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Surgical care of the geriatric patient

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Preoperative evaluation for older patients

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As the US population ages, an increasing number of old (75 years and older) and very old (85 years and older) patients are having elective and emergency surgery. With increasing age there are an expanded number of postoperative complications that can threaten older adults' independence and function, as well as morbidity and mortality. To enhance postoperative outcomes, many studies have focused on optimizing preoperative assessment and interventions.[1] Preoperative guidelines have been developed by the American College of Surgeons National

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Surgical Quality Improvement Program (ACS-NSQIP) and American Geriatric Society (AGS) highlight the assessment of geriatric-specific concerns in addition to standard risk assessment.[2]

In the older patient population functional status and comorbid illnesses are of paramount importance.[3] Older patients are more likely to have significant medical comorbidities, cognitive impairment, and frailty, all of which contribute to increased risk of perioperative and postoperative complications.[4] Understanding that the risk of postoperative delirium, falls, and pressure ulcers increases dramatically in this population, the preoperative evaluation process for older patients includes assessment of these risks and an opportunity to introduce interventions to mitigate these risks.[5] In addition, the decision to choose surgical treatment rather than other options must consider the likelihood of lost function and quality of life (QOL). Preoperative assessment provides an opportunity to educate and counsel the patient and family regarding risk reduction, potential immediate and late outcomes of surgical vs nonsurgical treatments, and the range of complications that may occur in the immediate postoperative period.[6]

Preoperative assessment

The logistics of obtaining a preoperative evaluation may vary for different health systems. Historically, when a surgeon and patient together decided to proceed with surgery, the surgeon arranged for a preoperative evaluation by the patient's primary care provider. Often the primary care provider was given a standard form or template for recording required information. In some settings, protocols required tests as part of a risk evaluation process.

In an attempt to standardize this process, many healthcare systems now use a comprehensive perioperative management (CPM) service to coordinate preoperative evaluations.[7] CPMs are often run jointly by anesthesiology and primary care. The surgeon refers the patient to the CPM and may provide the service with specific instructions regarding the patient's preoperative management. The CPM decides what information should be collected and directs the patient to a primary care provider who conducts the preoperative medical evaluation. The patient may also be directed to subspecialty services for separate preoperative evaluations, often cardiology and pulmonology. The CPM also decides which tests, if any, should be performed prior to surgery. When all the necessary information has been collected, the CPM provides guidance to the surgeon and patient on the risks of proceeding with surgery, decides the type of anesthesia, instructs the patient regarding preoperative interventions which may decrease postoperative complications, and provides the patient or surrogate with specific instructions on fluid intake, food intake, and medication management prior to surgery. This evaluation also provides an opportunity to discuss anticipated pain associated with the surgery and potential interventions to reduce discomfort following surgery.

Preoperative testing and unnecessary tests

Preoperative testing is widely overutilized. Numerous studies have underlined the futility of many tests, even if abnormal, in predicting surgical outcomes.[8] Kaplan and colleagues demonstrated that only 0.22% of tests were abnormal and may affect surgical outcomes—but these results were frequently neither acted upon nor affected surgical outcomes.[9] In a 2012 study looking at NSQIP data on 73,596 patients undergoing hernia surgery, there was no difference in major complications or wound-related complications when comparing testing (hematology, chemistry, coagulation, or liver function) to no testing.[10] Before requesting or ordering preoperative tests, one should consider the patient's history and physical examination, then determine whether any tests would change the perioperative management. Similarly, the surgical procedure should dictate routine preoperative tests, such as urinalysis prior to urologic procedures, *Staphylococcal* nasal screening before total joint replacement,[11] and complete blood count for surgery associated with major blood loss.

Although there are good data on the overuse of preoperative testing and lack of impact on surgical outcomes, guidelines regarding test use are not easy to interpret or clear-cut. For instance, the 2014 American College of Cardiology/American Heart Association (ACC/AHA) guidelines do not give absolute recommendations for EKG, but use the terms "reasonable" and "consider," with the exception of not recommending EKG for low-risk operations (evidence level B).[12] Many hospitals and ambulatory surgical centers have their own preoperative guidelines, which may not be evidence-based. If not up to date, local guidelines should be updated to include recent evidence from high quality studies (eg, controlled trials).

Methods to assess risk in older patients

Cardiac risk assessment

Cardiac risk assessment is an important part of the preoperative evaluation. The 2014 ACC/AHA guidelines divide surgical timing into 4 categories. Emergency operations are inpatient procedures that need to be performed within 2-4 hours. A preoperative cardiac assessment is generally limited to what needs to be done urgently to stabilize the patient and plan for postoperative care, to minimize delay to surgery. Urgent operations are typically in a timeline of 6-24 hours. Operations for hip fractures are an example in this category. The patient does not need surgery immediately, but there are numerous studies showing an increase in morbidity and mortality with unnecessary delays. Time sensitive surgeries are a new category in the 2014 guidelines. These are surgeries that should be performed within 1-6 weeks. Cancer operations such as breast cancer lumpectomies and colon cancer resections are examples. Careful decision-making must weigh the risk of delaying these operations for cardiac assessment and treatments, vs the risk of the cancer spreading during further evaluations. Lastly, elective operations can be performed at any point and have the greatest luxury in regards to time, in order to fully evaluate a patient and implement risk reduction treatments.

The 2014 ACC/AHA guidelines no longer separately classify patient and surgical risk factors. The 2014 guidelines classify patients as either high risk or low risk for a major cardiac event (MACE): the intermediate-risk level has been eliminated. Cardiac perioperative complications include events such as myocardial infarction, pulmonary edema, ventricular fibrillation, and complete heart block. High-risk patients have a MACE of 1% or greater and low-risk patients have a MACE of less than 1%.

