but involve an understanding and commitment to creating systems and expertise that focus on standardizing care, avoiding adverse events, and adapting treatments to the unique physiology and prognosis of the older adult.

While the details of such care will change as the evidence base expands, we expect the basic strategies outlined in this book to remain relevant for years to come. In the chapters that follow, readers will be introduced to the principles and specifics of caring for the typical FFP, based on the improved outcomes produced by orthogeriatric comanagement in organized fracture center programs. To set the stage, there are a number of principles that are important to recognize.

2 Key principles

2.1 Older adults are not simply adults with more illnesses

Compared with younger adults, older adults have unique physiologies, regardless of the presence or absence of specific comorbidities [9, 10]. Aging results in biological changes that render the older adult more susceptible to the harms of immobility, diagnostic tests, and medication effects. For this reason, many common medical practices can be ineffective or harmful in older adults. Examples include exaggerated hypotension in the presence of anesthetics and blood loss, low thresholds for delirium, complications due to polypharmacy, and rapid functional decline with immobility. This general decreased ability to respond to physiological stress is best described as frailty [11].

2.2 Hip fracture surgery can be performed safely and effectively even on frail patients

High-performing hip fracture centers produce low short-term mortality rates (ie, less than 2%), even in populations with high degrees of frailty and comorbidity [6, 12]. Advances in anesthesia, implant technology allowing for early weight bearing as tolerated, orthopedic procedural improvements, and orthogeriatric comanagement all contribute to rapid, safe, and effective repair of the overwhelming majority of hip fracture patients. Urgent surgery in the optimized patient is now standard care to avoid the short-term harms of ongoing pain, blood loss, and immobility.

2.3 Age is not the most important indicator of risk or prognosis in hip fracture patients

While age is a general predictor for outcomes and complications, it is more helpful to base risk assessments and treatment decisions on functional status, cognitive status, and comorbidity [13]. Asking patients about their day-to-day life can help estimate operative risk, recovery potential, and life expectancy better than disease-based assessments.

2.4 Surgical delay and immobility leads to irreversible muscle loss in the older adult

Early surgery is superior [14] and essential for frail and comorbid patients. The medical and surgical team must constantly weigh the impact of functional decline and operative delay against operative risk. Even the frailest patients can usually be optimized quickly, repaired, and begin immediate full weight bearing and rehabilitation [15].

2.5 Get the patient moving as soon as possible

Because rapid loss of muscle mass and function is a fundamental issue resulting in poor overall outcomes [16], all care pathways should be optimized to support early mobility and rehabilitation. While surgical delay and bed rest orders are obvious factors, polypharmacy, excessive testing, frequent subspecialty consultation, and inadequate pain control are all common barriers to mobilization that need to be minimized. Early mobility provides the necessary physical and emotional stimulation [17] for healing and recovery and helps minimize skin breakdown, constipation, and neuromuscular wasting. Mobility can be the difference between rapid recovery and prolonged hospitalization.

2.6 Less is often more

Most FFPs have multiple comorbidities and abnormalities on diagnostic testing, many of which are chronic, clinically irrelevant, or unable to be improved. Unfortunately, this often results in excessive testing and consultation, overdiagnosis, and polypharmacy. Organized programs work hard to avoid these distractions, and focus instead on key areas like hemodynamic stability, pain control, prompt fracture reduction, and mobilization [18].

2.7 Many surgeons, internists, and specialists do not understand typical geriatric medical physiology

Regardless of professional training, unique geriatric responses to therapies are not adequately emphasized in most medical school and postgraduate training programs [19, 20]. Clinical experiences in geriatrics often fail to focus on acute care approaches, and subspecialty training in many medical and surgical disciplines does not typically promote adaptation of clinical expertise to frail older adults [21]. Competency in acute geriatric care does not require formal fellowship training, but can be achieved with a continuing medical education approach. Attending a course, viewing educational media, or visiting an established geriatric fracture program can help develop competency in caring for older adults.

2.8 Many geriatricians, internists, and specialists do not understand acute perioperative medicine

Current medical training offers little focus on the perioperative period. Other than performing outpatient preoperative risk assessments in relatively robust patients or planning an elective procedure, most internists, subspecialists, and geriatricians do not gain expertise in acute stabilization, optimization, and recovery of patients undergoing urgent surgery. Approaches to common medical issues are different in perioperative patients from those in typical medical admissions [22].

2.9 Very little high-quality evidence is applicable to the care of older adults

Most medical and surgical evidence is based on adults that are very different from the geriatric fracture patient [23]. Geriatric populations do not experience the same balance of benefits and harms younger, healthier, and more robust adults do. Rather than trying to comply with multiple disease-specific guidelines, high-performing geriatric fracture centers create strategies based on general geriatric principles, like avoiding polypharmacy, anticipating and managing delirium, and rapid restoration of mobility.

2.10 Recognize failing patients at the end of life

For many patients, falls and fragility fractures are the result of decompensated medical illnesses and frailty, and many will have a life expectancy of less than 6 months [24]. Failing patients do not respond well to usual medical care, suffering more harm than benefits from hospitalization, testing, and treatment. Early recognition of failing patients is important to identify achievable goals, set realistic expectations for the family and the clinical team, and to focus future care appropriately on end of life. Orthopedic surgery plays an essential role in pain control and quality of life. All clinicians involved in the care of FFPs need to have an ability to recognize the failing patient (ie, frailty).

2.11 Organized fracture programs work

There is no single surgical technique, preoperative risk assessment tool, or standard medical consultation that will produce ongoing results as good as an organized approach to the FFP. Investments in an organized program with geriatric comanagement will yield improvement in outcomes, costs, and both patient and physician satisfaction [8, 25]. Organized programs are becoming the standard of care in many medical and surgical communities [26], and even for other surgical problems [27, 28].

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1.2 Principles of orthogeriatric surgical care

Michael Blauth

1 Introduction

Fragility fracture patients (FFPs) represent up to 40% of patients in many orthopedic trauma units worldwide. This trend is increasing. As a consequence, over the last decade, refined surgical care approaches have been developed from growing experience and close collaboration with geriatricians in order to improve patient outcomes and lower healthcare expenses.

Similar to fracture care in children, geriatric fracture care also differs in many aspects from the standard treatment of middle-aged adults. Due to the relative paucity of randomized trial data for many treatments, many of the following recommendations represent expert opinions with some based on biomechanical or clinical investigations.

The four AO Principles certainly apply to the care of fragility fractures and should be carefully adhered to:

1. Fracture reduction and fixation to restore anatomical relationships
2. Stability by fixation or splinting, as the personality of the fracture and the injury requires
3. Preservation of blood supply to soft tissues and bone by careful handling and gentle reduction techniques
4. Early and safe mobilization of the part and the patient

2 Goal setting

The entire patient must be considered including his/her medical problems, medications, living situation, and goals for care. Overall, the following issues assume prominence in care of FFPs:

- Pain relief
- Prevention of functional decline
- Maintenance of independence
- Prevention of complications, such as reoperations, pneumonia, pressure sores, urinary tract infection, and delirium

Making the right therapeutic decisions is much more complex than with younger patients. Fragility fracture patients are functionally and physiologically variable (from non-ambulatory “No-goes” to ambulatory “Go-goes”) that the benefits and risks of treatment are not as clear as in younger patients. Therefore, it is essential to establish a consensus for the treatment goals among all of the team members.

Defining individual goals for each FFP is an important step which should be established and agreed upon as early as possible by the interdisciplinary team. The individual goals influence diagnostic and therapeutic surgical and medical measures and should be clearly communicated. Goal setting avoids unnecessary steps and streamlines the treatment. Goals may be adjusted during the treatment process.

First, treatment goals should be very specific, clear and easy. Second, if you cannot measure it, you cannot manage it. Third, a goal needs to be attractive and acceptable to the patient and the clinical team. Fourth, the goal should be realistic, meaning achievable or “doable”. Fifth, the timeline to achieve the goal should be considered by setting a time frame.

It is useful to find short-term as well as long-term goals. Usually, the long-term goal is the expected outcome in several weeks or months, like to live independently or to walk without using a walking aid. When approaching a long-term goal, you need different short-term goals for each problem, like walking with a rolling walker after the first week, or removing a urinary catheter within 2 or 3 days after surgery.

The goals may be modified due to medical or surgical complications or if patients become unwilling or unable to continue or if they progress more slowly or quickly than expected. Goal setting should be integrated in the regular team meetings.

3 Time matters

Most studies suggest that performing surgery within the first 24–48 hours of admission decreases the number of complications and mortality. Delays longer than 72 hours are associated with an increased risk of multiple complications and mortality.

Surgical fixation reduces pain and blood loss significantly. It is also unethical to unnecessarily delay surgery.

The earlier surgical stabilization is performed, the better. This guiding principle is often violated because of the patient condition, patient consent, or hospital system barriers. The system of care must be optimized to avoid delay and iatrogenic problems.

The operating time should be as short as possible to reduce the stresses of surgery and its burdens on the patient.

The decision-making process regarding the definitive treatment in complex situations or relative indications is often delayed for multiple reasons. Goal setting and standardized communication pathways help to avoid unnecessary delay and expedite treatment.

4 Soft-tissue conditions

The musculoskeletal system of older patients is more vulnerable to problems and less tolerant of stress:

- Skin may be thin and less elastic due to atrophy or malnutrition and making pressure sores and degloving injuries more common. Wounds in older adults may also heal poorly for similar reasons. During positioning and draping, the surgeon must remember that the older patient's skin is fragile and can tear or be avulsed with minimal shear stresses. Shear forces from manual traction, removal of surgical drapes or localized pressure by splints and traction devices must be avoided (**Fig 1.2-1**). In surgery, meticulous positioning helps avoid skin breakdown.

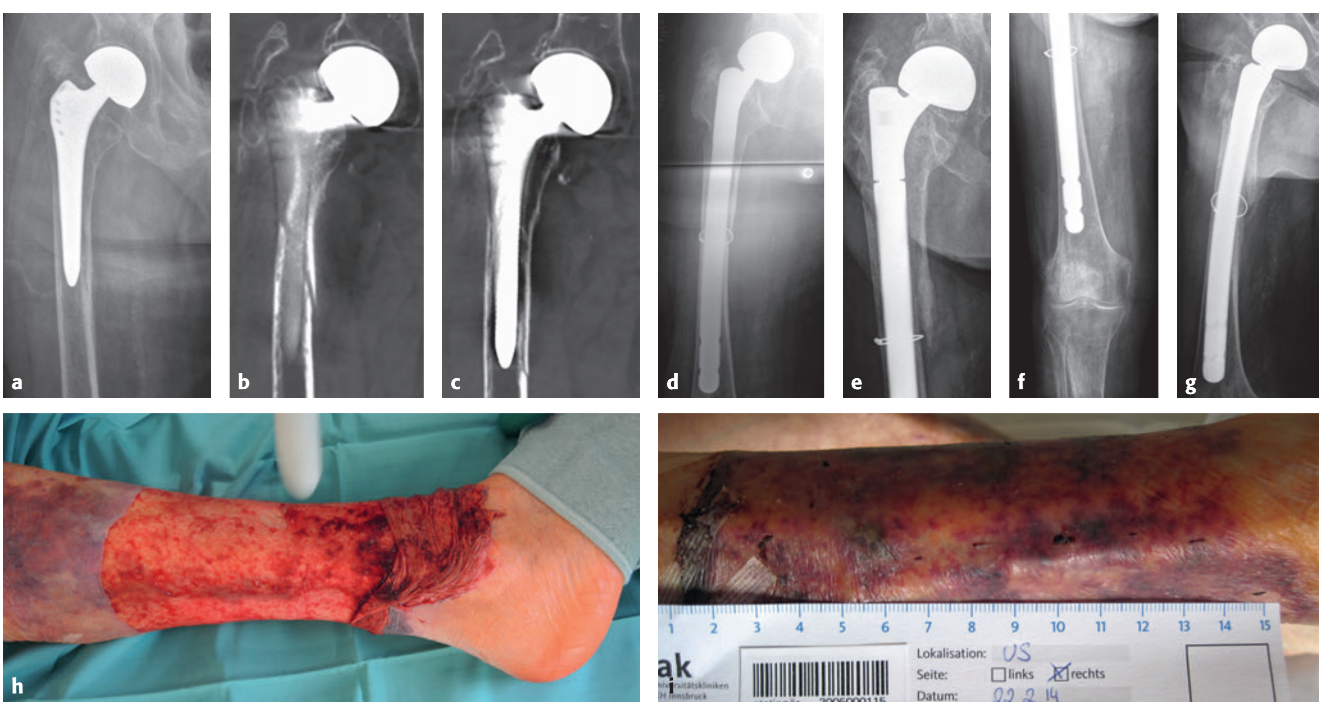

Fig 1.2-1a–i
a–c An 88-year-old woman with a type B2 periprosthetic femoral fracture.
d–g Revision hemiarthroplasty (**d**), follow-up at 2 months (**e–g**).
h After removing the covers, a degloving of the lower leg skin by gentle traction for intraoperative reduction became apparent.
i Uneventful healing after 10 days.

- Trophic changes: Arterial disease may result in ischemic changes and poor healing while venous hypertension produces edema, ulcers, and chronic skin changes. Using minimally invasive surgical (MIS) techniques may help to reduce problems.
- Hematoma: Surgeons must take great care to lose as little blood as possible. Meticulous hemostasis helps avoid tipping the patient out of equilibrium. Subcutaneous hematoma should be evacuated even with active anticoagulation to avoid rapid skin breakdown.
- Muscles are frequently atrophied and weaker than in younger patients (sarcopenia). Any manipulations during surgery should be carried out gently. Minimally invasive procedures are generally preferred.

Fig 1.2-2a–e
a A 76-year-old woman with a simple 2-part fracture of the left humerus.
b After anatomical reduction, a 3.5 mm titanium lag screw was used to provide absolute stability (not displayed). After tightening the screw just a little bit too much, a multifragmentary situation emerged. The reduction was challenging and a bridging type of construct was chosen.
c–e Uneventful healing after 2 months (**c, d**) and 5 months (**e**). The patient did not even have osteopenia.

5 Bone quality

Bony quality varies substantially from the typical wide osteoporotic tube with thin cortices to a thickened but brittle cortex in atypical fractures. Thus, cortex perforation or other iatrogenic damage generated by clamps or lag screws is more likely to occur than in normal bone (**Fig 1.2-2**). Forceful reduction maneuvers and aggressive handling of bone may result in extension of the injury beyond the original pattern. The use of clamps must be performed cautiously to avoid additional damage (**Fig 1.2-3**). Avoid the use of crushing reduction forceps helps avert worsening the comminution. Fracture patterns are often complex, with impaction occurring in the setting of a low-energy trauma.

Interestingly, the impact of osteoporosis as a standalone factor on "mechanical failures" of implants could not be shown in several clinical studies. Quality of reduction and implant placement are obviously even more important [1, 2]. In a retrospective study of proximal humeral fractures, it was shown that the risk for mechanical failure increases significantly with the combination of several negative factors [3].

