This article offers a German perspective on orthopaedic management of geriatric populations in higher-income countries.

Specific orthopaedic procedures necessitate a more intensive level of care in older adult patients, especially with co-morbidities, than in younger patients.

During the pre-, peri- and post-operative periods, several aspects such as patient blood management principles improve the outcomes of geriatric patients.

New interdisciplinary geriatric models of care including geriatric and orthopaedic specialties have to be established to take care of the special needs of geriatric patients.

Keywords: geriatric; peri-operative

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Specifics of geriatric populations

‘Getting older by itself is not a disease that has to be treated, but a social challenge that can and must be counteracted by modern, senior-specific forms of care in modern medicine in Germany.’ (F. Müntefering, Vice-Chancellor Germany 2005–2007)

At the end of 2014, there were approximately 81.2 million people living in Germany, 22.2 million were aged > 60 years. Between 1990 and 2014, the number of people in Germany aged 65 years and over rose by approximately 5.2 million to 17.1 million representing an increase of 43%. At the same time, the total population grew by only 1.8%. In 2014, just over 4.5 million people in Germany were at least 80 years old. Their number will continue to grow in the coming decades and will reach approximately 9.9 million in 2050. This corresponds to a population share of 13% (Fig. 1).

Increased health problems in old age mean that older people undergo in-patient treatment in hospitals more often than younger people. In 2014, around 19.6 million people in Germany were discharged from full in-patient hospital treatment. 43% of all in-patients were aged 65 and over.1–2 For people aged 65 years and over, diseases of the circulatory system were the main reason for a hospital stay in 2014. The second most common reasons for hospital stays were injuries and poisoning, followed by diseases of the musculoskeletal system, such as arthritis.

In 2014, a total of approximately 6.8 million operations were performed on people aged 65 years and over. Of these operations, 27% involved the musculoskeletal system. Particularly common procedures were joint replacements, especially hip replacements, treatment for fractures and skin and spinal operations. Furthermore, there exist challenging problems in treating older people due to the fact that nearly every organ-system is potentially affected with morphological and physiological changes, thus affecting any other conservative or operative treatment.2–3

The skin is also affected by aging, with a decreased vascularization and a reduction in elasticity so that there is an increased incidence of pressure sores.2–3 In geriatric individuals it can be expected that short-term memory will be impaired because of modified cognition, leading to a slowing down of rehabilitation. Therefore, a programme of individual physical activity and rehabilitation should be planned, keeping in mind the patient’s overall health status.4

Considering all these aspects, it is essential to develop specific concepts with regard to the special needs and capabilities of geriatric people. With regard to specific orthopaedic procedures, older adult patients, especially with co-morbidities, need a more intensive level of care than younger patients during the pre- peri- and post-operative periods.2–4

Pre-operative management

In the pre-operative period the patient’s goals and treatment preferences should be analysed and documented. Fasting recommendations should be followed, prophylactic
medications should be given, and medications lists should be reviewed for non-essential and inappropriate medications.

**Patient goals, preferences, and advance directives**

In a 2010 study, nearly half of patients over the age of 60 years required decisions about treatment in their final days of life. Although 70% of these patients lacked decision-making capacity, 68% of them had advanced directives, and the majority received care in accordance with their wishes. This fact underlines the importance of having such information documented. Therefore personal goals and treatment preferences should be addressed in the outpatient setting prior to surgery.

**Patient blood management pre-operatively**

Peri-operative anaemia and the need for allogeneic blood transfusion are related to increased morbidity. Patient blood management (PBM) is an evidence-based process to optimize the care of patients who might need transfusion. The focus is to improve patient safety and clinical outcomes by reducing the need for unnecessary allogeneic blood components. The management of pre-operative patients includes maximizing haemoglobin levels to prevent anaemia and optimizing coagulation function to limit bleeding. To reduce peri-operative allogeneic blood transfusion, keeping the pre-operative haemoglobin level above 12.0 g/dL is recommended in orthopaedic patients.

Especially in patients undergoing total knee or hip arthroplasty and hip fracture surgery, pre-operative anaemia is common, ranging from 24.9% to 44.9%, respectively. Therefore, peri-operative blood transfusions are common in total hip arthroplasty because of pre-operative anaemia and peri-operative blood loss. In addition, post-operative anaemia was found to be quite common amongst those patients (51.0% and 87.1%, respectively).