The 2 major models used to calculate MACE rates are the Revised Cardiac Risk Index (RCRI) and NSQIP. NSQIP allows for calculation of risks beyond cardiac events. The NSQIP surgical risk calculator predicts death, cardiac events, and venous thromboembolism and was built from data extracted from 1.4 million operations. However, to calculate risk with the NSQIP tool, the Current Procedural Terminology (CPT) code in addition to 21 data elements is needed. In contrast, the RCRI may be used more frequently due to its greater simplicity (Table 1). The RCRI is a 6-point scale that determines a patient's risk of MACE. One point each is given for: high-risk operations, history of ischemic heart disease, history of stroke, history of heart failure, diabetes mellitus on insulin, and a creatinine greater than 2 mg/dL. A score of 0-1 points yields a low-risk cardiac assessment with a MACE risk less than 1%. A score of 2 or higher is considered high risk as the MACE risk is greater than 1%. Two points is associated with a MACE risk of 6.6% and a score of 3 or above is associated with an 11% risk of MACE.[14]

Pulmonary risk assessment

In the older population, pulmonary complications contribute equally to poor outcomes, as compared with cardiac events. Pulmonary complications occur more commonly than cardiac complications and are associated with increased morbidity, hospital length of stay (by 5.5 days), and higher costs.[15] Postoperative respiratory failure has been shown to be an independent

Table 1
Revised cardiac risk index.

One point each	Examples
High-risk surgery	Intrathoracic Intraabdominal Suprainguinal vascular Emergent surgeries Prolonged duration Large fluid shifts
Ischemic heart disease	
Stroke	TIA or CVA
CHF	Preserved ejection fraction Reduced ejection fraction
Diabetic on insulin	
Creatinine greater than 2 mg/dL	

A score of 0-1 points yields a low-risk cardiac assessment with a (MACE) all-cause mortality, myocardial infarction, or coronary revascularization risk less than 1%. A score of 2 or higher is considered high risk as the MACE risk is greater than 1%. Two points is associated with a MACE risk of 6.6% and a score of 3 or above is associated with 11% risk of MACE.[14] CHF, congestive heart failure; CVA, cerebrovascular accident; TIA, transient ischemic attack. Reprinted with permission from Borson and colleagues.[13]

Table 2
Stop bang.

Snoring (louder than talking, heard through doors)	**B**MI > 35
Tired, fatigued, or sleepy during the day?	**A**ge > 50
Observed stopped breathing?	**N**eck circumference > 16 inches (40cm)
Pressure (treatment for HTN)?	**G**ender—male

> 2 STOP and > 1 BANG criteria associated with moderate to severe obstructive sleep apnea. BMI, body-mass index; HTN, hypertension. Reprinted with permission from Alvarez-Nebreda M.L. and colleagues.[19]

predictor of 30-day and long-term mortality and affects 3% of older patients with up to 25% mortality at 30 days after operation.

There are both patient factors and surgical factors that increase all patients' risk of postoperative pulmonary complications. Functional dependence, impaired sensorium, weight loss greater than 10% in the past 6 months, and malnutrition with a serum albumin less than 3.5 g/dL are all independent risk factors for postoperative pulmonary complications.[16] Older patients are more likely to have these comorbidities. The American Society of Anesthesiology (ASA) Classification class of 2 or higher, history of chronic obstructive pulmonary disease (COPD), obstructive sleep apnea (OSA), congestive heart failure, and functional dependence are risk factors for pulmonary complications for which treatment should be maximized before surgery.[17]

The type of surgery is also related to the risk of perioperative pulmonary complications in all patients and may contribute the largest amount of overall risk. Operations longer than 3 hours, urgent operations, general anesthesia (GA), and surgical site location near the respiratory system all increase the risk of pulmonary postoperative complications. An online risk calculator (http://www.surgicalriskcalculator.com/prf-risk-calculator) is useful for estimating risk.[18]

An issue with pulmonary risk assessment is that interventions demonstrate little evidence that they can decrease a patient's risk. In addition, it takes more time that may be feasible, before surgery, to optimize underlying pulmonary diseases, or improve functional status and nutrition. Discussions about pulmonary risks before surgery can alert the patient and family to potential problems that could delay recovery and cause changes to discharge plans.

OSA causes both cardiac and pulmonary perioperative complications. The gold standard for diagnosing OSA is a sleep study, but it is challenging to complete a sleep study and intervene prior to nonelective surgery. STOP-BANG is a screening test with validity evidence in adult patients that can guide the need for further testing (Table 2), but it is unclear if it is valid in an older population. Patients screening positive with at least 2 STOP criteria and 1 BANG

Table 3
Mini-cog.

3-Item Registration	Ask patient to remember: apple, tree, car. Have them repeat back to you. Provide 3 chances.	Not scored
Clock Draw: 10 past 11	Tell patient to draw a clock by first drawing a large circle, put all the numbers in the circle and then make the time as 11:10	0 points—any errors. 2 points—all numbers present and in sequential, clockwise order
3-item Recall	Ask for the three words you asked them to remember.	0-3 points—1 for each correct recall

Scoring: 0-2 points suggests impairment; 3-5 points suggests no impairment. Any score less than 5 may require further testing as it is sensitive, but not specific, for detecting cognitive impairment. Reprinted with permission from Nabozny and colleagues.[23]

Table 4
Short simple screening test for functional assessment.

1. Can you get out of bed or chair yourself?*
2. Can you dress and bathe yourself? *
3. Can you make your own meals? **
4. Can you do your own shopping? **

* Activities of Daily Living (ADL).
** Instrumental Activities of Daily Living (IADL).

criteria are at risk for moderate to severe OSA; capnography (monitoring respiratory rate, hypoxia with pulse oximetry, and carbon dioxide retention detection) may be of benefit in the perioperative period. Similar monitoring is recommended for patients who have known OSA but do not comply with recommended treatment. Anesthesiology has developed guidelines on the minimization of pulmonary complications in patients with suspected OSA such as for degree of sedation and postoperative monitoring in the postacute care unit.

Cognitive risk assessment

Recent studies strongly recommend baseline cognitive evaluation as part of the preoperative evaluation for older patients who are scheduled for surgery that requires GA.[20] This establishes a baseline for the patient as well as identifies pre-existing conditions. The prevalence of dementia increases with age and is the strongest independent risk factor for developing delirium postoperatively.

Although many cognitive assessment tools are available, the Mini-cog[21] has evidence of validity for this purpose, setting, and population (Table 3).[22] The Mini-cog is easy to administer and can be completed by a medical assistant or nurse. If a patient has existing cognitive impairment, the baseline status of cognitive and physical functioning should be determined and noted.