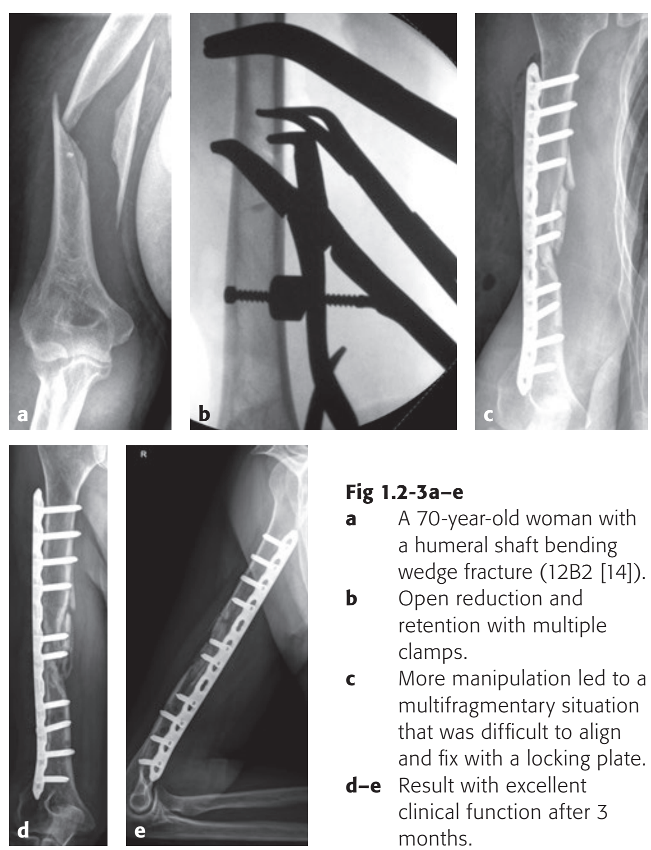

Fig 1.2-3a–e
a A 70-year-old woman with a humeral shaft bending wedge fracture (12B2 [14]).
b Open reduction and retention with multiple clamps.
c More manipulation led to a multifragmentary situation that was difficult to align and fix with a locking plate.
d–e Result with excellent clinical function after 3 months.

6 Bone deformation

Anterior and lateral bowing of the femur have a clinical impact in geriatric fractures and may make it very challenging to use standard intra and extramedullary implants [4]. A recent report also found that a significant increase in the lateral and anterior bow of the femur was associated with low-energy femoral shaft fractures. Therefore, the increased bowing of femoral shaft should be recognized as an important risk factor of this injury [5].

Specifically, lateral bowing of the femoral shaft may be increased in older adults as well as in younger patients with decreased bone mineralization.

Osteoporosis or osteomalacia induce a varus or bowing of the femur. The lateral femoral shaft is subjected to tensile strains during a variety of physical activities; walking has the strongest impact. This effect will be pronounced with bowing in osteoporotic patients [6]. Preexisting advanced varus knee osteoarthritis, with shifting the mechanical axis medially, has been considered as a minor reason for bowing of the femoral shaft.

Although atypical femoral fractures have been associated with long-term use of bisphosphonates (BPs), it was also noted that these fractures may develop without BPs use, especially in patients of Asian descent. In 2013, the Task Force of the American Society for Bone and Mineral Research revised the definition of atypical femoral fracture, removing specific diseases and drug exposures as one of the association from the minor features [7]. According to this definition, stress fractures caused by femoral bowing deformity may also be classified as atypical femoral fractures.

Despite being the most commonly recommended implant choice, intramedullary (IM) nails can be difficult to insert, as the curvature of IM nail is different from that of the radius of bowed femur. In cephalomedullary nailing, the distal end of nail may break or penetrate the anterior cortex of femur in the distal segment.

Reaming is often difficult as well and must be performed gently due to the narrow medullary canal and the brittle nature of the bone.

Also, the nailing may cause an inadvertent fracture or malreduction with a bony gap on the medial aspect of the bone, especially in the atypical femoral shaft fractures with bowing [8]. This effect may result in impaired fracture healing or even nonunion.

Plate fixation can be a solution in bowed femoral fractures. In such cases, the plate may need to be contoured before fixation, considering the contralateral, noninjured leg. Otherwise, the proximal or distal end of plate will step off the bone, and it may be a source of malreduction when screws are tightened [4].

7 Classification

Classification of fragility fractures is often challenging because of different fracture patterns. Osteoporotic fractures often occur in patterns not described in the currently used classification schemes. This frustrates attempts to classify the fractures and may result in incorrect procedure or implant selection. The AO/OTA Fracture and Dislocation Classification is useful for many, but not all, fragility fractures.

8 Indications for fixation

Most fractures of the lower extremity should be surgically managed. In a small group of bedridden, terminal patients, nonoperative palliative management of hip and other lower leg fractures may be adequate. Those decisions should be team decisions made with the geriatrician, patient, family, and medical team.

For the upper extremity, the need to preserve function should be considered to allow the patient to accomplish activities of daily living like eating, self-care, grooming, and ambulation. Attaining these goals may involve taking more surgical and overall risk. Therefore, surgical treatment may only be indicated if it will result in a significant improvement in function. In the proximal humerus, olecranon, and distal radius, nonsurgical management often leads to an acceptable functional result [9–11].

Some nonsurgical approaches are not tolerated as well as in younger individuals. Casts interfere with functionality and increase the risk of falls. Immobilization may render old patients immediately dependent for basic activities like eating and grooming, and promote accelerated functional decline. In a sense casts are also tethers that patients have difficulties to deal with. The cast will prevent a patient from accomplishing daily activities like walking, and the patient may therefore require placement in a nursing home. Casts and braces tend to exacerbate delirium in older adults (**Fig 1.2-4**).

Complete recovery after trauma is typically the goal of treatment below the age of 60 years. This does not apply to FFPs. In this age group, we focus on the restoration of individual functional needs. Decision making can be difficult due to the variable physiological and functional nature of older patients. It is often necessary to individualize treatment approaches with the consensus of the orthogeriatric team and patients' family.

9 Positioning

Correct intraoperative positioning avoids pressure sores and skin damage: It is essential to carefully position the patient on the surgical table. Avoidance of pressure sores is of particular importance as sores significantly interfere with recovery and take an extended time to heal. An infected pressure sore may actually result in sepsis and death in the older fracture patient.

In most cases, the supine position is preferred to allow for overall care by the anesthetist. When under regional anesthesia, the patient can breathe easier when supine and this position is usually more comfortable.

10 Single shot surgery

It is obvious that any kind of revision surgery must be avoided because of the limited patient reserves necessary to tolerate and recover from surgery and functional decline. The choice of treatment should be influenced by this principle. Hemiarthroplasty instead of fracture fixation for femoral neck fractures and other primary joint replacement surgeries are good examples.

11 Weight bearing as tolerated and functional aftertreatment

Usually, the surgeon's attention is focused on the intraoperative and immediate perioperative treatment period. Postoperatively, if the wound healing is progressing normally and x-rays are satisfactory, limited attention is paid to rehabilitation options and progress. The communication among surgeons, staff nurses, and physiotherapists regarding mobilization issues is often poor.

Early postoperative mobilization and unrestricted weight bearing as tolerated are important principles for a multitude of reasons. Prolonged bed rest or "sitting mobilization" are not adequate options because of the following consequences:

- Loss of muscle mass represents an independent risk factor for new falls and fractures in older adults.

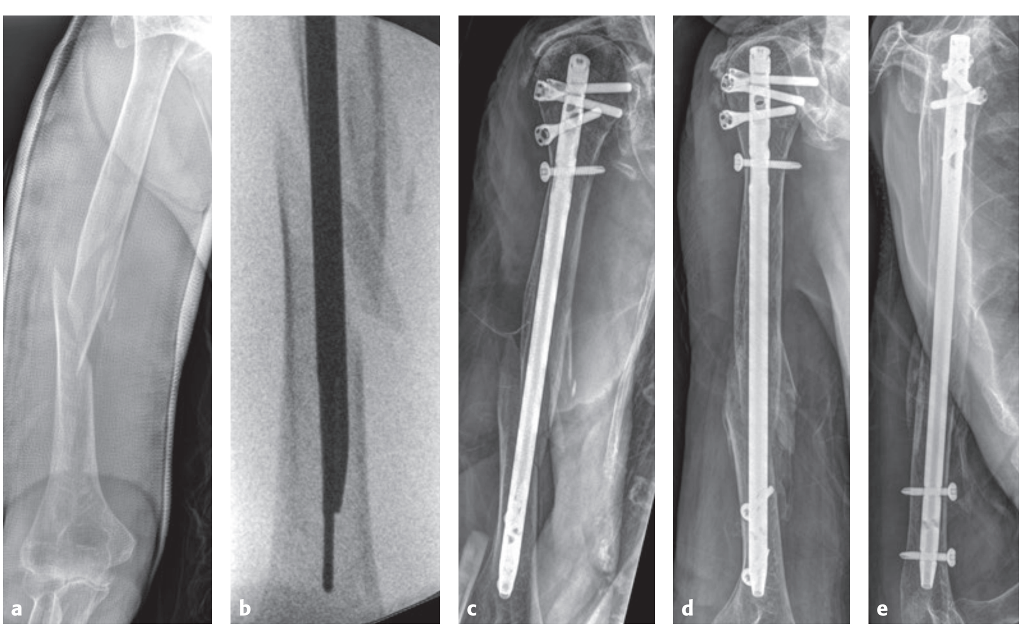

Fig 1.2-4a–e
a A 92-year-old woman with a humeral fracture (12B3). Bracing was not tolerated well.
b–c After 10 days close reduction and fixation with a long multilock nail.
d–e Uneventful healing after 3 months. The function reached the preinjury level.

- Restriction of weight bearing inflicts a significant physiological burden on the geriatric patient. The energy expenditure for ambulation without full weight bearing increases fourfold, leading to rapid exhaustion [12].
- Fragility fracture patients are often physically unable to perform partial weight bearing due to sarcopenia, lack of proprioception and weakness in the arms; or they are admitted with an already impaired functional deficit in upper and lower extremities, preventing them from using crutches or walkers in a way that the affected lower extremity is effectively spared.
- Patients develop unnecessary fear and get anxious about their inability to return to their preinjury functional status. Consequently, motivation may drop. The altered gait mechanism needs cognitive input and may lead to complaints of overload or low back pain.
- Many FFPs have some degree of cognitive impairment. They may not understand (or rapidly forget) instructions and instead follow their own impulses.
- Partial weight-bearing protocols are not evidence-based but often the result of the surgeon's own uncertainty.
- Even for patients on adequate pain medication, pain will typically guide the patient to use the appropriate weight bearing and safely progress with ambulation. Patients with severely impaired cognitive function are more prone to fall, but they have the same self-protective mechanisms as cognitively normal patients.

Early weight bearing can promote fracture healing and union of the fracture without increasing loss of fixation [13, 14]. Immobilization of joints is poorly tolerated in many older patients; early functional range of motion prevents joints from stiffening. The daily loss of muscle mass during periods of bed rest is dramatic. Modern surgical procedures and implants permit immediate unrestricted weight bearing for most fractures.

Temporary external transarticular fixation can be a unique solution in fractures around the knee if internal fixation does not seem to be stable enough for immediate mobilization, if soft tissues have to settle down or if there is no chance to apply implants directly to the bone (**Fig 1.2-5**) [15].

12 Fixation techniques

The major technical problem the surgeon faces is the difficulty producing secure fixation of the implant to the bone. There is less cortical and cancellous bone for the screw threads to engage and the pullout strength of implants is significantly lower in osteoporotic bone.

Bone mineral density correlates linearly with the holding power of screws. If the load transmitted at the bone-implant interface exceeds the strain tolerance of osteoporotic bone, microfracture and resorption of bone with loosening of the

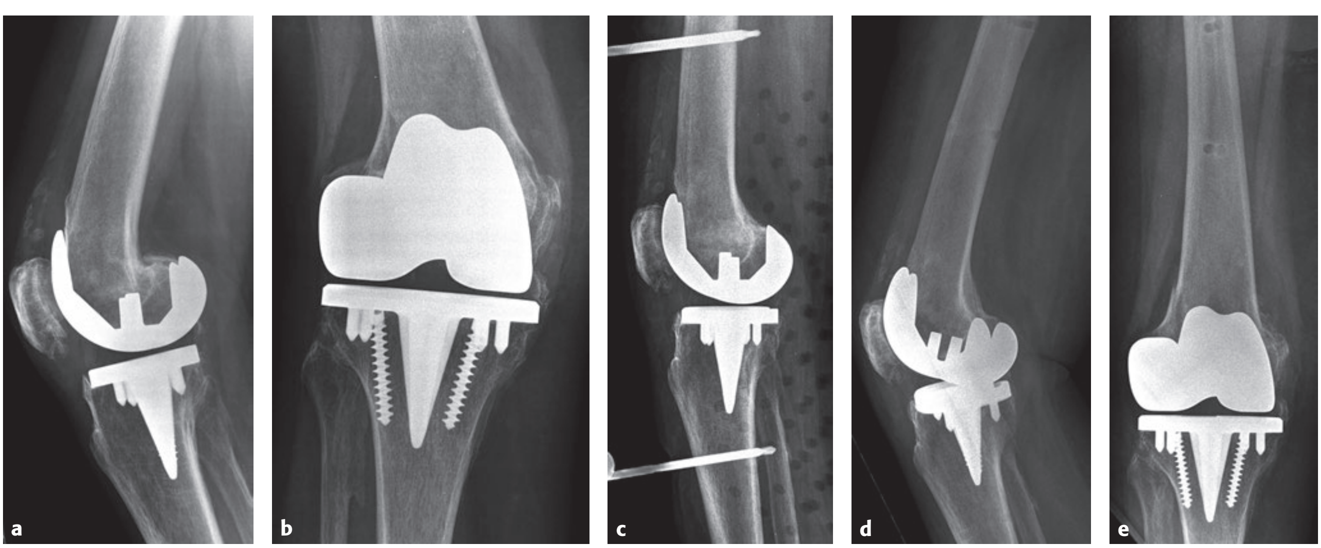

Fig 1.2-5a–e
a–b A 75-year-old woman with low periprosthetic fracture after total knee arthroplasty (TKA) and severe comorbidities.
c Temporary transarticular fixation for 8 weeks.
d–e Bony healing after 3 months. Final range of motion 0–10–100°.

implant and secondary failure of fixation will occur. The common mode of failure of internal fixation in osteoporotic bone is bone failure rather than implant failure.

Internal fixation must take the local bone mineral distribution into account. This varies with fracture location, age, and gender.

Proper preoperative planning, implant choice, fixation technique, and understanding of the biomechanical principles are essential.

The general principles of fracture management are applicable to most fragility fractures, but the decrease in bone strength requires some adaption to decrease the risk of failure.

12.1 Minimally invasive surgery

Minimally invasive surgery (MIS) techniques feature multiple "traditional" advantages that are even more helpful in FFPs than in younger patients. Many older adults are anticoagulated and suffer already from muscle weakness. Technically, MIS is easy to perform as soft-tissue layers can be separated easily. For more details, see Blauth et al [16].

Specifically designed instruments for MIS are available. It is important to develop a familiarity with their use.

12.2 Relative stability

Thin cortices cannot withstand the compressive forces that are needed to create absolute stability. Tightening lag screws a little too much may create iatrogenic fractures that worsen the situation significantly (**Fig 1.2-2, Fig 1.2-3**). In osteoporotic bone it may not always be possible to obtain and maintain anatomical reduction and compression with absolute stability because the weakened cortical and cancellous bone may fail under compression. It is essential not to mix the principles of relative and absolute stability in one fracture fixation.