Various studies have shown that peri-operative anaemia was associated with a blood transfusion rate of

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**Figure 1** Percentage of the population aged 65 years and over on 1 January 2015.
25–44%, post-operative infections, reduced physical recovery, and increased length of hospital stay and mortality. Treatment options for pre-operative anaemia are possible with iron, with or without erythropoietin, and may contribute to improved patient outcomes.6–7

Peri-prosthetic joint infection (PJI) is one of the most common and challenging complications of joint arthroplasty, especially in cases of revision surgery. It has been well documented that pre-operative anaemia and increased transfusion rates were independently associated with an increased risk of post-operative infections. A study of PJI reported that in 9,245 patients who underwent total knee arthroplasty (TKA) or total hip arthroplasty (THA), the quantity of allogeneic blood that was transfused was an independent predictor of PJI after primary joint arthroplasty.6–7

In Orthopaedic surgery, haematological evaluation and treatment for anaemia is recommended 3–4 weeks before the index surgery, thus allowing time for the treatment of anaemia before operation. If a screening blood test detects anaemia, evaluation should begin with an assessment of iron status. Moreover, serum iron, transferrin, and ferritin levels should also be evaluated.6–7 In the presence of confirmed iron deficiency anaemia, iron supplementation is indicated. The use of erythropoietin-stimulating agent (ESA) therapy in patients undergoing major, elective surgery is well established on the basis of randomized controlled trials. A meta-analysis of ESA therapy augmented with pre-operative autologous blood donation (PABD), demonstrated a significant benefit for both: recombinant human erythropoietin (rHuEPO) alone (relative risk [RR], 0.44; 95% confidence interval [CI], 0.31–0.64) and rHuEPO augmented with PABD (RR, 0.61; 95% CI, 0.49–0.75). If EPO is administered with oral or intravenous iron, this effect is increased.6–7

**Pre-operative fasting**

Pre-operative fasting is defined as a prescribed period of time during which patients are not allowed the oral intake of liquids or solids. A recent review demonstrated there was not a significant association between a shortened (two to three hours) clear fluid fast (versus milk or juice with pulp) and subsequent post-operative complications, including delirium.8

The American Society of Anaesthesiologists 2011 presented guidelines on pre-operative fasting in which they recommend that adults undergoing non-emergency surgical procedures should fast from the intake of clear liquids for at least two hours before elective procedures requiring general anaesthesia, regional anaesthesia, or sedation/analgesia. Examples of clear liquids include water, fruit juices without pulp, carbonated beverages, clear tea, and black coffee.5

**Antibiotic prophylaxis**

The relationship between appropriately dosed pre-operative antibiotics and reduced risk of surgical site infections (SSIs) is well-established. Studies have also suggested a mortality benefit at 60 days for older patients who receive pre-operative antibiotics within at least two hours of incision. Older patients may have compromised renal function and, as such, may require particular attention to dose.

There exist several practical guidelines such as the guideline published by the Society for Healthcare Epidemiology of America/Surgical Infection Society/American Society of Health-System Pharmacists/Infectious Diseases Society of America that recommend that pre-operative antibiotics should be given based on procedure, risk factors, and the hospital’s unique pathogen profile within 60 minutes before surgical incision.9

**Venous thromboembolism prophylaxis**

Older age confers additional risk for venous thromboembolism (VTE). It is important that older adult patients undergo VTE risk stratification.5 The most recent American College of Chest Physicians (ACCP) Guideline and ACS NSQIP Best Practices Guideline for the Prevention and Treatment of Venous Thromboembolism provide comprehensive direction.5 Older adult patients should be stratified for VTE and bleeding risk with a structured approach, based on available methods and local institutional norms, and a plan, including dosage and duration, should be determined based on the patient’s risk profile.10

**Medication management**

Several studies have shown that polypharmacy is a common problem in older adults. Nearly 50% of older adults take one or more medications that are not medically necessary or prescribed. Research has clearly established a strong relationship between polypharmacy and negative clinical consequences especially in the case of surgical interventions. Studies have shown that on an average 2–9 medications per day are taken by elderly people. The prevalence of inappropriate medication used by the elderly people was found to be from 11.5–62.5%11.