Cognitive impairment may compromise an older person's ability to actively participate in the decision-making process. Yet many older persons with early cognitive impairment are able to contribute meaningfully to discussions about personal values and the decision to operate.[24] Brief cognitive testing, such as the Mini-Cog, is not a substitute for assessing decisional capacity (Table 4).[25]

The surgeon must explain to the patient the surgical and medical options available to treat the condition, and potential complications and benefits associated with each type of intervention. A patient has capacity to make a decision if they can give a brief summary, in their own words, of the benefits and risks of the choices and explain how their decision aligns best with their personal values and beliefs. If the patient does not have decisional capacity, it is essential to ask the surrogate decision-maker what they believe the patient would decide, if the patient were able to make the decision, and to sign the consent form. If there is uncertainty regarding the patient's capacity, referring the patient for a capacity evaluation may be necessary.

Table 5
Fried frailty criteria.

1. ≥ 10 lb. unintentional weight loss over the past 12 mo
2. Decreased grip strength
3. Self-reported low energy and endurance
4. Low weekly energy expenditure
5. Slow walking speed

1 point for each: Not frail – 0-1; Intermediate frail – 2-3; Frail – 4-5.

A depression screen with the Patient Health Questionnaire 2[26] or Five Question Geriatric Depression Scale[27] is also useful. Depression is often missed in this population and can be difficult to distinguish from postoperative delirium when the baseline status is unknown.

Function

All elderly patients who are scheduled for surgery should have functional assessment as part of the preoperative evaluation process, as impaired function predicts poor perioperative outcomes[28] and may be a stronger predictor of morbidity and mortality than cardiac metabolic equivalents. Functional assessment is also critical for discussing potential discharge plans after surgery. There are many useful general functional assessment tools.[29] These data can be collected by asking the patient directly about current function or seeking information from someone who lives with the patient. The Short Simple Screening test for Functional Assessment[30] can quickly ascertain an overview of the patient's independence, with more detailed assessments used if problems are detected.[31,32]

If using NSQIP to calculate MACE, general functional status is categorized as independent, partially dependent, or totally dependent, based on the degree to which patients require human assistance. These categories can be alternative measures for assessing baseline function.

The Timed Up and Go is a reliable in-office test to measure physical function.[33] The only equipment needed is a chair, second-hand timer, and a walkway of at least 10 feet. The patient is observed and timed while standing from the chair, walking to the line, turning, walking back to the chair, and sitting down. If this takes the patient more than 15 seconds, then they are at increased risk for falls and subsequent functional decline. A preoperative exercise prescription or physical therapy referral is indicated if there are no medical reasons for abnormal gait or slow speed on Timed Up and Go assessment. Slow gait speed—less than 1 m/s—is independently associated with adverse postoperative outcomes in older adults.[34,35]

In addition to documenting functional baseline, functional consequences of surgery are relevant to the preoperative discussion. Up to 30% of older adults develop a new functional impairment during an acute hospitalization and by 1 year fewer than 50% of these individuals are back to baseline levels of functioning.[36]

Frailty assessment

All patients 75 years of age or older who are scheduled for surgery should be assessed for the presence of frailty with a standard frailty assessment.[37,38] Frailty places older patients at high risk for poor outcomes and functional decline. For example, frailty index score was more important than age for predicting outcomes in geriatric trauma patients.[39,40] A 2018 study demonstrated that clinical frailty scores helped predict 30-day and 6-month readmission or death in patients over the age of 65 years who were not severely frail.[41] The Fried Criteria for Frailty[42] addresses 5 frailty markers; most experts consider that if 3 of 5 are present, the patient meets the frailty definition (Table 5).

Preoperative interventions for older patients

Medication management

Where possible, medications that have been demonstrated to put an older patient at risk for postoperative complications should be reduced or discontinued prior to surgery, and should not be used during or after surgery. Benzodiazepines, anticholinergics, antihistamines, and prescription sleep aids are the classes most commonly associated with adverse outcomes.[43] Other medications, such as anti-Parkinson's or antipsychotic medications are also high risk but may be essential at their current dose.

Polypharmacy alone is a risk factor for poor outcomes and all encounters with the medical community serve as an opportunity to eliminate unnecessary medications, particularly in older adults. The preoperative evaluation can be a time to determine if certain medications are truly necessary. Many vitamins, herbal supplements, and over-the-counter medications can interact with prescription medications, increase perioperative bleeding risk, or impair wound healing. Specifically asking about these may prevent unnecessary interactions.

Prehabilitation

If a patient is already frail prior to surgery and/or significant immobility is anticipated following surgery, the patient should be given the opportunity to increase his strength and mobility prior to surgery. This can be accomplished by referring the patient to outpatient rehabilitation services and/or instructing the patient in exercises and activities which they can perform at home prior to the scheduled surgery. For example, a recent study demonstrated that preoperative inspiratory muscle training decreased postoperative pulmonary complications.[44] In addition, evaluation by physical therapy before surgery can identify additional equipment or home support needs and reinforce physician discussions about postoperative functional issues.

Nutrition

Unintentional weight loss is a risk factor for a variety of postoperative complications. This can be identified preoperatively via the history obtained from the patient and trends in weight or body mass index (BMI) showing a decline, regardless of the patient's initial BMI. If weight loss is identified, either 10 pounds or 10% of body weight, the cause should be investigated, as the etiology could be anything from depression to lack of access to proper food to undiagnosed malignancy. If time allows, interventions should be initiated to correct malnutrition and undernutrition, to optimize the nutrition status prior to surgery. When appropriate, the patient can be referred for a nutritional evaluation to obtain specific nutritional advice from a registered dietitian.

Emergency vs elective surgery

Many aspects of preoperative evaluation are affected if the patient requires emergency surgery. Time may not allow the depth of evaluation that can be obtained prior to an elective procedure. It is also not possible to use interventions such as prehabilitation and medication withdrawal. Cognitive status and decisional capacity can also be affected by conditions that require emergent surgical treatment, such as acute head injury, blood loss leading to hypotension, and severe pain and the medications required to reduce pain. When time allows, data regarding pre-existing conditions that place the patient at risk for postoperative complications should be collected. Depending on a variety of risk-benefit calculations, it may be possible to postpone surgery, to allow time to optimize the patient's care and reduce the risk of perioperative and postoperative complications.