As a simple rule, intramedullary devices are preferred over extramedullary devices if fracture patterns and soft tissues allow for it. Unfortunately, for metaphyseal fractures around the knee, locking options are not yet optimized for osteoporotic bone and thus nails are often not applicable.

Short plates with every screw hole filled will cause concentration of forces, which may exceed the strain tolerance of osteoporotic bone. Basic rules have been previously established in the literature [17, 18]:

- Simple transverse fractures are best addressed by intramedullary implants. If this is not possible, the fracture gap must be closed as much as possible, ie, bone contact must be achieved. Three to four holes should be left free and three to four bicortical locking head screws (LHSs) in each main fragment are needed.
- Spiral-type 2-part fractures should be reduced and "adapted" as much as possible and preliminarily fixed with suture or hardware cerclages or cables. If screws are used, they should be tightened with caution as "reduction screws". The first plate screw should be inserted at the end of the fracture line. Three to four bicortical LHSs in each main fragment are necessary depending on the type of bone (**Fig 1.2-6**).
- In comminuted fractures, the first screws should be placed adjacent to the fracture zone. Four to five bicortical screws in each main fragment are sufficient.

12.3 Splinting the whole bone

Subsequent fractures adjacent to the end of plates, nails or prosthesis occur due to the stress riser between the stiff implant and the soft bone. The frequency is not clear. If possible, the whole bone should be protected at the first fixation including the femoral neck in case of the femur (**Fig 1.2-7, Fig 1.2-8**). To achieve this goal, sometimes a combination of intramedullary with extramedullary implants becomes necessary.

12.4 Angular stable implants and blades

Implants with locking head mechanism and fixed or variable angle between screw and plate as well as angular stable locking options for intramedullary nails all have biomechanically shown to provide superior stability in bone with reduced cortical thickness.

Locking head screws cannot be overtightened or overinserted rendering them unstable because the thread gets destroyed. They should always be used in a bicortical mode to improve their working length with thin cortices.

In addition, locking screws have a larger core diameter than conventional screws, which results in a higher pullout strength and overall strength. This is especially helpful in metaphyseal bone where intramedullary nails may fail. The holding power of the LHS can further be increased by orienting them in different directions: This method is used with the proximal humeral plate and the distal femoral and proximal tibial plates.

A blade for fixation of pertrochanteric fractures offers biomechanical advantages over a lag screw. The blade condenses the bone around the implant, while screw insertion always results in some bone loss.

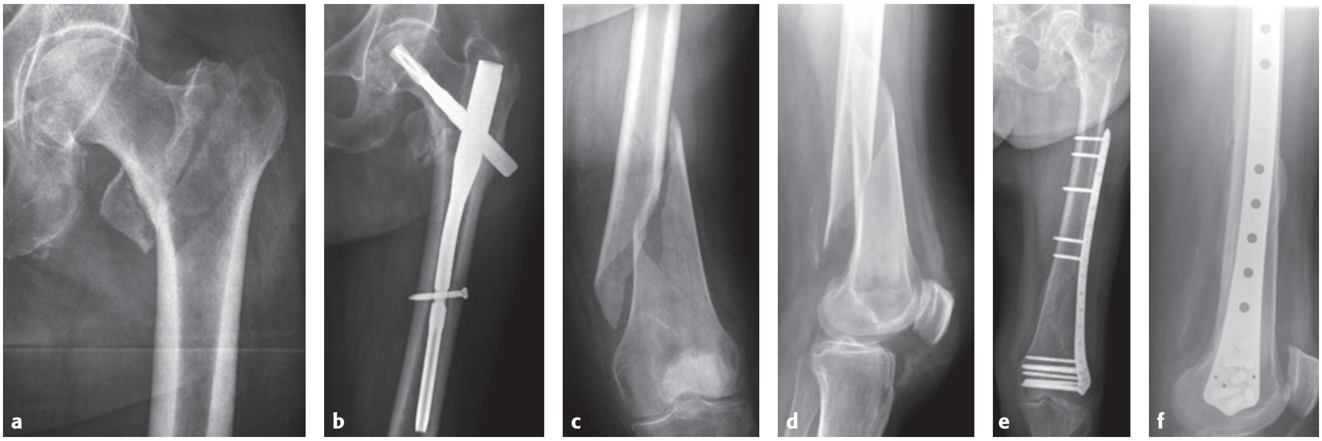

Fig 1.2-6a–f

a–b a A 77-year-old woman with a pertrochanteric fracture (31A2).
b Fixation with proximal femoral nail antirotation.
c–d The nail was removed 1.5 years later because of lateral thigh pain. Three years later, she sustained a spiral diaphyseal fracture (32A1).
e–f Minimally invasive reduction in lateral position and preliminary fixation with suture wire. Definitive fixation in relative stability with distal femoral plate, the first proximal screw starting at the end of the fracture and 10 cortices. Uneventful healing with small callus formation. Ideally, a longer plate to protect the whole femur would have been indicated.

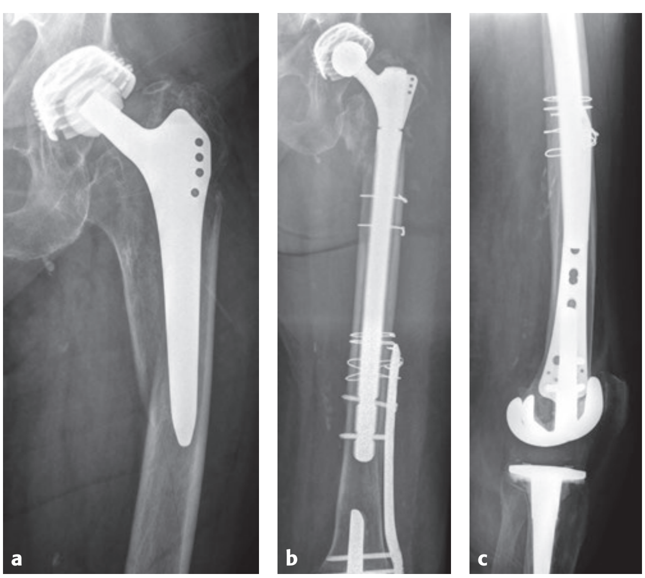

Fig 1.2-7a–c

a A 92-year-old woman with periprosthetic fracture type B2.
b–c Open reduction, fixation with cerclage wires and revision arthroplasty with a long-stemmed implant with locking options. Distal femoral plate to protect the bone between the two prostheses.

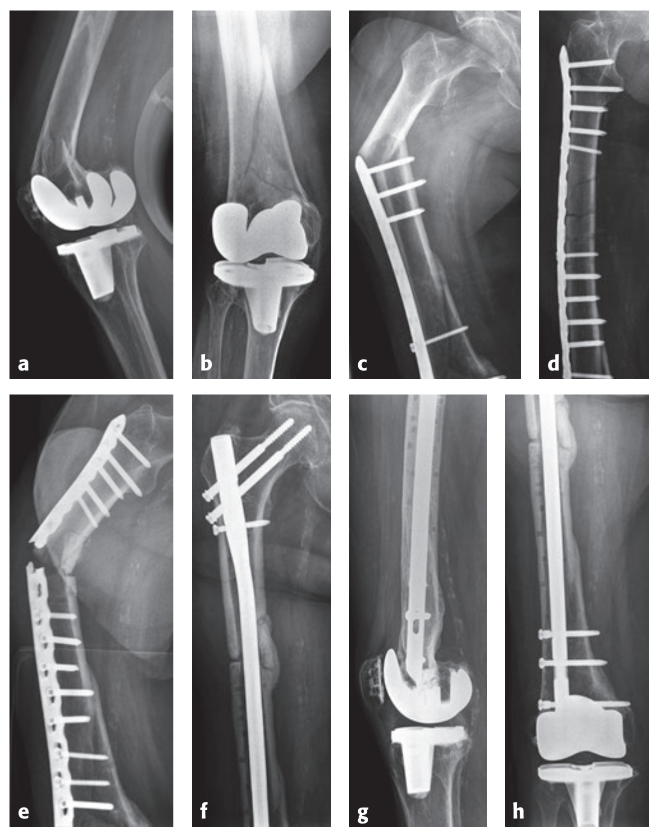

Fig 1.2-8a–h

a–b An 80-year-old woman with a periprosthetic knee fracture.
c Two and a half months after fixation with a distal femoral plate fracture adjacent to the proximal end of the plate.
d Application of a longer plate. Fixation in varus malalingment and with the fracture gap still open.
e The construct is too stiff and fails after another 2.5 months.
f–h Final solution with antegrade femoral nail. Distal locking with axial loading screws.

12.5 Anatomical alignment

Correct anatomical alignment represents an important prerequisite for uneventful bone healing. Fixation of osteoporotic bones is less tolerant for any deviation than in younger bone. Specifically varus malalignment should be avoided in femoral fractures.

Severe rotational malalignment is an underrecognized problem and occurs typically with very unstable proximal femoral fractures. Rotational malalignment should be avoided.

12.6 Bone impaction

Bone impaction at the fracture site is a key element in the surgical management of osteoporotic fractures as it reduces the risk of implant failure.

In many cases, like for example in the valgus-impacted fracture of the femoral neck, impaction is created by the trauma itself. Controlled impaction can be attained by tensioning internal fixation devices. Implants, such as the dynamic hip screw, which allow for controlled impaction of the fracture while preventing penetration of the joint by the hip screw.

12.7 Augmentation with polymethylmethacrylate

Fixation in osteoporotic bone can be improved by augmenting the bone with cement. Augmented purchase of the implant, in particular of screws, reduces the risk of hardware migration, cut out, cut through and pull out. It can also be used as a void filler to support the bone structure, for example, of a vertebral body or the tibial plateau, and prevent it from collapsing.

Polymethylmethacrylate (PMMA) remains the material of choice and may be used in different ways:

- For filling voids that mainly result after reduction of cancellous bone. A typical example is vertebral body compression fracture treated with closed reduction with vertebroplasty or kyphoplasty. The same principle can be applied to proximal tibial fractures; cement used as a void filler prevents the articular surface from collapsing after elevation.
- In standardized implant augmentation, the cement is typically injected with a specific cannula through perforated implants to improve the bone-implant interface by preventing high bone strain and distributing the force to the bone in a load-sharing rather than load-bearing configuration (**Fig 1.2-9**).
- In nonstandardized implant augmentation, the cement is applied via the screw hole or cortical window before or after the implant is inserted.

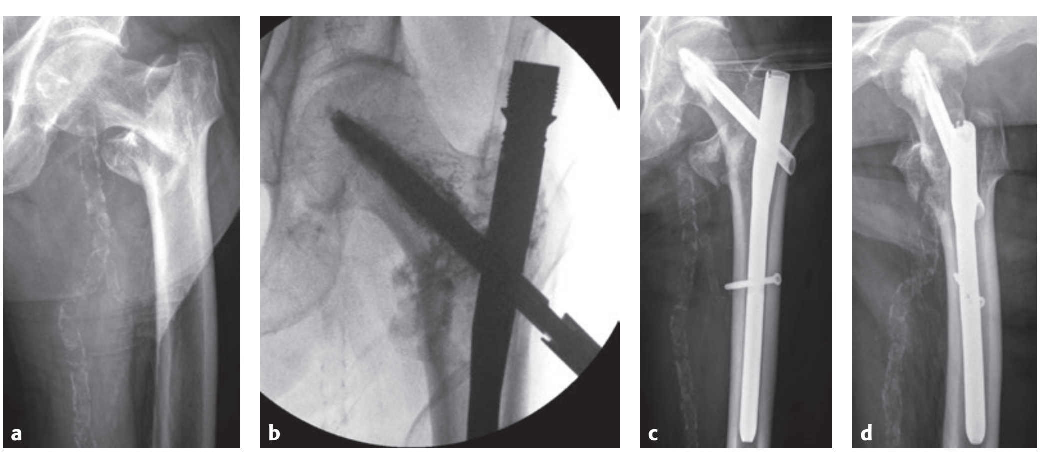

Fig 1.2-9a–d
a An 82-year-old man with a proximal femoral fracture (31A2).
b Close reduction with traction table. After insertion of nail and blade, the decision was taken to augment the blade because of severe osteoporosis and a very low resistance while inserting the blade. Intraoperative contrast dye test demonstrated no arthrogram, ie, no perforation into the hip joint.
c–d Injection of 4 mL of polymethylmethacrylate through a special cannula. Result after mobilization with center-center position of the head-neck-element and equally distributed cement.

Standardized implant augmentation has been thoroughly studied in recent years:

- Many sites have been tested biomechanically. In the proximal femur, proximal humerus, proximal tibia and sacrum, augmentation with PMMA cement improved cycles required to cause mechanical failure by ~ 100%; this applies only in osteoporotic bone.
- Small volumes of cement are sufficient. Larger quantities do not improve implant purchase significantly.
- Heat generation outside the cement does not exceed 42° C, because the metallic implant serves as a heat sink for the exothermic chemical reaction.
- No signs of cartilage damage next to the cement mass were noted in sheep experiments.
- Interference with bone healing has not been demonstrated so far.

Standardized implant augmentation with PMMA limits the negative effect of osteoporosis on implant fixation, "converting" osteoporotic bone into normal bone.

12.8 Autografts

Corticocancellous bone autografts to assist fracture healing and to fill gaps can also be harvested in older patients. Unless used as avoid filler, grafts should be fixed to the bone by cortical screws (**Fig 1.2-10**).

12.9 Allografts

Allograft bone has good mechanical properties but less osteogenic potential compared to autografts. In osteoporotic bone, allografts are used to fill metaphyseal voids and to prevent articular and other fragments from subsiding. This can be helpful in fractures of the proximal and distal humerus, distal radius and proximal tibia.

Allograft struts are also used in periprosthetic femoral fractures with poor bone quality to enhance the mechanical strength of the construct (**Fig 1.2-11**).

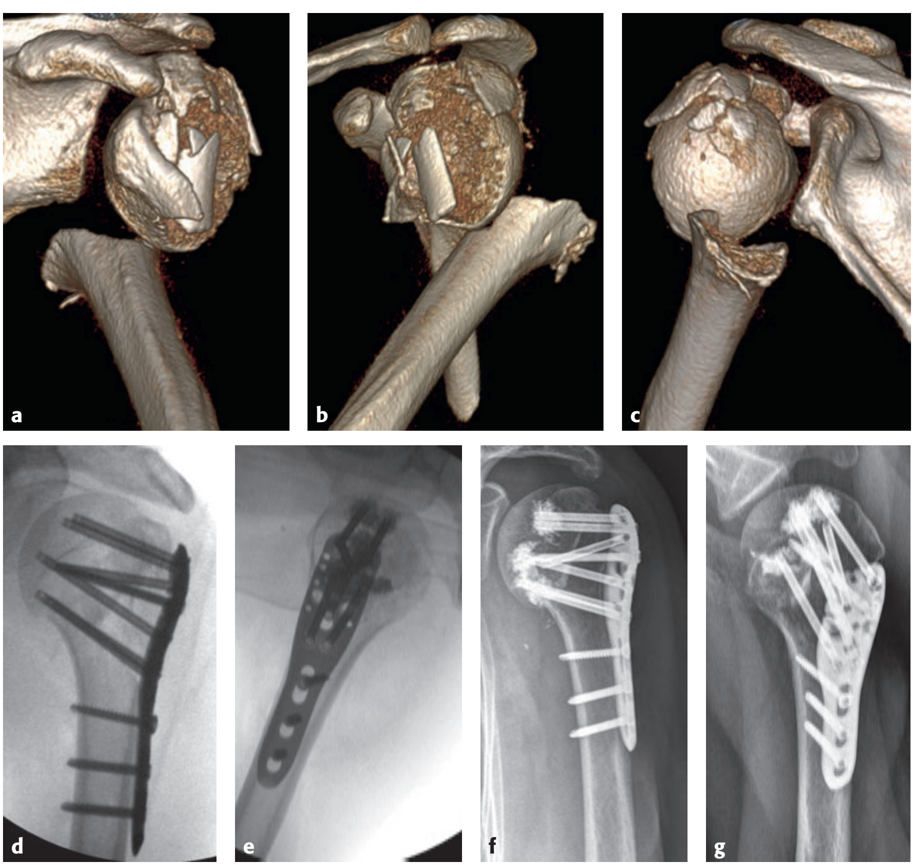

Fig 1.2-10a–g
a–c A 70-year-old woman with an unstable 3-part fracture.
d–e Fracture fixation was indicated despite the obvious risk for avascular necrosis because a stable reconstruction seemed to be possible. Anatomical reduction and fixation with PHILOS.
f Standardized implant augmentation via cannulated locking head screws with 0.5 mL of polymethylmethacrylate each to minimize the risk of mechanical failure.
g Injection of cement is only indicated and possible in osteoporotic bone. Follow-up after 3 months.