The probability of a drug–drug interaction increased with the number of medications; e.g. a patient who takes 5–9 medications had a 50% probability of a drug–drug interaction. In cases of frail elderly patients research has reported the prevalence of drug–disease interactions to be 15–40%. In a case-control study carried out among old-aged people, polypharmacy was found to be an independent risk factor for hip fractures.11

Non-essential medications should be stopped in the days leading up to surgery. Medications with withdrawal potential or that are medically indicated during the
peri-operative period (for example, cardiac medications) should be continued.11

**Intra-operative management**

Most intra-operative changes in physiological parameters have minimal impact on long-term outcomes, though they have potential to result in harm for certain patients or in certain contexts. Aging is associated with numerous physiological changes that affect pharmacokinetics and are important to consider during the intra-operative period. In addition, many intra-operative considerations that are important for any patient population are particularly important in the elderly, owing to their decreased ability to compensate for physiological stress.

**Reduce intra-operative blood loss**

There is a need to reduce the estimated intra- and post-operative blood loss. Before surgery the medical team must investigate the bleeding tendency of a patient, whether there is a medical history or relevant medication (e.g. Haemophilia, warfarin therapy). A minimally invasive surgical technique if possible, use of a pneumatic tourniquet, hypotensive anaesthesia, adequate positioning of the patient and stabilizing the patient’s body temperature during surgery have all been reported to contribute significantly to minimizing blood loss. By keeping the patient’s body temperature at normal levels, the blood loss is reduced by approximately 20–25%, but improved wound healing has also been reported.6–7

As a lysine analogue, tranexamic acid suppresses fibrinolytic activity by competitively inhibiting the binding of plasminogen and plasmin to fibrin. By blocking access to the fibrin template, this substantially decreases the kinetic rate of plasmin formation as well as the plasmin-mediated degradation of fibrin and fibrinogen.6–7

International research has shown that patients treated with intravenous tranexamic acid were less likely to require allogeneic blood transfusion than those treated with placebo; furthermore, tranexamic acid reduces the total amount of blood loss and the total number of units of allogeneic blood transfused.6–7

A study evaluating the efficacy of topical tranexamic acid in THA showed that the final reduction in Hb and haematocrit in the tranexamic acid group was less than that in the control group (P = 0.01). In addition, the blood transfusion rate was lower in the tranexamic acid group (17%) than that in the control group (35%) (P < 0.001).6–7

There are still concerns with regard to the increased risk of thromboembolic events with the use of tranexamic acid. Tranexamic acid does not increase the risk of thromboembolic complications such as deep vein thrombosis (DVT), pulmonary embolism, thrombotic cerebral vascular accident, or myocardial infarction.7

In cases where intravenous injection is used, it is recommended that 10–20 mg/kg is given 30 minutes before surgery or before tourniquet deflation, and that an additional 10–15 mg/kg is given every eight hours for 24 hours or every 24 hours for three days.12 In the case of oral administration, 1 g is given before surgery and 1 g is given every six hours for 18 hours after surgery.

With topical administration, an intra-operative or post-operative intra-articular injection should be given using 1 to 3 g tranexamic acid in 100 mL normal saline. It is thought that a decision is based on the patient’s condition and each surgeon’s preferences. Moreover, it is important to consider the patient’s underlying disease, such as liver cirrhosis, chronic kidney disease, or previous cerebrovascular accident.6–7

Intra-operative blood salvage is indicated especially if any massive bleeding is expected during surgery. Thus, intra-operative cell salvage is useful for complex Orthopaedic procedures such as revision arthroplasty. Anticipated blood loss of more than 1,000 mL, advanced age (P = 0.03), higher body mass index (P = 0.01), revision requiring exchange of both the femoral and acetabular components (P < 0.01), and revision procedures with a trochanteric osteotomy (P < 0.02) were all associated with successful post-operative infusion by intra-operative blood salvage.13