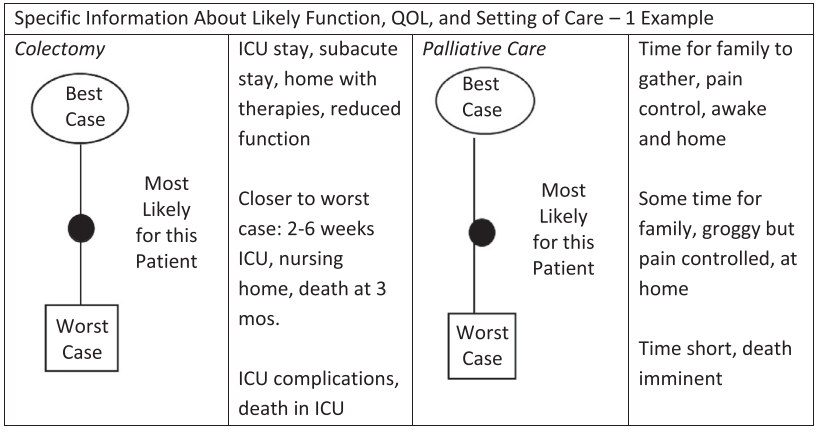

Fig. 1. Conversations using "best case/worst case" scenarios.[48] ICU, intensive care unit; QOL, quality of life.

Strategies for discussing benefits and risks of surgery

Although we must avoid ageism in perioperative discussions—being cognizant that chronological age on its own does not determine risk—it is important to consider the full clinical picture before proceeding with surgery. Based on overall assessment of the older adult, physicians must discuss both the best- and worst-case scenarios with the patient, as the benefits of surgery may be counteracted by the hurdle of recovery even when no complications arise. Many of the risk calculators previously mentioned focus on mortality in the immediate postoperative period, but QOL and delayed morbidity and mortality are important considerations in older adults. Recovery from noncardiac complications can be unattainable. Taylor and colleagues bypassed focusing on discrete perioperative complications and directed their attention to shared decision-making that looked at various possible trajectories, to illustrate different, possible outcomes for the patient.[45] Nabozny and colleagues acknowledged that although elderly patients and surgeons both sought QOL, in the setting of an acute surgery decision, both parties struggled to choose a nonsurgical path.[46]

Rather than using only the language of informed consent, or risks vs benefits of the procedure, physicians can also frame the discussion, for high-stakes decisions, around "best case/worst case" scenarios to help patients understand their own values and preferences for potential downstream events (Fig 1).

Average life expectancy can be calculated with models that incorporate age, gender, comorbid conditions, and function.[47] These models are specific to setting, such as community-dwelling vs nursing home resident. As these predictive indices are developed for populations, they are not specific to the individual patient, but can still provide a general perspective.

Shared decision making

It is essential that the goals of surgical care are carefully discussed, such as whether the proposed surgery is being done to decrease the risk of succumbing to a life-threatening illness, decrease pain, or improve function. The likely recovery process after surgery is also a key to discuss, as the decision for some patients to proceed with surgery may change if they understand that a prolonged stay in a rehabilitation or skilled nursing facility is highly likely. Similarly, if permanent appliances are needed, patients and their caregivers need to emotionally and mentally prepare for the resulting changes to daily life. If there is a substantial risk of not returning to the same level of physical functioning or QOL months to years after surgery,

Table 6
Geriatric preoperative questionnaire.

History Element	Result	Category	Reference
3-Item Recall	/3	Cognition	Mini-Cog
Clock-Draw	/2 Total: /5	Cognition	Mini-Cog
Down/depressed/hopeless for 2 wk during last 12 mo?	Yes/No	Depression	PHQ-2
Loss of interest in activities for 2 wk during last 12 mo?	Yes/No	Depression	PHQ-2
Can you get out of bed or a chair yourself?	Yes/No	Function	Short simple screening test for functional assessment
Can you dress and bathe yourself?	Yes/No	Function	Short simple screening test for functional assessment
Can you make your own meals?	Yes/No	Function	Short simple screening test for functional assessment
Can you do your own shopping?	Yes/No	Function	Short simple screening test for functional assessment
≥ 10 lb unintentional weight loss over the past 12 mo?	0 or 1	Frailty	Freid
Decreased grip strength?	0 or 1	Frailty	Freid
Self-reported low energy and endurance	0 or 1	Frailty	Freid
Low weekly energy expenditure	0 or 1	Frailty	Freid
Slow walking	0 or 1 Total: /5	Frailty	Freid

patients with limited life expectancy may choose to forgo a surgical option. Weighing the risks and benefits must take into consideration an older person's values regarding independence, symptom relief, and longer life (Table 6).

Summary

Surgical interventions in the older population have the potential to drastically improve a patient's function and preserve both quality and longevity of life. However, care must be taken to identify risk factors in the preoperative period, and, when possible, intervene prior to proceeding with surgery. In addition, reviewing the patient's goals of surgery in a "best-case/worst-case" scenario can help ensure that their expectations are appropriately aligned with their values and potential outcomes.

Postoperative management of the older patient

Marilyn Katz, MD, Nicole Silverstein, MD, Gail Sullivan, MD, MPH, Eric M. Mortensen, MD, MSc

Because so many older patients have existing medical conditions unrelated to the reason they require surgery, it can be difficult to determine whether postoperative morbidity and mortality are directly related to the surgery performed or the patient's underlying medical conditions. Mortality associated with the surgical repair of hip fractures illustrates this dilemma. Older patients who fall and fracture often meet criteria for frailty and have significant medical comorbidities, which put them at risk for increased mortality. This mortality risk is independent from the risk associated with hip fracture surgery.[25] In addition, pre-existing comorbid conditions may have caused the fall and fracture and need attention in order to prevent future trauma. Numerous studies report the surgical mortality risk in older patients with various pre-existing conditions undergoing different surgical procedures.[25] It can be difficult to apply these population data to specific risks for individual older patients. Age alone does appear to be

Table 7
Supportive measures to prevent and treat delirium.

Environment	Minimize unnecessary noise
	Remove unnecessary equipment
	Promote orientation (clocks, calendars)
	Adequate lighting based on time of day
	Avoid interruptions to nighttime sleep
Activity	Promote participation in self care
	Avoid physical or chemical restraints
Personal equipment	Access and use: glasses, hearing aids and dentures

Adapted from Amador and colleagues. Postoperative Delirium in the Older Patient.[32]

an independent risk factor for perioperative and postoperative complications;[26] the NSQIP risk calculator is a useful tool for determining mortality risk and includes age in the calculation.[27]

Delirium

Delirium is an illness with an acute onset that manifests with waxing and waning cognitive function (Table 7) and is associated with serious postoperative complications such as skin breakdown and aspiration, delayed mobilization and rehabilitation, and reduced survival.[28] An estimated 40% of delirium is preventable.[28] There are extensive data regarding pre-existing independent factors associated with a patient developing delirium in the immediate postoperative period. Identified risk factors include evidence of cognitive impairment, poor functional status, renal insufficiency, depression, malnutrition, vision impairment, and a previous episode of postoperative delirium.[29] Several medications also contribute to an increased risk of postoperative delirium; these include psychoactive medications and opioid analgesics. Risk factors which predispose patients to postoperative delirium should be collected during the preoperative evaluation process for all patients 75 years of age or older.