12.10 Joint replacement

Joint replacement plays an important role in older patients. It is commonly used in the proximal femur, mainly with femoral neck fractures. The indication for fracture arthroplasty is not as clear in proximal humeral fractures. A reverse shoulder arthroplasty is useful in cases where stable fixation is not possible. The use of an endoprosthesis in fractures of the distal humerus, distal radius and proximal tibia remains controversial.

More rapid restoration of adequate function along with a reduced life expectancy and fewer revision surgeries are appealing arguments in favor of immediate joint replacement.

There is a paucity of published evidence to inform clinical care in this area. If the general goals of fracture treatment can be achieved without violation of the above-mentioned principles, fracture fixation is usually preferred.

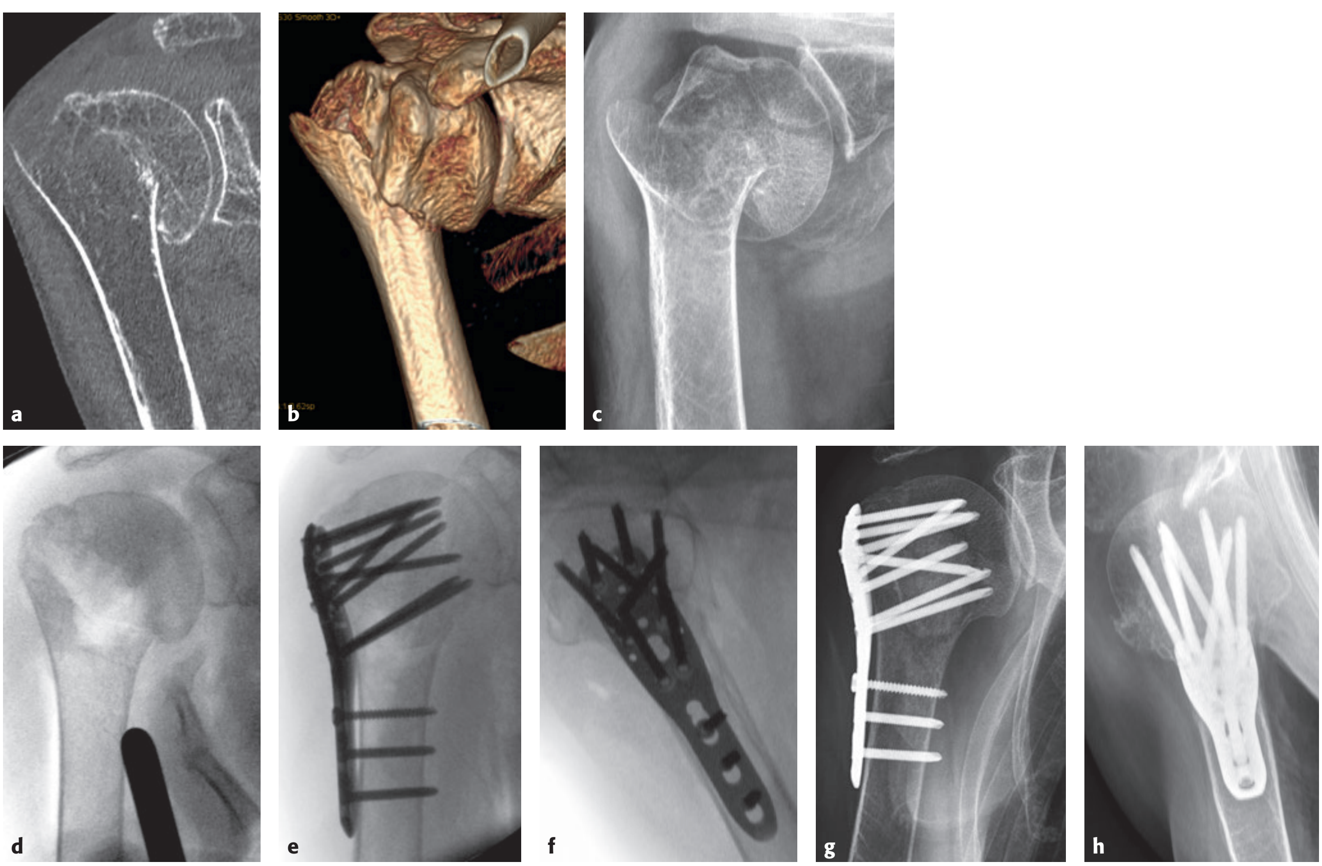

Fig 1.2-11a–h

a–c A 76-year-old woman with a displaced 2-part fracture of the proximal humerus. Severe osteoporosis with T-score lumbar spine -3.8, femoral neck -3.6 and a slender head fragment.

d–f Central void after open reduction (**d**) that is filled with a structural allograft from the bone bank (**e–f**).

g–h Follow-up after 3 months.

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1.3 Principles of orthogeriatric anesthesia

Ali Shariat, Malikah Latmore

1 Introduction

This chapter examines age-related changes that render older adults susceptible to adverse events in the perioperative period and provide a summary of current best practices regarding anesthesia for fragility fracture patients (FFPs) [1]. The major complications related to anesthetic interventions in older adults include perioperative cardiovascular morbidity, eg, hypotension, arrhythmias and acute coronary syndromes, respiratory failure, kidney injury, and delirium.

Despite these risks, high-performing geriatric fracture programs report remarkably low perioperative mortality rates of less than 2%, even in highly comorbid and frail referral populations [2, 3]. This chapter reviews relevant physiological changes in older adults, the assessment and preparation of fragility fracture patients for anesthesia and surgery, and the risks and benefits of general anesthesia (GA), regional anesthesia (RA) and multimodal analgesia. Unique geriatric considerations with regard to anesthetic choice, intraoperative positioning and teamwork are also examined.

2 Important pathophysiological changes in older adults

2.1 Cardiac morbidity

Perioperative cardiac morbidity (PCM) is the leading cause of death during and after surgery and includes myocardial infarction (MI), congestive heart failure (CHF), unstable angina, serious dysrhythmia, and cardiac death [4, 5]. Stressors such as perioperative pain, blood loss, anesthesia, and fluid shifts all contribute to an imbalance between myocardial oxygen demand and supply [1]. In addition, the aging process results in specific changes to the autonomic nervous system including increased sympathetic nervous system activation, decreased parasympathetic activity, and decreased baroreceptor activity, limiting the ability of the older adult to respond effectively to surgical stress [1]. Older patients are more likely to have preexisting cardiac comorbidities, such as coronary artery disease (CAD) or congestive heart failure (CHF). These factors all contribute to a decrease in cardiovascular reserve and lower the threshold at which older adults develop cardiac complications and hemodynamic instability [4, 6].

2.2 Pulmonary morbidity

Normal aging results in clinically significant changes in the respiratory system, including loss of alveolar surface area, decline in intercostal muscle mass and strength, kyphotic thoracic spine changes, and calcification of rib cage cartilage [7]. These changes reduce chest wall compliance, elastic recoil of the lungs, and the strength of the respiratory muscles [8, 9]. Normal central respiratory responses to hypoxia and hypercapnia are reduced by approximately 50% in older adults [10]. The cough reflex is less forceful and effective, increasing the risk of aspiration pneumonia [9]. Older patients have increased sensitivity to the respiratory depressant effects of opioids due to an increase in the volume of distribution as well as a decrease in renal and hepatic clearance [9, 11].

2.3 Cognitive dysfunction

Older adults are especially susceptible to delirium in the perioperative period, and there is concern that perioperative delirium may also contribute to longer-term cognitive dysfunction [12] (see chapter 1.14 Delirium for more information on delirium). An abrupt decline in perioperative cognition is a robust predictor of increased mortality within the first 3–12 months after surgery [12–14]. Theories explaining the relationship between cognitive dysfunction and mortality include direct damage to the brain, inability of patients with cognitive impairment to care for their own health, and consideration of cognitive decline as an indirect marker of systemic organ disease [14].

Medical complications such as pneumonia, deep vein thrombosis, pressure ulcers, MI, gastric ulcers, and depression are more common in patients with postoperative delirium [15].

Since cognitive decline in the postoperative period can have an enormous impact on postoperative complications and functional recovery, minimization of delirium in the perioperative period is an important goal.

3 Preoperative risk assessment and preparation

Poor preoperative preparation has been implicated in 40% of deaths attributed to surgery and anesthesia [16].

Most published guidelines concerning preoperative optimization are based on patients undergoing elective surgery. Under elective conditions, preexisting systemic disease is closely investigated in order to define the disease, quantify its severity, and optimize the patient's condition for operative repair. Many of these practices and protocols can only be loosely extrapolated to urgent cases such as hip fracture, as the risks of surgical delay resulting from hemodynamic instability, delirium and immobility typically exceed the benefits of further preoperative testing.

Older age alone is no longer considered an important predictor of perioperative risk. Rather, the overall physical and functional status and the number and severity of comorbid conditions are considered more robust predictors of outcome [1]. Quantifying comorbidity and functional capacity are important tools to predict outcome. See chapter 1.4 Preoperative risk assessment and preparation for a more thorough discussion of preoperative risk assessment and preparation.

3.1 Functional capacity

Functional capacity is a more accurate predictor of intraoperative risk than most specific comorbid conditions or the results of extensive diagnostic testing [17].

Functional capacity can be assessed in terms of metabolic equivalents (METs) of activity. Ability to perform activities of greater than four METs is considered good functional capacity; examples of such activities include climbing up a flight of stairs, walking more than 6.4 km/h (4 mph), or doing heavy household work [18]. This threshold (> 4 METs) has been used to indicate adequate reserve for most orthopedic and other intermediate-risk surgeries.

3.2 Cardiac risk

While the development of robust risk assessment tools is of increasing relevance for elective surgical procedures, there remains a dearth of studies to accurately estimate risk for the typical FFP. The Revised Cardiac Risk Index [19] is the most widely studied tool for hip fracture surgery and stratifies cardiovascular risk based on the presence of six predictors of cardiac morbidity and mortality:

- High-risk surgery (typically vascular or intraperitoneal)
- History of ischemic heart disease
- History of CHF
- History of cerebrovascular disease
- Insulin-dependent diabetes
- Preoperative serum creatinine > 2 mg/dL

The presence of two or more factors identifies patients with moderate to high risk for perioperative complications. These criteria have been used during elective surgical planning as triggers to consider additional noninvasive testing, further medical therapy, and/or invasive monitoring [17, 19]. These factors are likely to also predict outcomes in the urgent surgical setting.

History of unstable angina, CHF, significant dysrhythmias, severe valvular disease, and pacemaker or an automated implantable cardioverter defibrillator (ICD) placement should be determined [18]. If a patient has a pacemaker or an ICD, a plan for perioperative management should be discussed. Information to be obtained includes the type and manufacturer of the device as well as the underlying dysrhythmia or other cardiac condition that led to the placement of the device. Perioperative management of the device must be individualized, with some devices requiring preoperative interrogation and possibly reprogramming by the cardiology team [18].

3.3 Procedure risk

In addition to risk stratification for patients, surgical procedures may also be classified according to risk. High-risk procedures include emergent procedures, major vascular procedures, and prolonged procedures with major fluid shifts and blood loss. They are typically defined as having adverse cardiac event risks greater than 5%. Low-risk procedures include endoscopy, breast surgery, and cataract surgery and have an adverse cardiac event risk lower than 1%. Most orthopedic procedures are considered intermediate risk and have an adverse cardiac event risk between 1% and 5% [18].

3.4 Routine preoperative testing

Only after clinically significant diseases have been identified on a medical history and physical examination should further testing be considered; this testing should only be pursued if it is likely to change management, improve outcomes, and provide benefits that outweigh the harms of surgical delay [18] (see also chapters 1.4 Perioperative risk assessment and preparation and 2.6 Orthogeriatric team—principles, roles, and responsibilities). In hip fracture patients, operative delay of more than 48 hours after admission increases the odds of a 30-day mortality by 41% and a 1-year mortality by 32% [20].

The American Society of Anesthesiologists in collaboration with the American Board of Internal Medicine Foundation recommend the following baseline preoperative laboratory tests: complete blood count, basic or comprehensive metabolic panel (ie, electrolytes, renal function and glucose), and coagulation studies for patients when significant blood loss and fluid shifts are expected [21].

In patients with established heart disease, an electrocardiogram may provide important prognostic information about short-term and long-term mortality, and provides a baseline against which perioperative changes may be judged [18].

More advanced preoperative cardiac testing (eg, transthoracic/esophageal echocardiography or cardiac stress testing) in asymptomatic, stable patients with known cardiac disease (eg, CHF or valvular disease) is not recommended and is generally not appropriate for hip fracture patients in the absence of signs and symptoms of significant active cardiovascular compromise [21, 22].

With the exception of concern for severe aortic stenosis, echocardiographic assessment of valvular function does not lead to clinically important changes in management [18].

3.5 Medication management

All preoperative medications must be correctly identified, recorded and considered for continuation or discontinuation during the perioperative period. The risk of intraoperative hypotension and excessive blood loss is elevated in older trauma patients, and teams must consider the potential impact of home medications on blood pressure and bleeding. Some common perioperative considerations include:

- Long-term beta-blocker therapy should be continued perioperatively due to the benefits of heart rate control and decreased myocardial oxygen consumption, and the potential harm of withdrawal when abruptly stopped [18]. In patients not receiving long-term beta-blocker therapy, beta-blockers should not be initiated prior to surgery due to the increased risk of hypotension, stroke, and death [18].
- Angiotensin-converting enzyme inhibitors (ACEIs) and angiotensin receptor blockers (ARBs) can lead to increased episodes of intraoperative hypotension and acute kidney injury, particularly when used in association with diuretics [23]. Most experts recommend discontinuation of ACE inhibitors/ARBs and diuretics preoperatively [17].
- Long-term antiplatelet therapy with aspirin, clopidogrel and other antiplatelet agents is typically stopped in the preoperative period. For patients who have undergone coronary stent implantation within the past 6 weeks, dual antiplatelet therapy with aspirin and P2Y12 platelet inhibitor should be continued unless the risk of surgical bleeding outweighs the risk of stent thrombosis [18].