**Anaesthesia in the older adult**

Anaesthetic medications have broad physiological effects, potentially causing changes in systemic vascular resistance, cardiac pre-load, lung mechanics and oxygen diffusion, neurotransmitter function, and blood flow to end-organs. In this context, many of the effects of anaesthetic agents can be exaggerated, and adjustments to medication dosages may be required in older adults.6

**Regional vs general anaesthesia in older adults**

Although a recent Cochrane review suggests there may be benefits to selecting regional instead of general anaesthesia as a primary anaesthetic modality in certain patient groups, this issue remains controversial due to the quality of the studies and the lack of consideration of the risks of neuraxial blockade in many of the studies. Some observational studies have noted that regional anaesthesia was associated with better outcome than general anaesthesia, but other studies did not.5,7,14

A large database analysis of 18,158 patients observed that regional anaesthesia was associated with a lower inhospital mortality (odds ratio, 0.71; 95% CI, 0.54–0.93) and a lower incidence of pulmonary complications (odds ratio, 0.75; 95% CI, 0.64–0.89) but confounding bias cannot be ruled out.14 In a large observational study in the United States, the lack of benefit on mortality rate has been recently confirmed. In fact there is no reason to favour regional
versus general anaesthesia in these patients; if there exists a difference, it is probably small. However, regional anaesthesia is contra-indicated in a significant proportion of patients treated with platelet antiaggregant (clopidogrel, prasugrel, ticagrelor, and ticlopidine) or anticoagulant. Contra-indication is only relative with aspirin.

Peri-operative analgesia in the older adult

There are numerous techniques and approaches to analgesia, including intravenous opioids, oral opioids, non-opioid analgesics, regional techniques (such as neuraxial blockade and peripheral nerve blocks), and alternative methods (for example, acupuncture, music therapy, massage, cryotherapy).

Older adults (> 65 years) in particular are sensitive to opioid analgesics, and use of medications beyond the minimum doses needed to achieve adequate analgesia should be avoided. Opioids can lead to complications such as cognitive dysfunction or delirium; in addition, older adults are at higher risk for haemodynamic and respiratory impairment associated with opioid analgesics. Common analgesics and anxiolytics to avoid include barbiturates, benzodiazepines, non-benzodiazepine hypnotics (eszopiclone, zolpidem, zaleplon), pentazocine, skeletal muscle relaxants (carisoprodol, chlorzoxazone, metaxalone, methocarbamol, orphenadrine), non-COX NSAIDs.

When added to general anaesthesia and compared with systemic opioid-based pain relief, regional techniques in select patients can reduce pain, sedation frequency, duration of tracheal intubation and mechanical ventilation, time to return of gastrointestinal function, risk of peri-operative myocardial infarction, and overall risk of peri-operative cardiovascular complications. Peripheral nerve blocks can be useful in many older adult patients, particularly those undergoing orthopaedic procedures, though there is controversy over the relative benefit of a single injection versus continuous nerve block.

Patient safety

Patient safety is important especially with regard to older adults. In cases of skin atrophy and decreased skin integrity, the risk of peripheral nerve damage and pressure injuries from malpositioning is increased. A national study found the prevalence of intra-operative skin ulceration to be 8.5%. Therefore, the health care team should ensure proper positioning and padding of bony prominences of elderly patients undergoing surgery to maintain skin integrity and limit pressure on peripheral nerves.

Post-operative management

During the post-operative phase, early mobilization, requiring early weight-bearing, is one of the main objectives. This affects the treatment options in the geriatric population. In cases with a hip fracture, arthroplasty is usually recommended in the geriatric population because it enables early weight-bearing and provides better surgical results, although new osteosynthetic techniques provide encouraging results.

In patients with cognitive disorders, most authors recommend arthroplasty, particularly cemented arthroplasty. In a large cohort (n = 4,335), the one-year incidence of repeat surgery was 23% after osteosynthesis versus 3% after arthroplasty, and pain was greater and patient satisfaction lower in the osteosynthesis group.