The Confusion Assessment Method (CAM) and CAM-ICU are delirium screening tools with evidence of validity in the inpatient and ICU settings.[29] The CAM-ICU can be used to assess cognition in intubated patients.

Medications

Medications, including over-the-counter medications and herbal supplements, can trigger delirium. Polypharmacy—4 or more different classes of medications—alone is associated with an increased risk of delirium in older adults.[28] Benzodiazepines are highly associated with delirium in older adults. If used chronically, they should be continued because abrupt discontinuation may trigger benzodiazepine withdrawal. If the patient has a history of alcohol abuse, acute benzodiazepine use may be necessary to prevent or treat alcohol withdrawal. Otherwise, the use of benzodiazepines in the perioperative period, for anxiety or for agitation due to delirium, should be avoided unless there are no other options.[29]

Sleep hypnotics are also high-risk medications in older adults. Although recommended for intermittent or temporary use, many patients take these medications daily and have done so chronically. If possible, the dose and frequency should be tapered in the perioperative period, with discussions regarding their risk of delirium and falls. Whenever possible, good sleep hygiene practices should be followed in the hospital. For example, patient rooms should be quiet and dark, with minimal interruptions, so that patients have an opportunity for restorative sleep while hospitalized. Other medications associated with delirium, such as anti-Parkinson's medications, digoxin, and beta blockers, are difficult to taper or discontinue in the perioperative period as their absence can cause significant complications.

Certain medications are strongly associated with delirium, particularly muscle relaxants, scopolamine, psychiatric medications, gabapentinoids, and opioids, and should be used only

when there are no other alternatives. Other medications often used in the perioperative period, such as nonsteroidal anti-inflammatories (NSAIDs), fluoroquinolones, H-2 blockers, and gabapentinoids have the potential to cause delirium, although not commonly. Careful review and pruning of the medication list in the older postoperative patient is recommended.[29] Finally, AGS Expert Panel guidelines of 2014 strongly recommend not using cholinesterase inhibitors—dementia palliative medication—to prevent or treat postoperative delirium.[30]

Pain

Pain may be a risk factor for delirium in this patient population, yet use of opioids and constipation are also delirium triggers. Due to these risks, it is critical to distinguish postoperative delirium from pain. Many institutions have instituted perioperative pain protocols to minimize the use of opioid analgesics while maximizing pain control, which aligns with the AGS recommendation to support pain control while minimizing use of postoperative opioids. Preoperative administration of COX 2 inhibitors also results in significant reduction of postoperative morphine consumption at 24 hours after surgery,[31] but the use of COX 2 inhibitors and NSAIDs in older adults must be balanced with the risk of side effects such as renal function decline, hypertension, edema, and gastric bleeding. Some NSAIDs, particularly celecoxib, ibuprofen, and meloxicam have been identified as triggers for delirium, so this risk should also be weighed when selecting pharmacologic therapy.

Due to the risks associated with both opioids and NSAIDs, around-the-clock use of acetaminophen should remain the foundation on which to build a multimodal approach to pain control. Other modalities include nerve blocks, intra-articular use of analgesics at the time of surgery, and topical agents, such as lidocaine patch and topical NSAIDs. Some hospitals offer integrative medical approaches, such as Reiki and cognitive behavioral therapy, although supporting evidence for these interventions is slim.

Management

The first line of delirium management is to determine the precipitating etiology, which may be multifactorial. This requires looking closely at the individual's predisposing factors, changes in vital signs and physical examination (beyond the change in mental status), medications, and environment. The most important features are a careful history and physical examination that can be compared to the preoperative history and physical to highlight possible triggers. Once precipitating factor(s) have been identified, targeted testing may be helpful. For example, anemia, infection, or electrolyte abnormalities may cause or contribute to delirium. However, routine pan-testing with laboratory tests and radiology studies is not a cost-effective approach and may delay appropriate treatment. Treatment should be guided toward correcting modifiable risk factors, such as hydration in the setting of postural hypotension or medication reduction.

Supportive care is beneficial during the process of delirium correction. Such nonpharmacologic approaches focus mainly on a suitable recovery environment and require trained staff.

If interventions and supportive care with nonpharmacologic delirium approaches are not successful, then medications can be considered when the patient's agitation threatens survival or serious complications. The AGS recommends using the lowest effective dose for the smallest amount of time necessary for a severely agitated patient who is at risk of harm to themselves or others. However, the AGS recommends against the use of antipsychotics and benzodiazepines for the treatment of hypoactive (nonagitated) delirium. Research does not support the use of prophylactic antipsychotics to prevent delirium.[32]

Falls

Older patients are at increased risk for falls during postoperative recovery. Falls can lead to pain, decreased physical function, and further medical care, including surgical care. Falls may

also result in prolonged hospital stays, the need for postacute care, and litigation. Factors which predispose the patient to fall include cognitive impairment, frailty, and the use of high-risk medications, particularly benzodiazepines, antipsychotics, antidepressants, sleep hypnotics, and other psychoactive medications. In a Cochrane study, the evidence regarding the use of bed exit alarms and low height beds did not support any increase or decrease in injury. The review also looked at bed rails but was unable to identify any randomized controlled studies.[33] Bed alarms can alert staff that a patient has left the bed but will not prevent an immediate fall. In contrast, hospital-based mobility programs, such as brief daily walking programs, have shown increased function at discharge and no increased risk of falls.[34] In addition, these programs have been shown to increase mood and wellbeing. ICU-based mobility and range of motion interventions have been shown to be safe and similarly show positive benefits, such as improved function and muscle strength. Medical need for immobility, such as traction, is a contraindication to participation in these types of programs.