Additional discussion of preoperative medication management can be found in chapter 1.4 Preoperative risk assessment and preparation. Discussion of the management of long-term anticoagulation during the perioperative period can be found in chapter 1.6 Anticoagulation in the perioperative setting.

4 Intraoperative anesthetic choices

General and regional anesthesia each have potential advantages and disadvantages for hip fracture patients, and anesthetic choices require a thorough understanding of the physiological changes related to trauma and the stress of surgery. As will be discussed in topic 4.1, recent systematic reviews and metaanalyses [24] do not support the superiority of one method of intraoperative anesthesia (ie, general versus regional) over the other in the urgent repair of fragility fractures; reasonable differences in practice patterns exist within institutions and worldwide.

4.1 Definitions and concepts

General anesthesia is typically delivered through a combination of intravenous and inhalational agents and results in loss of consciousness, lack of response to stimuli and typically requires ventilatory support.

Regional anesthesia encompasses neuraxial (NA) techniques (eg, epidural and spinal anesthesia), and peripheral nerve blockade. Regional anesthetic techniques can be combined with systemic sedatives, but do not typically involve complete loss of consciousness or the need for complete ventilator support.

The stress of surgery causes a cascade of neural and humoral mediators that trigger tachycardia, blood pressure lability, and hypercoagulability, and can lead to MI, pulmonary infection, and thromboembolism [23]. Since pain plays a central role in triggering this stress response, effective analgesia can mitigate the ensuing adverse effects on various organ systems and improve outcomes [25]. General anesthesia modulates this response through the central nervous system, while RA blocks this pathway at the level of peripheral nerves or at the spinal cord [26].

Effective management of pain in the postinjury period is crucial, as uncontrolled pain may lead to both short-term complications and chronic pain syndromes [26].

Unlike RA, adequate blockade of the surgical stress response under GA requires large doses of opioids given prior to incision [25, 27]. Large doses of opioids increase the incidence of opioid-related adverse effects such as respiratory depression, sedation, nausea, ileus, and pruritus.

The addition of epidural anesthesia blocks the perioperative increases in adrenaline, cyclic adenosine monophosphate [28], renin, aldosterone, cortisol [29, 30], and vasopressin [31]. When epidural anesthesia is begun prior to surgery and maintained for 24 hours after surgery, muscle catabolism is minimized [32].

As noted previously, some aspects of this stress may be reduced by the administration of RA [1].

4.2 General versus neuraxial anesthesia

General anesthesia is required for patients with contraindications to NAs (eg, coagulopathy, infection at site, increased intracranial pressure), and may be preferred by some anesthesiologists and surgeons for patient-specific or procedure-specific issues. Some literature [33] suggests that regional techniques are associated with less delirium and fewer perioperative complications, but anesthetic practice varies greatly worldwide, and there are no large randomized trials of FFP to definitively inform this question [1, 24, 34]. For fractures of or trauma to the lower extremity, spinal, epidural, nerve blocks and GA may be used to provide anesthesia and analgesia. Proximal humeral fractures typically require GA in the FFP population.

4.3 Neuraxial anesthesia

A number of metaanalyses have compared outcomes of NA versus GA alone in a variety of surgical procedures and patient populations, but there remains a paucity of high quality literature as it applies to FFPs. In older cohorts, NA, whether used by itself or in combination with GA, was associated with a 59% reduction in postoperative respiratory depression. In studies focused on the use of NA in elective nonorthopedic surgeries, the odds of postoperative pneumonia are reduced by 39% and pulmonary embolism by 55% [35]. The largest studies of hip fracture patients [36] suggest decreased mortality and respiratory complications with NA but are limited by their observational and retrospective nature.

Compared to intravenous opioid therapy, NAs for pain control decrease the incidence of new angina, dysrhythmia, and CHF in high-risk patients [37]. A large systematic review comparing NA to GA found a reduction of approximately 33% in the incidence of MI [35]. A further systematic review found a decrease in PCM and mortality when epidural analgesia is continued for 24 hours after surgery [38]. Improved mortality rates and decrease pulmonary morbidity has been validated in at least one large retrospective study of older patients undergoing hip fracture surgery [39]. Opinions [40, 41] differ as to the extent of benefit conferred by regional anesthetic techniques, but improved outcomes seem to be greatest for high-risk patients [37, 42].

Due to a lower volume of cerebrospinal fluid (CSF), the presence of spinal stenosis, and reduced myelination of the nerves, older patients generally have a reduced latency time, higher dermatomal level, and increased block density with spinal anesthetic than younger patients. For these reasons, local anesthetic dosage should usually be reduced when performing NA in geriatric patients [26].

The presence of anticoagulation is often a limiting factor in the consideration of NA techniques for FFP. Epidural and spinal hematomas are rare but devastating complications of NA with the most significant risk factor being the presence of anticoagulation [43]; anticoagulation is much more prevalent with the increased emphasis on perioperative thromboprophylaxis in recent years [44]. Prior to the placement of a neuraxial anesthetic, the patient's coagulation status must be assessed, as NA is contraindicated in these patients. The American Society of Regional Anesthesia and Pain Management guidelines are applied to patients receiving neuraxial interventions as well as 'deep plexus' blocks or catheters (eg, lumbar plexus block) [45].

The following regional techniques are contraindicated in anticoagulated patients:

- Neuraxial, ie, epidural or spinal
- Paravertebral blocks
- Deep plexus blocks, ie, lumbar plexus and lumbar sympathetic plexus

Although these guidelines apply to all patients, older patients are more likely to have comorbid cardiovascular disease requiring anticoagulation or antithrombotic therapy, making a focused evaluation of anticoagulation status especially relevant.

Postdural puncture headache (PDPH) is the most common complication of spinal anesthesia and is caused by delayed closure of the dura resulting in a continuous CSF leak and decreased CSF volume and pressure. The incidence of PDPH diminishes significantly with increasing age and is rare in the older adults [46].

4.4 Lower extremity peripheral nerve blocks

All peripheral nerve blocks that are used for surgery of the lower extremity can also be used for analgesia following traumatic injury [26]. Femoral, sciatic, lumbar plexus and fascia iliaca blocks are all possible and their selection is dependent on the location of injury, type of operation and ability to position the patient [26].

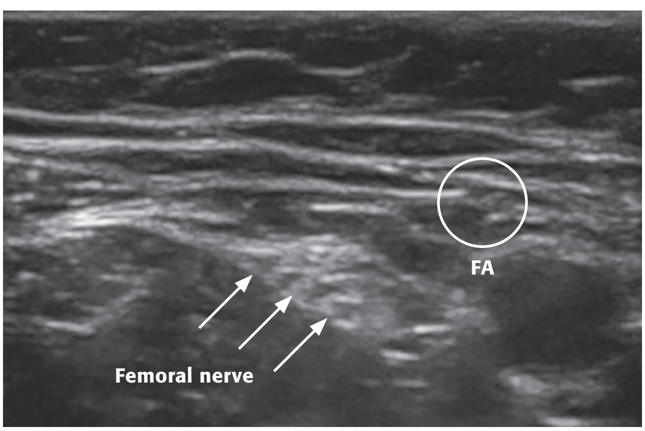

Fig 1.3-1 Ultrasound image of the femoral nerve. Abbreviation: FA, femoral artery.

Issues to consider regarding lower extremity nerve blocks:

- The fascia iliaca block is performed in a region that is distant from vascular and other vital structures, making it relatively safe. It has been widely studied as a preoperative treatment of pain following hip fracture with reductions in acute pain and delirium [47]. Recently, however, the distribution, reproducibility, and utility of this block have come under question [48].
- The lumbar plexus block, consisting of L1–4 spinal roots with a contribution from T12, lies in the psoas muscle where these nerves can be blocked. The terminal nerves of the lumbar plexus are the iliogastric (L1), ilioinguinal (L1), genitofemoral L1/2), lateral femoral cutaneous nerve (L2/3), the femoral nerve (L2-4) and the obturator nerve (L2–4) [49].
- Femoral block is useful for trauma of the femur or patella (**Fig 1.3-1**) [49].
- The sciatic nerve block is widely used for surgery and/or pain control of the entire leg below the knee with the exception of the cutaneous distribution of the medial aspect of the lower leg [49].

4.5 Upper extremity peripheral nerve blocks

Issues to consider regarding upper extremity nerve blocks:

- For trauma of the shoulder, lateral clavicle, or proximal humerus, an interscalene block, performed at the level of C5 and C6 roots or the upper trunk, can provide excellent analgesia and/or anesthesia (**Fig 1.3-2**, **Fig 1.3-3**) [50]. This block can cause 100% hemidiaphragmatic paralysis either due to local anesthetic coursing towards the phrenic

Fig 1.3-2 Ultrasound transducer and needle position for performance of ultrasound-guided interscalene block in the out-of-plane orientation.

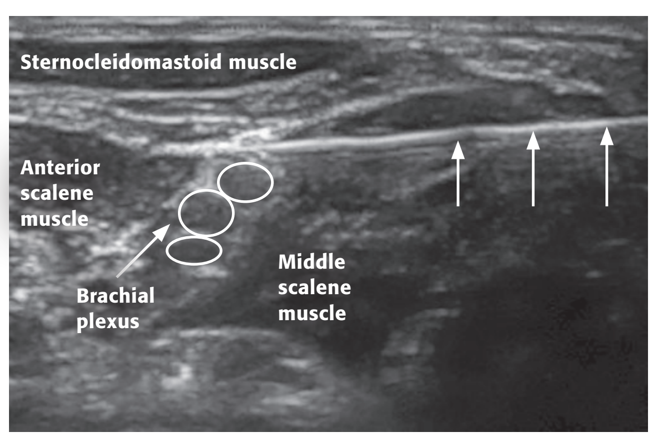

Fig 1.3-3 Ultrasound image of interscalene brachial plexus with needle in the in-plane orientation. Arrows point to the incoming needle.

nerve or due to cephalad spread of local anesthetic towards C3–5 roots and therefore must be considered with caution in patients who have limited respiratory reserve [51]. It is contraindicated in patients with contralateral pneumothorax or pneumonectomies, contralateral phrenic nerve palsy, or contralateral recurrent laryngeal nerve palsies [52]. In such cases, GA is the preferred method of anesthesia.

- For more distal injuries, supraclavicular, infraclavicular, or axillary blocks may be used [26]. In trauma patients, the cervical spine must often be cleared prior to removal of the cervical collar and placement of an interscalene block [26].
- Supraclavicular blocks also carry a risk of phrenic nerve paralysis, albeit less than with the interscalene approach. Pneumothorax is a risk when performing either supraclavicular or infraclavicular blocks [26]. Due to a decrease in nerve myelination in older patients, greater diffusion of local anesthetics is possible utilizing lower volume. Therefore, as with NA, effective doses of local anesthetics should be reduced when performing peripheral nerve blocks in geriatric patients [1].

4.5.1 Nerve injury and peripheral nerve blocks

Nerve injury can result from a number of factors related to the patient (eg, preexisting trauma and/or neuropathy), surgery (eg, mechanical, tourniquet), or the nerve block and most often involves a combination of factors [53]. Neural injury resulting from a nerve block is rare, occurring with a frequency of 0.4 per 1,000 blocks [54] but can result from direct mechanical trauma of the needle, neurotoxicity from the local anesthetic, or an intraneural injection of local anesthetic [53]. According to the double crush hypothesis, patients with preexisting nerve injury or neural disease are at greater risk of developing a clinically significant neuropathy if a nerve is subsequently injured at a second location along the neural pathway [55]. For this reason, nerve blocks following traumatic injury should be approached with caution and include a robust assessment of risks and benefits as well as discussion with the patient and the surgical team. Age-related changes in the somatic nervous system include peripheral nerve deterioration and decreased myelinated nerve fiber conduction [1].

It is unclear whether such changes increase the older patient's susceptibility to nerve injury due to the performance of RA. However, preoperative assessment and documentation of preexisting neural compromise are important.

4.5.2 Compartment syndrome

Treatment of pain following a traumatic injury to an extremity with RA carries the risk of masking the pain of compartment syndrome [56]. Performing RA after traumatic injury therefore remains a controversial topic with early case reports indicating a delay in the diagnosis of compartment syndrome [57, 58]. However, more recent case reports show that breakthrough pain in the presence of a regional block is not masked by peripheral nerve blocks [56, 59]. Moreover, the emergence of breakthrough or crescendo pain, together with edema of the affected extremity, in the presence of a continuous nerve catheter has been suggested as evidence of compartment syndrome [60]. This topic remains controversial and requires an assessment of risks and benefits and close communication between the orthopedic and anesthesia teams.

4.5.3 Effects of sedation

There has been some emerging evidence that patients who are more heavily sedated under RA have an increased risk of postoperative delirium and may even have an increased risk of mortality after 1 year than those who are more lightly sedated [61, 62]. However, these studies have not established a causative relation between anesthetic depth and mortality, have not been confirmed by other studies [63], and their validity has been questioned [64]. Due to the susceptibility of the geriatric population to postoperative delirium, heavy sedation is likely not ideal in this population.

4.6 Multimodal analgesia

Multimodal analgesia involves the use of a variety of analgesic agents, each with different mechanisms, to treat pain [26]. The use of multimodal analgesia has become a mainstay of perioperative pain management in order to reduce opioid use and related adverse effects including respiratory depression, sedation, nausea, ileus, and pruritus [65, 66]. Moreover, when opioids are used as a single modality, higher doses are required, increasing the risk of adverse effects [67–69]. These adverse effects may be more pronounced in older adults due to impaired pharmacodynamics and pharmacokinetic handling of the drugs [70]. While opioid-sparing therapies are of potential benefit to older adults, the risks of other pharmacological agents are not particularly well studied. Many nonopioid analgesic agents have limiting adverse effects, particularly in the clinically unstable FFP.

Specifically, nonsteroidal antiinflammatory drug use is limited in the immediate perioperative period due to concerns with gastrointestinal bleeding and renal injury in the hemodynamically tenuous older adult. Caution should also be taken with the use of gabapentinoids due to dose-related adverse effects such as sedation and dizziness, especially given the goals of early ambulation.

Recently, intravenous acetaminophen has become available in the United States and has produced promising results and few adverse effects. In patients having hip and knee arthroplasties, reduced morphine consumption and improved Visual Analog Scale pain scores have been noted with the inclusion of acetaminophen [71]. The cost of intravenous acetaminophen limits its use in many centers. Additionally, the N-methyl-D-aspartate antagonist ketamine has profound analgesic properties and has been shown to be an effective component of a multimodal analgesic regimen by diminishing opioid use, decreasing postoperative pain, and improving time to reaching physical therapy goals in orthopedic patients [72–76]. But it requires additional study in older trauma patients due to the risk of dysphoria, sedation, hallucinations, and postoperative cognitive dysfunction.

5 Intraoperative positioning

Careful patient positioning is of utmost importance during the intraoperative period, particularly in patients who are deeply sedated, under GA, or have a regional anesthetic, rendering them unable to alert physicians to early signs of injury [77]. Although patient positioning is an important consideration for all patients in the operating room, special care must be taken when applied to the older patient due to increased incidence of osteoporosis, hypertension, diabetes mellitus, and peripheral vascular disease [78–81]. Ischemic stroke is an especially feared complication in the beach chair position [82]. The effect of gravity decreases venous return, reducing cardiac output and cerebral perfusion pressure. Risk factors for stroke are far more common in older patients, necessitating meticulous management of hemodynamic factors, such as maintenance of blood pressure as close as possible to the patient's baseline values [83]. For these reasons, the regular use of hypotensive anesthesia for improved visualization in arthroscopic shoulder surgery should be either avoided or used with great caution in patients with risk factors for stroke, such as hypertension or cerebrovascular disease [82]. Alternatively, the beach chair position can be avoided altogether.