Post-operative patient blood management

In cases with low post-operative Hb level, restrictive transfusion trigger is another important target to reduce the transfusion rate. Allogeneic blood transfusion is not necessary if the Hb is > 8.0 g/dL in the absence of symptoms attributable to tissue oxygen deficit or continuing bleeding. Low Hb transfusion triggers, such as < 7.0 g/dL in general surgical patients and < 8.0 g/dL in elderly high-risk patients, are well tolerated with adequate fluid management. Therefore, careful monitoring of a patient’s physical condition is essential, including pulse rate, blood pressure, and the presence of dyspnoea.

Post-operative delirium

Delirium is perhaps the most significant age-related post-operative complication. It is characterized by an acute decline in cognitive function and attention, with evidence from the history that this is due to physiological derangement, a medication, or multi-factorial causes. Importantly, delirium is distinct from chronic cognitive decline and dementia. The diagnosis of dementia in the pre-operative period is important for risk stratification and for its implications in diagnosing delirium post-operatively.

In the geriatric patient population, the prevalence of post-operative delirium ranges from 9–44%, with the highest rates observed after high-risk procedures, such as revision arthroplasty surgery, vascular surgery, and hip fracture surgery. Delirium is associated with worse surgical outcomes, longer hospital length of stay, functional decline, higher rates of institutionalization, higher mortality, and higher costs and resource utilization.

As many as 30–40% of cases of delirium are preventable. It is important to recognize the distinct but highly interrelated concepts of baseline delirium risk factors and precipitating factors, which contribute cumulatively to the development of delirium. During the post-operative period, surgery acts as a physiological stress, the intensity of which is determined by the extent of the operation.

Current evidence regarding routine delirium screening in all patients is conflicting. The benefits of routine
post-operative screening for delirium in all older adult patients include early detection and treatment; however, routine screening can also result in misdiagnosis, inappropriate treatment, and increased costs. Therefore the health care team should be well trained in detecting and treating older patients with delirium.5

After addressing underlying causes, health care professionals should treat older adults with post-operative delirium with multicomponent non-pharmacological interventions and reserve pharmacological interventions only for patients who pose substantial harm to themselves or others with agitated, hyperactive delirium behaviour.5,18

**Pulmonary complication prevention**

Older adult patients are at risk for post-operative pulmonary complications, including atelectasis, hospital-acquired pneumonia, and acute respiratory failure. These complications increase the risk of long-term morbidity following surgery.

In addition to interventions designed to optimize pulmonary status during the pre-operative and intra-operative periods such as inspiratory muscle training, minimally invasive surgical approach and cessation of smoking (if possible in older patients), there are several post-operative strategies that can be used to prevent pulmonary complications in the older patient, such as early postoperative mobilisation or reduction of opioid medication.5

**Fall risk assessment and prevention**

Falls are a significant problem in older adults. Studies have shown that approximately 30% of people over 65 years of age in the community fall every year. One retrospective study demonstrated that 1.5% of surgical inpatients experience post-operative falls, and that the average age of patients who fell was 64 years of age.5,19

Most falls are caused by complex interactions and combinations of factors, such as polypharmacy, muscle weakness after surgery and regional anaesthesia. Consequently, multi-factorial interventions, generally comprising a risk assessment and addressing each risk factor, have proven to be most effective in various practice settings.

Fall prevention interventions in the hospitalized older adult were reviewed in a 2010 Cochrane review, which examined studies in the acute hospital and nursing home setting. In both, multi-component interventions, including supervised exercises, environmental elements, assistive technology, and knowledge interventions, were found to significantly reduce the rate of falls and number of patients who fell.19

**Nutrition in the post-operative period**

Older adult patients who are hospitalized have high rates of malnutrition (up to 38.7%). Several studies have also highlighted the association of post-operative malnutrition markers with adverse outcomes such as pulmonary infections, SSI and length of stay.5,8

Several studies and systematic reviews have reported that early feeding in selected patients is not harmful. These studies have notably excluded older adult patients; as such, there is no consensus on the true benefit or harm of early feeding in elderly populations. The European Society for Clinical Nutrition and Metabolism (ESPEN), has established guidelines for enteral nutrition in both post-operative and geriatric patients (cancelled)

**Urinary tract infection prevention**

Urinary tract infections (UTI) are among the most common post-operative complications, representing 32% to 40% of all nosocomial infections, and are associated with significant health care costs. Older adults are at particular risk for UTI, especially if immobilized.5

If an older adult patient has an indwelling catheter, daily review and documentation of its indication should be completed and attempts be made to remove the catheter as soon as possible. Indwelling catheters should be not be used as a substitute for nursing care of the older adult patient who is incontinent.