Pulmonary

Optimizing pulmonary function, considering postponing surgery if the patient has had a recent pulmonary infection, or considering prehabilitation for patients undergoing abdominal surgery, may help prevent pulmonary complications. Getting patients out of bed and ambulating, incentive spirometry and deep breathing exercises, and selective use of nasogastric tubes (primarily patients with ileus at risk of aspiration) are the only interventions in the postoperative period shown to decrease the risk of pulmonary complications.[35] Patients require coaching and frequent reminders by staff to use incentive spirometry and deep breathing effectively; delirium makes adherence more difficult.

Pressure sores

Pressure sores are lesions caused by unrelieved pressure, with or without friction and shear, that causes damage to the skin or underlying tissue. Pressure sores lead to increased length of hospital stay, morbidity, and mortality with up to 60,000 deaths per year.[36] Risk factors include extrinsic factors (eg, shear, moisture, and friction) and intrinsic factors (eg, increasing age, nutritional problems, corticosteroid exposure, comorbid conditions, obesity, smoking, and hypotension). Type of anesthesia (increased risk with epidural or spinal anesthesia) and surgery duration are also important risk factors for pressure ulcers. Skin assessment should be performed for all surgical patients using Norton or Branden scales; this should be the nursing standard of care. Pressure redistribution devices, such as static-air mattresses intraoperatively, reduce the incidence pressure ulcers. In the postoperative period, effective interventions include turning patients every 1-2 hours, not sliding the patient, using special mattresses, providing nutritional support, and optimal wound care.

Frailty

Frailty is an increased susceptibility to stressors as a result of age- and disease-related declines in function. Frailty results in decreased physiological reserves, which compromise the older adult's ability to cope with physiological stress; this increases the risk of mortality and postoperative complications. Up to 40% of patients aged 80 years or older, compared with 10% of patients between 65 and 75 years of age, may meet frailty criteria.[37] There are several strategies used to identify frail patients. One approach is the multidimensional frailty score, which includes 6 domains: comorbid conditions, polypharmacy, physical function, psychological status, nutrition, and risk of postoperative delirium.[17] This method was demonstrated to have

good sensitivity (84.0%) and specificity (69.2%) for predicting all-cause mortality rates. An alternative phenotypic definition of frailty uses 5 factors: shrinking (unintentional weight loss of 10 pounds or more [4.5 kg] in the last year), weakness (decreased grip strength measured by a handheld dynamometer), self-reported exhaustion, low physical activity (using the Minnesota Leisure Time Activities Questionnaire), and slow walking speed.[37]

Methods found useful to improve frailty in the elderly include addressing poor nutritional status and impaired functional status. For those with poor nutritional status, it is suggested that protein supplementation with nutritional shakes be started at least 10-14 days prior to surgery.[17] In the postoperative period, adequacy of nutritional intact and monitoring for signs of aspiration should be assessed daily. Older adults may need small, more frequent (1-2 hours) nutritional offerings and close monitoring by staff. Bedside swallow assessments may provide useful information regarding feeding strategies.[38]

Several models of care have been studied and may be helpful in minimizing functional decline associated with surgery. The Nurses Improving Care of Health System Elders, Acute Care for Elderly units, and Hospital Elderly Life Program are well-established programs to limit functional loss and improve discharge outcomes.[37] Elements of these programs can be implemented at any institution: early mobilization, early referral for physical and occupational therapy, routine geriatric medicine consults, safe hospital environments, and comprehensive discharge planning.

Postacute care and discharge planning

The patient's ability to function independently, without human assistance, in terms of mobility, dressing and undressing, performing personal hygiene, and eating are all important predictors of the patient's ability to return directly home following surgery. A variety of pre-existing conditions as well as factors specific to postsurgical care can affect the patient's likelihood of experiencing a functional decline and need for inpatient postacute care following surgery. These factors include pre-existing frailty, cognitive impairment, malnutrition, and poor social supports. Postsurgical factors include prolonged immobility, acute confusion, falls, and pressure sores following surgery.

New models in perioperative care

As the population continues to age and more operations occur in older adults, new multidisciplinary models are being studied to improve perioperative outcomes. Multidisciplinary collaborations looking at medical, psychosocial, and functional capabilities are used to establish more detailed and patient-specific perioperative treatment plans to decrease morbidity and mortality. Duke University published results of a Perioperative Optimization of Senior Health program utilizing an integrated multidisciplinary team with preset coordination to improve outcomes in this high-risk population. Their team incorporated geriatrics experts to target comorbidities, polypharmacy, mobility, nutrition, and delirium in older patients undergoing elective abdominal surgeries. Through a focused, detailed preoperative evaluation and postoperative continuity of care, Perioperative Optimization of Senior Health produced a shorter length of stay and lower readmission rates at both 7 and 30 days. Patients were also more likely to be discharged back home than to a higher level of care. Delirium rates were increased postoperatively, but there were fewer mean number of complications.[39]

A Cochrane Library Review in 2018[40] looked further into comprehensive geriatric assessment (CGA) in surgical patients. In reviewing 8 randomized trials (7 involving hip fracture patients) the authors concluded that CGA probably reduces mortality in hip fracture patients, improves discharge back to the same level of care they were in prior to surgery, and probably reduces length of stay. They found little data to support a reduction in costs. There were no data to support a difference in rates of readmission, major postoperative complications, and delirium.

From these studies, it makes sense to consider preoperative comprehensive geriatric evaluations of older patients, particularly those 75 years and older, to fully understand medical issues, psychosocial issues, and functional barriers to a quick recovery from surgery. There is evidence to support geriatric evaluation in general hospitalized older patients and data is starting to emerge regarding perioperative benefits. Further collaborations and implementation processes need to be studied with attention to time, costs, and resources required as well as patient-related benefits in function, discharge site, and comorbidity.

Summary

Optimizing the postoperative environment for older patients starts proactively with a comprehensive preoperative assessment to identify individual risk factors from postoperative complications. Delirium remains a common and serious complication for older adults. Standard approaches to the postoperative hospital environment including orientation (visible date, clock, and care team), promoting nighttime sleep (dark and quiet room, minimal interruptions) and familiarity with surroundings (familiar objects, familiar people) can be implemented routinely. If delirium does arise, early identification, assessment and personalized mitigation strategies are key to resolution. Other postoperative complications seen in older adults, such as falls, pulmonary problems, pressure sores, and functional loss, are all more likely to occur in the presence of delirium. Multidisciplinary care teams pose a promising way to enhance patient safety, morbidity, and mortality, as do comprehensive geriatric perioperative evaluations.