6 Partnering with anesthesiologists

The practice of medicine in general, and anesthesia in particular, has often been compared with other high-stakes professions such as aviation where evidence has long shown that inadequate teamwork is one of the main reasons for preventable error [84]. Effective communication, mutual monitoring, and both giving and receiving feedback are all essential elements of teamwork [82, 84] (see also chapter 2.6 Orthogeriatric team—principles, roles, and responsibilities).

7 References

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1.4 Preoperative risk assessment and preparation

Joseph A Nicholas

1 Introduction

Skilled preoperative assessment and optimization of the geriatric fracture patient directly contributes to excellent outcomes. Although there is a paucity of relevant literature on older adults undergoing urgent surgery, best practices are heavily informed by geriatric principles combined with evidence extrapolated from other populations and settings. The perioperative medical practices supported by much of the existing literature require modification for the physiologies and vulnerabilities of older adults, and geriatric fracture care should not simply replicate practices patterns used for the stable and healthier elective surgery patient.

Medical centers using a standardized geriatric medicine approach to preoperative care have reliably demonstrated improved outcomes in mortality, length of stay and reduction in complications [1–3]. This chapter focuses on the strategies used by many of these centers in the areas of risk assessment and optimization.

Key principles and goals:

- Early surgical fixation, particularly for highly frail or comorbid patients
- Optimization by a general medical service for surgery in less than 24 hours for most patients, and many in less than 6 hours
- Pain control with parenteral opiates and regional nerve block techniques
- Anticipation of hypotension in the intra and postoperative period; liberal use of intravascular hydration, and cessation or reduction of most antihypertensive medications
- Avoidance of excessive perioperative testing, medical consultation and polypharmacy

2 Unique perioperative aspects

In addition to risk assessment and surgical planning, the perioperative management of older adults is focused on active efforts directed towards pain control, maintenance of hemodynamic stability and avoidance of functional decline. Early surgery is the most important way to achieve these goals, and the preoperative medical assessment needs to prioritize early surgery and early mobility over many other chronic medical issues. For these reasons, high-performing geriatric fracture centers have implemented clinical pathways that emphasize timely transition to operative repair, even in highly comorbid or frail older adults. Many notable comorbidities warranting more intensive preoperative testing and consultation prior to elective surgery are not vigorously pursued in the geriatric fracture setting.

3 Preoperative risk assessment

For almost all patients, the benefits of operative fracture repair, including hemostasis, pain control and mobilization, exceed the risks related to anesthesia and surgery. This is due to both the improved safety of advanced anesthetic and surgical techniques and the excessive morbidity and mortality of hip fracture patients in the absence of surgical repair. Patient-specific risks can be roughly estimated with the careful use of preoperative risk calculators, and may allow for better anticipation of patient-specific outcomes and complications.

3.1 Risk calculators

The Nottingham Hip Fracture Score [4] is the best-validated instrument for predicting 30-day and longer outcomes in the hip fracture population, and incorporates measures of comorbidity burden, functional status (ie, type of residence), cognitive status (ie, mini-mental test score), nutritional status (ie, albumin), and key demographic factors (ie, age, gender). Elements like institutionalization and mini-mental test score are not universally consistent across different international settings, but likely can be approximated and remain useful for estimating perioperative risk and short-term outcomes (**Table 1.4-1**, **Table 1.4-2**).

A number of additional calculators have been developed in the attempt to provide a reasonable estimate of serious complications in surgical patients; none are validated in older adults undergoing urgent orthopedic surgery. Three calculators that were examined in the most recent American College of Cardiology/American Heart Association (ACC/AHA) guidelines include the Revised Cardiac Risk Index (RCRI) [6], the Myocardial Infarction or Cardiac Arrest calculator [7], and the American College of Surgeons' National Surgical Quality Improvement Program Surgical Risk Calculator [8]. The key features of the RCRI are summarized in **Table 1.4-3**.

3.2 Other assessments of prognostic importance

Despite the historical emphasis on comorbidity scoring for estimating surgical risk, functional and cognitive impairment have long been recognized in geriatric medicine to predict many clinically significant perioperative complications and mortality [10]. There are several tools to quickly classify cognitive and functional status into meaningful categories; these can be easily incorporated into standard medical, surgical or nursing assessments.

3.2.1 Functional capacity

The Parker Mobility Score is a simple measure of function that has been derived and validated in the hip fracture setting, and evaluated in multiple settings and for multiple important outcomes (**Table 1.4-4**). More extensive functional status evaluation can be helpful in the rehabilitation phase.

Variable	Value	Points
Age, y	66–85 > 85	3 4
Gender	Male	1
Admission hemoglobin	≤ 10 g/dL	1
Admission mini-mental test score	≤ 6 of 10	1
Living in an institution	Yes	1
Number of comorbidities	≥ 2	1
Malignancy	Yes	1

Table 1.4-1 Nottingham Hip Fracture Score, adapted from Maxwell et al [4].

Nottingham Hip Fracture Score	Estimated 30-day mortality, %
1	1
3	3
5	7–10
7	16–23
10	45–57

Table 1.4-2 Nottingham Hip Fracture Score and predicted mortality rates, adapted from Moppett et al [5].

Risk factors	Points
High-risk surgery (intraperitoneal, intrathoracic, suprainguinal vascular)	1
Ischemic heart disease history	1
Heart failure history	1
Stroke or cerebrovascular ischemia history	1
Diabetes requiring insulin	1
Renal failure with creatinine > 2 mg/dL	1

Total points	Risk of major cardiac event, %
1	1.0
2	2.4
≥ 3	5.4

Table 1.4-3 Perioperative Risk Calculator: Revised Cardiac Risk Index, adapted from Devereux et al [9].

Mobility	No difficulty	With an aid	With assistance	Not at all
Around house	3	2	1	0
Out of house	3	2	1	0
Shopping	3	2	1	0

Total (NMS)	1-year mortality, %
≤ 3	56
4–5	38
> 5	15

Table 1.4-4 New (Parker) Mobility Score (NMS) [11].

3.2.2 Cognitive assessments

Impaired cognition is significantly associated with functional dependence and poor outcomes, and by itself is a marker of increased perioperative risks and postoperative dependency [12]. For patients without a preexisting diagnosis, diagnostic assessment for dementia is often not possible during the preoperative period, due to the complicating presence of delirium. In these situations historical features can often suggest the presence of dementia; impairments in telephone use, handing of finances and medication self-administration best correlate with underlying dementia [13]. For patients without delirium, the Mini-Cog test is a validated, efficient tool with good ability to identify dementia [14]. See chapter 1.14 Delirium for further discussion.

3.2.3 Exercise capacity

Exercise capacity is used as a surrogate for functional capacity and physiological reserve, and has been incorporated into the ACC/AHA guidelines to discriminate high- and low-risk patients, using a threshold of 4 metabolic equivalents of task [15]. Common activities that meet this threshold include walking up a flight of stairs, walking up a hill, walking at a minimum pace of 6.4 km/h (4 mph), or heavy housework like scrubbing floors and moving heavy furniture. For patients undergoing elective surgery, these guidelines suggest that patients who can perform this level of exertion do not require additional cardiovascular testing preoperatively. This level of exercise capacity should be relatively reassuring for the geriatric fracture patient as well.

4 Routine preoperative testing

The standard preoperative evaluation should be limited to bedside clinical evaluation, basic blood work and essential radiographic studies. Excellent perioperative outcomes can be obtained with the following tests: radiography of the fracture, hemoglobin level and platelet count, basic serum electrolytes and renal function, and a resting electrocardiogram [3].

Recommended preoperative tests include:

- Standard:
  - Complete blood count
  - Basic electrolytes and renal function
  - Serum calcium
- Typically recommended:
  - Electrocardiogram
  - Coagulation studies
    (particularly for patients taking warfarin)
  - Albumin
    (to correct calcium and screen for malnutrition)
- Metabolic bone evaluation:
  - Vitamin D levels
  - Parathyroid hormone (PTH) levels
  - Thyroid studies

As part of a standard protocol, it may be helpful to perform metabolic bone assessments (ie, calcium and phosphorus, PTH, thyroid hormone, vitamin D levels) or help identify malnutrition (ie, albumin levels), although the results of these studies are not essential prior to proceeding to surgical fixation. Standardized order sets and protocols can help streamline this preoperative testing process and minimize inappropriate variation in care [16].

Bedside clinical evaluation should focus on the assessment of intravascular volume status and the rapid identification of the few active medical conditions that warrant surgical delay, including acute pulmonary edema, acute coronary syndrome, sepsis, unstable arrhythmias, or acute stroke.

5 Advanced investigations

For most fragility fracture patients there is no demonstrated benefit to routine advanced investigations such as echocardiography, noninvasive cardiovascular stress testing, or prolonged preoperative cardiac rhythm monitoring. Retrospective studies suggest that routine advanced cardiovascular testing, including echocardiography, results in significant surgical delay without clinically important changes in management [17, 18]. In addition, the preoperative care teams should carefully avoid preoperative workup of otherwise stable chronic comorbidities like chronic renal failure, chronic stable coronary disease, or chronic neurological deficits; there is no known benefit to more intensive workup and consultation prior to fracture fixation. Other routine tests of uncertain preoperative impact include routine urinalysis, chest radiography and biomarker assays, ie, B-type natriuretic peptide and troponin levels. The high incidence of asymptomatic bacteriuria in older adults, particularly women, can prompt inappropriate antibiotic use, and nonspecific biomarker elevations may lead to acute interventions that promote hypotension, bleeding and surgical delay. Until there is better prospective data supporting routine use of biomarker assays in fragility fracture patients, these should be limited in this setting to symptomatic patients.

6 Preoperative medical treatments

In addition to clinical assessments and risk stratification, preoperative optimization typically requires a small set of interventions to minimize surgical delay and intraoperative hypotension.

6.1 Intravascular volume restoration

Almost all older adults with femoral fractures suffer from acute intravascular volume depletion and require volume restoration to minimize perioperative hypotension. Initial hemoglobin assessment prior to volume restoration can significantly underestimate the degree of anemia, and blood loss will often continue until the fracture is reduced and fixed, especially in the patients with recent use of antithrombotic or anticoagulant medications.

Most published reviews support the initiation of isotonic intravenous fluids as soon as possible for patients without clinically significant acute pulmonary edema. Geriatric fracture centers typically report preoperative hemoglobin targets of 10 mg/dL, in anticipation of further blood loss during the perioperative period [19].

In general, it is easier to treat the consequences of pulmonary edema from overhydration than to manage those related to volume depletion (ie, hypotension, stroke and renal failure).

6.2 Pain management

Acute pain control is another cornerstone of acute preoperative care for fragility fracture patients. Inadequate pain control is associated with increased adrenergic drive and myocardial oxygen demand and contributes to a number of complications including delirium, tachyarrhythmia and myocardial infarction.

Pain control is one of the reasons that early surgical fixation is associated with improved postoperative complications. In the preoperative phase, most published protocols use standard doses of intravenous opioids to achieve adequate pain control. Morphine sulfate, hydromorphone and oxycodone have all been shown to be effective and safe when used in adjusted doses for frail older adults. In addition, there is a growing body of literature on the safety and efficacy of blocks of the femoral nerve other local nerve blocks, particularly with ultrasound guidance [20]. Successful nerve blocks can produce faster time to analgesia and result in less opioid use for the duration of the block. Intravenous acetaminophen/paracetamol has not been well studied in this population, but is expected to be helpful as well, although its use may be limited by cost in many institutions. Techniques for pain assessment and management in older adults is more thoroughly covered in chapters 1.12 Pain management and 1.7 Postoperative medical management.

6.3 Medication management

One of the most nuanced areas in perioperative optimization includes the management of long-term medications in older adults. Each medication should be evaluated for its potential efficacy or harm in the acute fracture setting, and determine the risk of continuation, acute cessation or, in the case of some anticoagulants, reversal. This is optimally done by a medical physician with experience in perioperative care of older adults. Additional approaches are discussed in further detail in chapter 1.13 Polypharmacy.

6.3.1 Antihypertensive medications

The high risk of perioperative hypotension in the older fracture patient makes the routine continuation of long-term blood pressure medications particularly dangerous in this setting. With the exception of beta-blockers and clonidine, acute cessation of most other commonly used antihypertensive medications is not problematic.

6.3.2 Beta-blockers

Perioperative beta-blocker recommendations have undergone dramatic changes over the past 10 years, and the initiation of beta-blockers in patients prior to surgery is no longer recommended [21].

Patients taking long-term beta-blockers should have them continued in this setting, although dose attenuation may be required in patients with perioperative blood pressures in the low-normal range. Other medications used for long-term heart rate control, eg, diltiazem, verapamil, may also need to be continued.

6.3.3 Angiotensin-converting enzyme inhibitors and angiotensin-receptor blockers

Angiotensin-converting enzyme inhibitors (ACEIs) and angiotensin-receptor blockers (ARBs) are known to cause hypotension and acute kidney injury in the perioperative setting [22, 23], as well as contribute to acute kidney injury in hemodynamically unstable patients [24]. In the typical fragility fracture patient with increased risks for hypotension and acute renal failure, routine cessation of ACEIs/ARBs in the preoperative period is usually appropriate.

6.3.4 Statins

Both the ACC/AHA and the European Society of Cardiology guidelines support the continuation of statin therapy for patients already taking them. There is no evidence for the acute initiation of statin therapy in patients undergoing urgent nonvascular surgery.

6.3.5 Diuretics

In light of concern for intravascular volume depletion, all diuretics are typically held in the preoperative period.

6.3.6 Noncardiovascular medications

Oral diabetic medications typically should be held preoperatively to avoid clinically significant hypoglycemia in the perioperative phase. Patients using insulin will also need attenuation of long-term insulin doses; the use of frequent blood glucose monitoring and the use of short-acting insulin is the safest approach in the dynamic perioperative period. Patients receiving long-term psychiatric medications will often need these continued, although dose attenuation or temporary cessation in the event of excessive sedation or other side effects may need to be considered. Patients on long-term opioid or benzodiazepine therapy are at risk for withdrawal with abrupt cessation, and parenteral replacement may be necessary if patients are not able to take oral medications. Patients receiving long-term opiate therapy may need to have augmented doses of opiates to overcome tolerance and achieve effective pain relief. Overall, patients require routine monitoring for acute toxicity and complications of long-term medications in the perioperative setting.

6.3.7 Antithrombotic and anticoagulants

Management of anticoagulation in the perioperative setting is as much art as science, and the impact of the use or cessation of anticoagulant medication needs to be closely monitored until the patient has recovered. In the preoperative setting, almost all antithrombotic and anticoagulant medications should be held or reversed, depending on the attainment of adequate hemostasis and on the risk of thrombosis for particular indications [25]. This issue is more thoroughly covered in chapter 1.6 Anticoagulation in the perioperative setting.

7 Other preoperative issues

There are a number of common perioperative medical complications that impact postsurgical outcomes; many of these develop or require intervention in the postoperative period. Comanagement with a general medical service with experience with common geriatric syndromes is essential to optimal outcomes. Some of these issues emerge in the preoperative phase and are introduced here.