**Functional decline**

Elderly patients are at a high risk for functional decline during and after hospitalization. Over 30% of older persons develop a new disability pertaining to activities of daily living during hospitalization. After one year, less than 50% of these patients have recovered to previous levels of function.

Though much of the literature on functional decline has focussed on elderly patients hospitalized with medical illnesses, the stress of surgery further increases the risk of functional decline during the post-operative period. Of note, many of the risk factors for falls are also risk factors for functional decline. Though related, they remain distinct phenomena, and clinicians should take steps to address both separately.5,20

**Pressure ulcer prevention and treatment**

The hospitalized elderly are at high risk for developing pressure ulcers, largely due to their co-morbidity burden. Up to two-thirds of pressure sores develop in patients over the age of 70 years. The majority of these occur in the acute hospital setting, usually during the first two weeks of hospitalization.

Health care teams should assess pressure ulcer risk in all older adult post-operative patients. There are several validated scales stratifying patients at risk by assessing sensory perception, moisture, activity level, mobility, nutrition, and the potential for friction and shear.5,21
Care transitions

Transitional care refers to interventions that intend to ensure continuity and co-ordination of care as patients move between health care settings. Up to one out of five Medicare beneficiaries experience re-admission within 30 days in the USA. Optimal care transitions from the hospital to home or post-acute care settings can help reduce hospital lengths of stay, emergency department use, and rates of re-hospitalization.

Improving care transitions for the older adult requires a re-orientation of hospital care. In addition to understanding the specific needs of the patient population, adapting to resource limitations, it is also important that there is commitment to improving geriatric care from senior administrative staff.5,20

Conclusions and perspectives

In elderly and especially in geriatric patients, musculoskeletal diseases will continuously increase within the coming years and decades. They remain frequent and complex processes with a high impact on long-term mortality and various effects on daily life activities and quality. An alignment of multidisciplinary hospital teams (physicians and nurses) and hospital care paths toward optimal care as well as an optimal planning of the needed surgery are essential to improve morbidity and mortality and to achieve positive outcomes.

Several actions and concepts have to be undertaken to optimize the outcomes of geriatric patients who have to undergo orthopaedic surgical procedures; not only in case of trauma but also for so-called ‘elective’ orthopaedic reasons such as revision-arthroplasties or spinal surgery which are quite common in elderly patients.17

Geriatric models of care

The goals of these models of care include prevention of age-related complications – the so-called ‘geriatric syndromes’ – and addressing hospital characteristics that contribute to increased risk. In addition to these goals referring to the duration of hospitalization the patient’s enrolment in an appropriate rehabilitation programme is essential to reduce the need for institutionalization and facilitate functional recovery as well as re-integration into everyday life.22

In addition to preventing some of the age-related complications mentioned above, geriatric models of care are also able to reduce cost and length of hospital stay, reduce risk of mortality, increase likelihood of discharge to home, improve care transitions, and improve patient satisfaction and functional status at discharge.22

Various approaches have been employed to integrate orthopaedic and geriatric care for elderly patients mostly in cases of trauma (e.g. hip fracture). These concepts, the so called ‘orthogeriatric models’ have demonstrated an improvement in long-term clinical outcome. Most of these concepts have included an orthopaedic ward with geriatric consultation or an orthopaedic ward with daily geriatric management.5,16,22 These management procedures have shown a sustained reduction of mortality and, furthermore, have shown that patients develop an improved walking ability and less morbidity.

At our institution, we created an integrated geriatric-orthopaedic unit devoted to the post-operative care of elderly patients undergoing elective as well as non-elective orthopaedic procedures (Integrated Geriatric-Orthopaedic Concept; InGerO) The medical staff from the emergency, anaesthetic and critical care, geriatric, orthopaedic surgery, and rehabilitation departments define priorities for these patients. One of the key aims is to create a dedicated unit where team skills can be more easily developed.5,16,22

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