Anesthetic management for common surgical procedures in elderly patients

Azuka Onye Otukoya, DO, Adam Sachs, MD, Jeffrey B. Gross, MD

As of 2016, there were 37 million people in the United States aged 65 years or older and this number continues to grow.[41] The elderly population comprises a disproportionately large percentage of surgical patients.[42] Even the healthiest elderly individual having surgery is at an increased risk of serious complications, including myocardial infarction and stroke, when compared to the younger cohort. These patients are also more likely to require an ICU level of care, have a longer hospital stay, and incur additional hospital readmissions.[43]

Elderly patients experience degenerative changes and decreased functional reserve, in the structure and function of all organs and tissues, especially the cardiopulmonary, renal and, central nervous systems.[44,45] Reserve further decreases in patients with other comorbidities, like coronary artery disease, COPD, and diabetes, which all result in further anesthetic and surgical implications.

General overview of anesthetic management for elderly patients

Preoperative evaluation

The preoperative evaluation focuses on the history of the present illness, comorbidities, current medications, and the functional reserve of vital organs, most importantly, cardiovascular and pulmonary reserves (Table 8).[44] The ASA Physical Status Classification System (ASA score) is a part of the preoperative evaluation (Table 9). It is a well-known predictor of adverse

Table 8
Anesthesiology preoperative evaluation for elderly patients.

History of present illness	Detailed history of patients' current illness and the reason for surgical intervention; Time course for illness and previous treatments
Past medical history	Associated comorbidities with special attention to cardiovascular and pulmonary comorbidities
Medications	Identify use of beta blockers, angiotensin-converting-enzyme inhibitors/angiotensin II receptor blockers (ACEIs/ARBs), insulin/oral hypoglycemic drugs, anticoagulants/antiplatelets; date of last dose
Past surgical history	Identify complications from previous anesthetics
Allergies	Confirm medication and associated type and severity of reaction
Review of systems	Special attention to cardiovascular, pulmonary systems
Physical exam	Includes Mallampati class, metabolic equivalents (METs), dentition, focuses on heart, lungs and abdomen
Functional status	Bed bound? Walks with cane or walker? Able to complete activities of daily life?
ASA Score	Classifications I-V, E designates an emergency
Labs	CBC, electrolytes, liver function tests, coagulation studies, thromboelastography (TEG) where appropriate
Diagnostic tests	EKG, pulmonary function tests, chest X-ray, transthoracic or transesophageal echocardiography
Cognitive status	Mini cognitive assessment
Nutritional status	Patients may be on total parenteral nutrition, gastric or jejunum tube feedings, can order prealbumin

ASA, American Society of Anesthesiologists; CBC, complete blood count; EKG, electrocardiogram; TEG, thromboelastogram. Reprinted with permission from Barnett SR.[44]

Table 9
ASA physical status classification system with examples.

ASA I	Healthy patient	Examples: No comorbidities, nonsmoker, no or minimal alcohol use
ASA II	Mild systemic disease with no substantive functional limitations	Examples: Current cigarette smoker, social alcohol drinker, well-controlled diabetes mellitus and/or hypertension, obesity ($30 < BMI < 40$), mild lung disease
ASA III	Severe systemic disease with substantive functional limitations	Examples: Substantive functional limitations; one or more moderate to severe diseases. Examples include (but not limited to): poorly controlled DM or HTN, COPD, morbid obesity ($BMI \geq 40$), active hepatitis, alcohol dependence or abuse, implanted pacemaker, moderate reduction of ejection fraction, ESRD undergoing regularly scheduled dialysis, premature infant PCA < 60 wk, history (more than 3 mo) of MI, CVA, TIA, or CAD/stents
ASA IV	Severe systemic disease that is a constant threat to life	Examples: Recent (less than 3 mo) MI, CVA, TIA, or CAD/stents, ongoing cardiac ischemia or severe valve dysfunction, severe reduction of ejection fraction, sepsis, DIC, ARD or ESRD not undergoing regularly scheduled dialysis
ASA V	Near death and not expected to survive without procedure	Examples: Ruptured abdominal/thoracic aneurysm, massive trauma, intracranial bleed with mass effect, ischemic bowel in the face of significant cardiac pathology or multiple organ/system dysfunction
ASA VI	Declared brain dead undergoing organ procurement	
E	ASA Class with the addition of an E signifies an emergent surgery	

BMI, body mass index; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; CVA, cerebral vascular accident; DIC, disseminated intravascular coagulation; DM, diabetes mellitus; ESRD, end-stage renal disease; HTN, hypertension; MI, myocardial infarction; TIA, transient-ischemic accident.
ASA Physical Status Classification System (Copyright © 2018) used with permission from the American Society of Anesthesiologists. Reprinted with permission from American Society of Anesthesiologists.[46]

postoperative outcomes but does not include age.[46] Perioperative cognitive screening tests are not commonly part of the routine preoperative evaluation of elderly patients scheduled for elective surgery.[41] Culley and colleagues examined the use of the Mini Cognition Screening test in elderly patient presenting for major joint replacement surgery. They found that poor preoperative cognition was predictive of poorer postoperative outcomes including delirium, longer hospital stays, and higher chances of being discharged to a place other than home.[47]

Elderly patients often take different medications for various serious comorbid conditions. These include beta blockers (BB) and angiotensin converting enzyme inhibitors (ACEI) or angiotensin receptor blockers (ARB) for cardiovascular disease. There has been much controversy surrounding the use of BBs and ACEIs/ARBs during the perioperative period. A study by Lindenauer and colleagues found that prophylactically administering BBs during the perioperative period resulted in clinically significant reductions in mortality in patients with a RCRI score of 3 or greater. They recommend that patients with a high RCRI of 2 or greater may benefit from prophylactic administration of beta blockers during the perioperative period.[48] Those already on beta-receptor blocking agents should continue their medication during the perioperative period to decrease the risk of an adverse cardiac event. A large, prospective, study by Roshanov and colleagues demonstrated that withholding ACEIs/ARBs before major noncardiac surgery decreased the risks of perioperative morbidity and mortality.[49]

During the preoperative evaluation, the anesthesiologist will determine the proper anesthetic to administer to the patient during surgery: local, regional, or GA. The decision depends on the type/invasiveness of the surgery, patient-specific comorbidities, and functional status.