7.1 Delirium

Delirium is an acute, waxing and waning change in mental status marked by deficits in attention, and often complicated by agitation, lethargy or disorganized thinking [26]. It is common in hospitalized older adults, particularly in those with underlying cognitive disorders including dementia. Delirium can be provoked by underlying medical issues, which should always be sought. In the preoperative setting, uncontrolled pain should be strongly considered, particularly in patients with no other obvious cause. Initial attempts at management should include treating underlying clinical issues, optimizing pain control and attempting nonpharmacological supports like gentle reorientation, decreasing excessive stimulation, and restoring eyeglasses and hearing aids. For severe agitation or distress, low-dose haloperidol (0.5 mg intravenously or orally) can be administered safely in most patients. Delirium is not a contraindication to surgical fixation; fracture reduction and mobilization may be necessary to promote resolution.

7.2 Urinary retention

Urinary retention can be due to a number of contributing factors, including pain, delirium, and prostatic hypertrophy and is a common adverse effect of opioid medications. Bedside physical examination and ultrasonic bladder scan can assist with the diagnosis. Urinary catheterization carries risks such as infection, urinary tract bleeding and delirium, and should be used judiciously.

7.3 Polypharmacy

In light of the number of competing acute and chronic issues faced by older adults, polypharmacy and its effects can be viewed as a distinct clinical issue. Polypharmacy is defined as the use of six to nine medications at once and has been associated with a high likelihood of drug-drug interactions. Polypharmacy is associated with delirium, functional decline and poor surgical outcomes. In addition to avoiding poorly tolerated classes of medications like anticholinergic agents and benzodiazepines, careful reduction in the number and doses of other medications may be helpful in optimizing outcomes. See chapter 1.13 Polypharmacy for a more thorough discussion.

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1.5 Prognosis and goals of care

Joshua Uy

1 Introduction

For older adults, a hip fracture is often a life-altering event. Even after successful surgical repair, there remain significant consequences for life expectancy, impaired function, and diminished quality of life. Hip fracture outcomes vary widely, from full recovery to end-of-life decline. In addition, other fragility fractures of the spine, pelvis and ribs are also associated with similar prognostic implications, including high rates of 1-year mortality [1]. Incorporating patient-specific estimates of prognosis into routine practice can lead to better anticipation of complications, more realistic goals for rehabilitation, appropriate care of comorbidities, better patient and family communication and identification of palliative needs.

2 Prognostication of outcomes—general approaches

Outcome prognostication in the older adult can be very challenging, but useful estimates are possible. The literature offers many tools that can be used to adequately separate older adults who have a good estimated prognosis from those who are likely to do poorly in the immediate future. These tools range from complex calculators that incorporate 15–20 different health history and physical examination parameters to single items such as gait speed or grip strength. Generally speaking, prognostication in older adults is best achieved by routinely evaluating the three different patient factors age, comorbidities, and functional status.

2.1 Age

Age alone is a good but clinically insufficient predictor of life expectancy with consistent trends of decreasing life expectancy as a person ages [2]. A 65-year-old man in the United States will live an average of 18 more years compared to nearly 21 years for the typical 65-year-old woman. By age 85, life expectancy drops to 6.1 and 7.3 years for men and women in the US, respectively. Despite these general estimates, there is a wide distribution in the life expectancy at any given age [3]. For example, life expectancy for 85-year-old men can range as much as fourfold, from about 2 to 8 years. To further refine patient-specific estimates of life expectancy, it is important to also consider a patient's comorbidities and personal functional trajectory.

2.2 Comorbidities

As expected, patients with more comorbidities have lower life expectancies and experience more surgical complications. The Charlson Comorbidity Index (CCI) [4] is a well-known example of a pure comorbidity scale used for prognostication. The CCI assigns a weighted point value to a number of common diseases and can also be age-stratified by assigning a point for age for every decade after 40 (see **Table 1.5-1**).

Higher scores correlate with higher mortality. A hospitalized patient with a score of 0 will have a 1-year predicted mortality of 12%; patients with scores of 3–4 have a 1 year mortality of 52%, and scores greater than 5 predict an 85% 1-year mortality [4].

Charlson Comorbidity Index	Points assigned
Myocardial infarction	1
Congestive heart failure	1
Peripheral vascular disease	1
Cerebrovascular disease	1
Dementia	1
Chronic pulmonary disease	1
Connective tissue disease	1
Ulcer disease	1
Mild liver disease	1
Diabetes	1
Hemiplegia	2
Moderate or severe renal disease	2
Diabetes with end organ damage	2
Any tumor	2
Leukemia	2
Lymphoma	2
Moderate or severe liver disease	3
Metastatic solid tumor	6
AIDS	6

Table 1.5-1 Charlson Comorbidity Index scoring (without age score).

In hip fracture patients, a CCI is also an independent predictor of 30-day mortality; patients with a CCI > 6 are more than twice as likely to die during this time frame [5].

2.3 Functional status

It addition to age and comorbidity assessment, it has been increasingly recognized that function is an important independent prognostic indicator in older adults. Functional debility is a common pathway for any disease, as it increases in severity and is typically easy to assess. The most common geriatric functional scale is the Barthel Index of Activities of Daily Living [6], in which patients are assessed for independence in the following daily abilities: toileting, continence (bowel and bladder), transferring, mobility, stair use, feeding, grooming, bathing and dressing. Lower scores reflect increased dependency, which is also an independent predictor of mortality (**Table 1.5-2, Table 1.5-3**).

Functional assessment is most important in the oldest patients. Function correlates more closely with mortality than comorbidities for those older than 80 years, while for those younger than 70 years comorbidities are better at predicting mortality [9]. Other studies have used function to predict survival in cancer, heart failure, surgeries and dementia [10–14].

The most valid predictors of postsurgical outcomes come from comprehensive tools that incorporate elements of age, comorbidity and function. The best studied of these in the hip fracture population is the Nottingham Hip Fracture Score (NHFS), which assigns points for age, gender, number of comorbidities, cognitive impairment, anemia, institutionalization and malignancy [15]. Patients can be grouped as low risk (NHFS ≤ 4) or high risk (NHFS > 5) with differences in survival at 30 days (96.5% versus 86.3%) and 1 year (84.1% versus 54.5%) [16]. **Table 1.5-4** summarizes the NHFS scoring.

Despite the presence of procedure-specific outcome estimates, it is critical to recognize that individual older adults will have a wide range of responses to medical and surgical treatments. Assessing age, comorbidities and function allows for a more individualized assessment and care plan.

Without individualizing care based on prognosis and frailty, the clinician is at great risk for overtreatment of some patients, and undertreatment in others. Individualizing care based on patient-specific assessment allows for a treatment plan that is tolerable, purposeful, effective, and consistent with a patient's goals of care.

Activity	Scoring range (points) 0 = dependent
Toileting	0–2
Bowel continence	0–2
Bladder continence	0–2
Grooming	0–1
Feeding	0–2
Dressing	0–2
Transferring	0–3
Mobility	0–3
Stairs	0–2
Bathing	0–1

Table 1.5-2 Barthel Index of Activities of Daily Living [7].

Performance of ADL	Median life expectancy in years
No difficulty with ADLs	10.6
Able to do all ADLs with some difficulty and bathe and walk with a lot of difficulty	6.5
Able to toilet, dress and transfer with a lot of difficulty and unable to bathe or walk	5.1
Able to perform only one ADL, unable for all others	3.8
Complete dependency in ADLs	1.6

Table 1.5-3 Median life expectancy for community adults older than 70 years, based on the Barthel Index of Activities of Daily Living assessment [8].
Abbreviation: ADL, activity of daily living.

3 Functional prognosis for hip fracture patients

In addition to significant mortality associations, hip and other fragility fractures have specific prognostic implications for functional outcomes. Understanding these implications allows patients, families and care teams to have realistic expectations for the future, and to anticipate and prepare for upcoming needs.

Variable	Value	Points
Age, y	66–85	3
	> 86	4
Gender	Male	1
Admission hemoglobin	≤ 10 g/dL	1
Mini-mental test score	≤ 6 of 10	1
Living in an institution	Yes	1
Comorbidities	> 2	1
Malignancy	Yes	1

Table 1.5-4 Nottingham Hip Fracture Score.

3.1 Mortality

About 25% of older adults with hip fractures die within the year. Mortality rates are nearly 50% higher for men than women and more than double for those older than 85 years [17]. Other factors associated with higher 1-year mortality include cognitive impairment (91% higher), prefracture gait instability (up to seven times higher), and nursing home residence (75% higher).

3.2 Functional outcomes

Functional outcomes may be more important than mortality to patients and families. The recovery from a hip fracture takes months and postfracture dependence can develop in more areas than just ambulation. Most patients will require rehabilitation in a nursing facility (about 60%) or an acute rehabilitation facility (about 25%) after the hospital stay. A small minority will be discharged directly home (15%) [18].

Maximum recovery of cognition (ie, resolution of delirium), depression and upper extremity activities of daily living (ADLs) is most often seen at about 4 months. Maximum recovery of gait and balance will be seen at about 9 months. Maximum recovery of lower extremity ADLs, instrumental ADLs, and social function will be seen at 11 months [19].

Some functional loss will be permanent. For many hip fracture patients, achieving complete independence is not possible. Functions that are unlikely to recover include: ability to climb 5 steps (10% achieve recovery), getting in and out of a shower (17%), getting on and off the toilet (34%) and housekeeping (38%). Functions that are more likely to recover include putting on pants (80% achieve recovery), cooking (76%), using a telephone (78%), getting in and out of a bath (69%), walking 3 meters (~ 10 feet) (60%), and shopping (58%). The consequence of this slow functional recovery is that between 15% and 33% of patients with hip fractures will still be in a nursing home 1 year after their fracture [20].

The major predictor for the degree of functional recovery is the patient's prefracture level of function [21]. For example, for a patient without preexisting disability, nearly half will experience a rapid recovery (over approximately 3–6 months). On the other hand, for those with even mild prefracture disability the prognosis changes considerably; almost none are expected to recover rapidly, half will experience a gradual recovery (over approximately 6–9 months), and half will experience little or no recovery.

The trajectory and pace of prefracture functional decline can also be a big determinate for recovery. For example, among those with moderate disability, around 87% of those experiencing a prefracture progression of disability will have no recovery compared to only 14% of those with stable disability.

Together, all this information suggests that for most patients the year after a hip fracture is highly dynamic and challenging. Patients and families may have to contend with the likelihood of a slow recovery taking place over several different systems of healthcare, with intensive financial requirements, significant risks of mortality, rehospitalization and permanent loss of function, and the redefinition of family relationships to include difficult caregiving roles and the shifting of expectations. The healthcare team at each site of care, ie, hospital, acute rehabilitation, nursing home and home health, should play essential roles in educating and preparing families for these transitions.

4 Identifying goals of care

Hip fractures often occur within the wider context of frailty and functional decline. As described in chapter 1.11 Sarcopenia, malnutrition, frailty, and falls, frailty is a complex state where outcomes of standard medical and surgical treatments are less predictable and typically inferior to those seen in younger, more robust patients. In frailty, therapeutic windows between harms and benefits are often smaller or nonexistent, and achieving traditional disease-specific goals may lead to actual harms.

A medical example for this is using glucose-lowering medications to obtain glycosylated hemoglobin target less than 7 in patients with diabetes, a standard recommendation that is associated with harms in frail older adults. A surgical example is attempting a functionally unnecessary surgical fracture reduction and developing a postoperative deterioration of the kidney function necessitating dialysis.

4.1 Value-based decisions

Because frail patients have a more problematic response to standard therapy, patients and families often have to make value-based decisions, and prioritize amongst competing treatments and outcomes. These patient-specific values and priorities are referred to as goals of care. Defining these goals with each patient helps to clarify a clinically meaningful target for all medical care. For example, a hip fracture patient who lives alone and has a high fall risk may make a decision to prioritize safety and longevity over independence by moving in with one of their children. Another patient with similar function and fall risk may prioritize independence over safety and choose to live alone. Patients and families often choose to prioritize comfort, longevity or a chance for independence differently. These priorities should inform the medical and surgical treatment plans, so that the patient has the best chance of meeting his or her individual goals.

Goals of care are best assessed with open-ended questions [22] such as "What should we consider when making decisions about your care?" Assessing goals of care is a bedside clinical skill that develops over time. Learning to ask and learning to actively listen will help guide the older adult and their family through a potentially challenging life transition.

In the setting of a hip fracture, there are several specific issues related to goals of care, including resuscitation status, acceptable functional outcomes, and willingness to endure treatment plans.

4.2 Resuscitation

Formal ascertainment and documentation of resuscitation wishes (ie, code status) are appropriately required in most healthcare systems. A hip fracture is a good time to verify patients' expectations and wishes about cardiopulmonary resuscitation (CPR). Here too, clinicians should have some general information about the effectiveness of CPR in this population.

The efficacy of resuscitation is significantly limited in older adults and particularly in those with frailty or functional impairment. Postcardiopulmonary resuscitation survival to hospital discharge in previously independent older adults is estimated at 13–18% with lower rates of survival in those with dependency. As many as 30% of survivors of CPR are left with new neurological impairments [23, 24]. In light of the low likelihood of independent survival, many patients may opt to forgo any attempts at resuscitation.

Resuscitation in the operating room or anesthesia areas is expected to be more successful than elsewhere in the hospital, and patients may elect to suspend "Do Not Resuscitate" during the surgical and immediate postoperative period.

The American College of Surgeons [25] supports exploring a person's goals and limits in the context of the operating room, as patients likely have different desires for attempts at resuscitation in this situation. Some tools used in resuscitation such as intubation, for instance, are already a part of surgery and may not be uniquely burdensome. Others like chest compressions or electrical cardioversion likely carry a greater potential burden and worse prognosis. No single model or protocol is appropriate for all older adults undergoing hip repair, and shared decision making between the surgeon and patient is necessary. Some recommendations for phrasing resuscitation status discussions are listed in **Table 1.5-5**.

4.3 Other limits of care

In addition to resuscitation, older adults may wish to place other limits on the intensity of hospital or posthospital care, to place limits on a range of interventions while they are still alive. For some patients this may mean a firm desire to avoid intensive care unit admissions, for others it may mean allowing the surgeon to operate on them as many times as it takes to have the best possible outcome. In any case, the care team should not assume that patients are willing to undergo management of any and every complication that may develop after a surgery, a concept known as surgical buy-in [27].

Discussing resuscitation status	
Introduction questions:	
• Do you have an advance directive or a living will? • I would like to ask you a question that some patients may find difficult or other do not have the answer to.	Sometimes patients have already made decisions and documented them. Simply asking is an easy way to start. For other patients, asking permission to talk about code status decreases the pressure already inherent in the question and allows the discussion to be more collaborative.
How to ask about code status:	
• If you were to die unexpectedly, would you want us to attempt to bring you back to life?	Emphasizes that a code status is only relevant when someone has actually died and that there is no guarantee of success.
• Do you want us to allow a natural death?	While not as relevant for a surgical code status, this can prompt a person to think about what is natural to them.
Phrasing to avoid:	
• Do you want us to do everything?	This is biased toward an affirmative answer, is very vague, and focuses on the intervention instead of the goal.
• Do you want to be resuscitated?	The setting is unclear (that the person is dead) and can mean everything from intravenous fluids to CPR.
• If your heart stops, do you want us to restart it? If you stop breathing, do you want to be on a breathing machine?	Focusing on an organ distracts from the big picture that the person has died. Asking if someone wants their heart restarted makes it sound simple and easily successful. Asking if they want to be on a breathing machine can apply while they are alive apart from a code status.

Table 1.5-5 Suggestions for framing discussions about cardiopulmonary resuscitation [26].
Abbreviation: CPR, cardiopulmonary resuscitation.

When older adults undergo an urgent surgery, the decision about how to manage future potential complications may not yet have been made. It is important to routinely reassess goals after an urgent surgery to prevent the potentially faulty assumption of surgical buy-in [28].

Regularly assessing limits on care is important because what a person is willing to undergo may depend on the likelihood of a patient-defined successful outcome.

5 Managing multimorbidity in frail patients

Finally, in addition to coming to decisions on CPR and other potential limits on interventions, the hip fracture admission is an appropriate time for the medical team to reevaluate a person's entire medical treatment plan to align with the patient's goals of care, as elicited from the patient or their surrogate decision makers. After a hip fracture, two things can change:

- Quality of life goals may take priority over continued compliance with standard therapies
- Long-term disease-specific treatment benefits may become irrelevant due to shortening overall life expectancy.

The anticipated benefits of many chronic disease therapies like in hypertension, hyperlipidemia, diabetes mellitus or coronary artery disease are typically small or nonexistent during the last years of life and can easily be overwhelmed by the harms of treatment with polypharmacy, multiple consultations and diagnostic tests as well as medicalization of life. A suggested framework for evaluating chronic disease therapies in the frail older adult is outlined in the following list:

1. Is the intervention known to be effective in older adults?
2. Is it expected to produce a patient-desired clinical end point?
3. Is the patient expected to live long enough to benefit from the therapy?
4. What is the chance of achieving the anticipated benefit of the intervention?
5. What are the potential harms of treatment (ie, adverse effects, costs, healthcare encounters, need for monitoring)?
6. Is the intervention likely to achieve the patient's goal?
7. Is it a priority among the patient's other medical problems?
8. Is there a cultural or spiritual belief that needs to be considered?

Compared to disease-specific therapies, the most efficacious approaches to multimorbidity are poorly understood. While there are guidelines to help set priorities in medically complex and frail patients [29], managing multimorbidity is often more of an art than a science. The challenge of multimorbidity is that sometimes treating one disease can cause another disease to get worse. For example, using nonsteroidal antiinflammatory drugs for osteoarthritis can worsen heartburn or congestive heart failure. While a full discussion of balancing risks and harms of medical treatments is beyond the scope of this article, an approach to prioritization of competing issues is offered in **Table 1.5-6**. As one moves up the prioritization framework from primary prevention to active symptoms, the medical problems become a bigger threat to health and mortality. It is worth focusing on lower priority issues only if the higher priority issues are resolved. For example, there is no justification for tight control of diabetes (priority 3) if the older adult is suffering from recurrent falls (priority 2). In this sense, it may be wise to reduce the intensity of diabetes treatment by minimizing medications. Lower priority items also typically have a longer time frame to clinical benefit than higher priority items. Last, the overarching priority is to individualize a plan that is consistent with the patient's own goals and values.

5.1 Hospice

Hospice plays an important role for patients with hip fractures, both for patients who suffer hip fractures while already receiving hospice therapy, and for the many for whom the hip fracture is either a cause or consequence of an end-of-life decline. For patients near the end of life, pain control is of utmost importance. For patients with a life expectancy of weeks to months, hip fracture repair often offers the best chance at pain control, particularly for patients who are trying to minimize the sedation associated with high doses

Priority	Category	Clinical examples
Highest	Active symptoms/acute medical illness	Pain, dyspnea, nausea Hip fracture, pneumonia, CHF exacerbation
	Syndromes affecting quality of life	Falls, weight loss, cognitive decline, functional decline, polypharmacy
	Secondary prevention of chronic disease complications	CHF, COPD, DM, HTN, osteoporosis
Lowest	Primary prevention of chronic disease	Cancer screening, dietary restrictions

Table 1.5-6 Prioritization framework for multimorbid patients
Abbreviations: CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; HTN, hypertension.

of opiates and other medications. It is not uncommon for some hip fracture patients to transition during the postsurgical period to hospice care, particularly if persistent delirium or dysphagia complicate the postoperative period. In order to counter a sense among clinicians and families that hospice and withdrawal of ongoing medical care is not appropriate following a successful surgical fixation, an explicit time-limited trial for recovery can be useful to negotiate a more humane and realistic treatment plan in patients with poor prognosis [28].

As palliative concepts in surgery begin to mesh more and more with palliative concepts in medicine, it is clear that even for hospice patients and patients heading toward hospice, surgery still has an important palliative, noncurative role [30].

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1.6 Anticoagulation in the perioperative setting

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1 Introduction

The common presence of anticoagulant and antiplatelet agents in fragility fracture patients (FFPs) presents unique challenges in the perioperative period. Management decisions typically involve balancing short-term bleeding and thrombosis risks and considering the use of bridging anticoagulant therapy. Delaying surgery to manage the effects of these medications can increase the likelihood of adverse events, such as delirium, pneumonia, pressure ulceration, and mortality [1–3]. In the immediate perioperative period, the risks of bleeding often outweigh the risks of thrombosis for most older adults.

Standards of care and published guidelines in this area vary widely throughout the world. This chapter reflects the principles for anticoagulation management in the perioperative period, with specific recommendations based on current US and European approaches. Consultation with local guidelines may be necessary to align practice with other national or regional standards.

2 Perioperative anticoagulant management

2.1 General approach

There are four considerations in the management of antithrombotic agents in the perioperative period [4]:

1. The short-term risk of acute thromboembolism if the anticoagulation/antiplatelet agent is discontinued
2. The risk of major bleeding from the procedure if the anticoagulation/antiplatelet agent is continued
3. The effectiveness, availability and safety of reversal agents (eg, plasma and vitamin K)
4. The overall need to minimize surgical delay and maximize mobility

Additionally, part of the preoperative assessment should include the procedure-specific bleeding risk, and the anticipated consequences of bleeding if anticoagulants are resumed during this time. For example, percutaneous screw fixation has a much lower risk of bleeding than that of hip arthroplasty, and the harm of continuation or early resumption of long-term anticoagulation is presumed to be lower than for patients treated with arthroplasty or implant fixation [5].

2.2 Anticoagulants and antiplatelet agents

Both anticoagulants and antiplatelet agents interfere with thrombus formation. Anticoagulant medications (eg, warfarin, heparin, apixaban, dabigatran, and rivaroxaban) interfere with the coagulation cascade and clotting factors, while antiplatelet agents (eg, aspirin, and clopidogrel) target platelets. While all of these agents can contribute to clinically significant blood loss, anticoagulants are generally more potent at preventing venous, arterial or intracardiac thrombosis, and are also more likely to cause serious postoperative bleeding. Specific indications and issues are detailed below. **Figure 1.6-1** shows the mechanism of action of some of these agents.

2.3 Reasons for use

In order to assess the risk of short-term cessation of anticoagulant or antiplatelet medications, it is important to determine the a priori indication for their use.

Older adults are often anticoagulated for various medical conditions including atrial fibrillation (AF), venous thromboembolism (VTE) (eg, hypercoagulable states, deep vein thrombosis [DVT], pulmonary embolism [PE]), and prosthetic heart valves, each of these indications having a different short-term risk of thrombosis during the perioperative period.

2.4 Thrombotic risk assessment by indication

After confirming the indication for anticoagulation, it is important to determine the short-term risk of thrombosis when stopping an anticoagulant. Note that the risk of thromboembolism for these indications is typically reported as an annual risk; for most patients the short-term risk during a typical perioperative period is assumed to be much lower.

2.4.1 Atrial fibrillation

The most common indication for anticoagulant use in the older adult population is for prevention of thromboembolic strokes in nonvalvular AF.

The risk of thromboembolism varies and can be estimated by the $CHADS_2$ and the enhanced CHA_2DS_2-VASC scores [6, 7]. The relevant criteria and associated risk of stroke are shown in **Table 1.6-1** and **Table 1.6-2**.

2.4.2 Venous thromboembolism

In those with venous thromboembolism, the risk of recurrent thrombosis, thrombus propagation, and embolization is greatest in the first 3 months after the diagnosis and initiation of therapy [8]. This risk also varies depending on whether the VTE was provoked, unprovoked, or resolved.

2.4.3 Mechanical heart valves

Patients with mechanical heart valves are at significantly increased long-term risk for embolic stroke. The risk varies by the type, number, and location of prosthetic valve and associated medical conditions (**Table 1.6-3**) [9].

	Risk factor	Point value	Total score	Annual stroke risk, %
C	Congestive heart failure	1	0	1.9
H	Hypertension—blood pressure consistently above 140/90 mm Hg (or treated hypertension on medication)	1	1	2.8
A	Age ≥ 75 years	1	2	4
D	Diabetes mellitus	1	3	5.9
S2	Prior stroke or TIA or thromboembolism	2	4	8.5
			5	12.5
			6	18.2

Table 1.6-1 The $CHADS_2$ can be used to estimate the risk of thromboembolism.
Abbreviation: TIA, transient cerebral ischemia attack.

	Risk factor	Point value	CHA_2DS_2-VASC total score	Stroke risk, % per year
C	Congestive heart failure (or left ventricular systolic dysfunction)	1	0	0
H	Hypertension—blood pressure consistently above 140/90 mm Hg (or treated hypertension on medication)	1	1	1.3
A	Age: ≥ 75 years	2	2	2.2
D	Diabetes mellitus	1	3	3.2
S2	Prior stroke or TIA or thromboembolic event	2	4	4
V	Vascular disease (eg, peripheral artery disease, myocardial infarction, aortic plaque)	1	5	6.7
A	Age: 65–74 years	1	6	9.8
Sc	Female gender	1	7	9.6
			8	12.5
			9	15.2

Table 1.6-2 CHA_2DS_2-VASC score and stroke risk to estimate the risk of thromboembolism.
Abbreviation: TIA, transient cerebral ischemia attack.

Risk category	Mechanical heart valve	Atrial fibrillation	Venous thromboembolism
High • > 10%/year risk of ATE OR • > 10%/month risk of VTE	• Any mechanical mitral valve • Older aortic valve • Recent (< 6 months) stroke or TIA	• $CHADS_2$ score of 5 or 6 • Recent (< 3 months) stroke or TIA • Rheumatic valvular heart disease	• Recent (< 3 months) VTE • Severe thrombophilia
Moderate • 4–10%/year risk of ATE OR • 4–10%/month risk of VTE	Bileaflet aortic valve and one of the following: • Atrial fibrillation • Prior stroke/TIA • Hypertension • Diabetes • Heart failure • Age > 75 years	• $CHADS_2$ score of 3 or 4	• VTE within past 3–12 months • Recurrent VTE • Nonsevere thrombophilic conditions • Active cancer
Low • < 4%/year risk of ATE OR • < 2%/month risk of VTE	• Bileaflet aortic valve without atrial fibrillation and no other risk factors for stroke	• $CHADS_2$ score of 0–2 (and no prior stroke or TIA)	• Single VTE within past 12 months AND • No other risk factors

Table 1.6-3 American College of Chest Physicians (ACCP) suggested risk stratification for perioperative thromboembolism.
Reproduced from Douketis et al [10] with permission of the ACCP.
Abbreviations: ACCP, American College of Chest Physicians; ATE, arterial thromboembolism; TIA, transient cerebral ischemic attack; VTE, venous thromboembolism.

2.5 Bleeding risk assessment

Older adults are prone to bleeding in general and many adults at relatively high risk for thrombosis also have an elevated risk for bleeding. Cardiovascular aging, comorbidity and some medications can result in friable blood vessels and prolonged postoperative bleeding after orthopedic surgery. In addition to procedure-specific risk estimates, there are different prediction tools to evaluate bleeding risk in individual patients [11–13]. The HAS-BLED score [12] evaluates 1-year risk of major bleeding (defined as intracranial bleeding, bleeding requiring hospitalization, hemoglobin decrease > 2 g/L, and/or transfusion) in patients with AF (see **Table 1.6-4**). There are no well-validated predictors for short-term bleeding risks, but the risk factors in the HAS-BLED tool are likely relevant in the perioperative setting as well.

2.6 Management of long-term anticoagulation in preparation for surgery

Most hip fracture surgery is considered urgent and requires reversal of anticoagulation within 24–48 hours. Approaches to preparing patients for safe fracture fixation vary by agent.

2.7 Warfarin

Warfarin anticoagulation results in a prolonged international normalized ratio (INR). For hip fracture repair, the INR should be reduced to a subtherapeutic threshold; most experts recommend achieving an INR of ≤ 1.5 prior to surgery [14–16].

An elevated INR prior to surgery increases the risk of intraoperative bleeding and associated complications like spinal or epidural catheter bleeding as well as wound hematoma, infection, and possible need for reoperation [17].

There are multiple options to reverse warfarin:

- Oral and intravenous (IV) vitamin K have been shown to have equivalent efficacies in reducing INR values over a 24-hour period. Oral vitamin K has been shown to be more effective than subcutaneous dosing when lowering an elevated INR value, and is typically used in doses ranging from 2.5 to 10 mg [18]. While the optimal dose of vitamin K to lower INR values is unclear, the use of 3 mg intravenously has been shown to be safe and effective in one study [19, 20]. The use of oral vitamin K over IV vitamin K is advantageous as it avoids the risk of fatal anaphylaxis, which has been reported previously with older preparations [21]. Subcutaneous and intramuscular vitamin K administration is associated with unpredictable absorption and should be avoided.
- Fresh frozen plasma is an alternative and/or adjunct to vitamin K to correct coagulopathy [22]. This is human plasma that contains many plasma proteins including coagulation factors. One proposed formula to obtain an INR of less than 1.5 recommends:
  - 1 unit for an INR of 1.5–1.9
  - 2 units for an INR of 2.0–3.0
  - 3 units for an INR of 3.0–4.0
  - 4 units for an INR of 4.0–8.0
  - More than 4 units for an INR of more than 8.0 [23]

  Each unit of plasma has a volume of 190–240 mL. The challenges with plasma include its short duration of action (ie, 4–6 hours) and risks including adverse transfusion effects (eg, infection, acute lung injury) and volume overload and the associated risk of congestive heart failure.

	Risk factor	Point value	HAS-BLED total score	Bleeds per 100-patient years
H	Hypertension (systolic blood pressure > 160 mm Hg)	1	0	1.13
A	• Abnormal renal function (long-term dialysis, renal transplant, serum creatinine > 2.4 mg/dL) • Hepatic function (chronic hepatitis, bilirubin > 2× upper normal with liver enzymes > 3× upper normal)	1 1	1	1.02
S	History of stroke	1	2	1.88
B	Bleeding (ie, major bleeding history)	1	3	3.74
L	Labile INRs (ie, therapeutic range < 60% of time)	1	4	8.7
E	Elderly (≥ 65 years old)	1	5	12.5
D	• Drugs (concomitant antiplatelet, NSAIDs) • Alcohol consumption > 8 drinks/week	1 (each)	> 5	Insufficient data

Table 1.6-4 HAS-BLED score to evaluate 1-year risk of major bleeding.
Abbreviations: INR, international normalized ratio; NSAID, nonsteroidal antiinflammatory drug.