Pharmacologic changes in the elderly

For a given drug dose, elderly patients experience higher plasma drug concentrations when compared to young adults. Decreased protein binding can lead to increased drug availability and as a result increase the clinical effect of the drug. An increase in the percentage of body fat in the elderly can lead to longer elimination times for lipid-soluble drugs. Most anesthetic drugs interact with the central nervous system. Because elderly patients have a 30% decrease in cerebral mass, and further decreases in neurotransmitters like dopamine, serotonin, and tyrosine, they experience an increased sensitivity to many commonly used anesthetic agents and a decreased minimal alveolar concentration and ED5.[43,45]

Anesthetic considerations for abdominal surgery

Preoperative considerations

Colorectal pathology requiring surgical intervention is common in the elderly population. In elective cases, these patients are often dehydrated with a suboptimal nutritional status secondary to a decrease in oral intake associated with the primary pathology, bowel preparation, and NPO requirements.[45] The preoperative evaluation should identify signs of bowel obstruction and nausea, vomiting, or acid reflux. All medications should be reviewed and a preoperative complete blood count, electrolyte panel, and blood glucose level should be checked.

Enhanced Recovery After Surgery (ERAS) has become a mainstay in the care of patients undergoing major abdominal surgery over the past few years and has been adopted in other surgical fields, including cardiothoracic and orthopedic surgery. The goal is to decrease perioperative mortality and morbidity. Perioperative goals include but are not limited to providing education and counseling for the patient, preoperative optimization including smoking cessation, perioperative pain management, judicial fluid administration, optimal temperature control, deep venous thrombosis (DVT) prophylaxis and postoperative nausea and vomiting (PONV) control (Table 10).[50] Both the ERAS recommendations and the 2017 ASA practice guidelines for preoperative fasting recommend allowing the ingestion of clear liquids for up to 2 hours prior to surgery and allowing a light meal, like toast, up to 6 hours prior to surgery in healthy patients. Those with delayed gastric emptying should be treated as a “full stomach” as per ERAS guidelines.[51]

Table 10
Enhanced recovery after surgery (ERAS) recommendations.

Preadmission education and counseling: To allay patient fears and anxiety, a thorough discussion regarding procedure, anesthesia and what to expect during the perioperative period is warranted
Preoperative optimization: *Smoking cessation* 4 wks prior to surgery is best but can be beneficial even up to 24 h before surgery; *alcohol cessation* in abusers at least 4 wks before surgery
Preoperative bowel preparation: Surgeons moving away from routinely using preoperative bowel regimen due to physiological consequences of dehydration
Preoperative fasting and carbohydrate treatment: *Clear fluids (excluding alcohol):* allowed up to 2 h prior to surgery; *Solid food:* light meal (toast) up to 6 h prior to surgery; routine use of preoperative carbohydrate loading via enriched clear liquid
Preanesthetic medication: Due to delay in postoperative recovery patients should not receive routine preanesthetic medications for anxiolysis. For patients receiving neuraxial anesthetic, small doses of short-acting analgesics and anxiolytic can be used in small doses and titrated to effect.
Venous thromboembolism (VTE) prophylaxis: Pneumatic compression stockings, pharmacologic prophylaxis with low molecular weight heparin, extended prophylaxis with low-molecular weight heparin (LMWH) in patient with colorectal cancer
Infection prophylaxis and skin care: Routine use of intravenous antibiotic prophylaxis 30-60 min prior to the start of colorectal surgery. Antibiotic should be redosed accordingly in for procedures
Anesthetic protocol: Anesthetic that allows rapid-awakening postprocedure, optimal fluid therapy, analgesia, and hemodynamic changes to minimize surgical stress response; Epidural and spinal anesthetic for postoperative analgesia; if contraindication to neuraxial analgesia the addition of patient controlled analgesia (PCA) may be warranted
Postoperative nausea and vomiting (PONV): Multimodal approach to preventing PONV for patients with 2 or more risks factors undergoing a colorectal procedure
Modifications of surgical access: Depending on surgeon availability and skill, laparoscopic approach to surgical interventions of the colon
Nasogastric tube (NGT) placement: An NGT placed during the intraoperative period should be removed prior to emergence from anesthesia and should not routinely be used during the postoperative period
Goal-directed fluid therapy: Balanced crystalloids like Normosol and lactated Ringer's solution should be used during the intraoperative period. Fluid should be guided by minimally/noninvasive cardiac output monitors in patients with high-risk comorbidities, during long procedures, or if blood loss is in excess of 7 mL/kg; Vasopressors should be used in place of fluids if there is epidural-induced hypotension
Drainage of the peritoneal cavity: Routine drainage not recommended
Urinary drainage: Transurethral bladder catheter recommended for 1-2 days and can be taken out even if thoracic epidural analgesia (TEA) still in place
Postoperative ileus prevention: TEA and laparoscopic surgery recommended for colon surgery where possible; avoid fluid overload and NGT decompression; Chewing gum, magnesium, and alvimopan can be added where needed
Multimodal analgesia: TEA for open surgery with the addition of low doses of opioid medications for breakthrough pain. For laparoscopic surgery spinal analgesia using a low dose of opioid medication can be used. Addition of acetaminophen and NSAIDs (nonsteroidal anti-inflammatory drug) during postoperative period
Nutrition: Preoperative nutritional evaluation; minimal preoperative fasting; postoperative as soon as possible; oral nutritional supplements can supplement oral intake
Glucose control: Avoid hyperglycemia
Quality improvement: Systematic review of practice to determine outcomes and measure compliance to protocols

Enhanced Recovery After Surgery Recommendations (ERAS) used with permission from Elsevier. Reprinted with permission from Gustafsson and colleagues.[50]

Intraoperative considerations

The main intraoperative goals of care for elderly patients include blunting the stress response to surgical stimuli, providing optimal surgical conditions, largely through relaxation of the abdominal musculature, and maintaining optimal hemodynamic conditions for the patient. Induction of GA can be carried out with the usual intravenous anesthetics. Muscle relaxation for large open abdominal incisions is important for optimal surgical conditions and nondepolarizing neuromuscular blockers like rocuronium can be used as an infusion for maintaining muscle relaxation. The introduction of sugammadex, a cyclodextrin reversal agent, has made reversal of neuromuscular blockade from rocuronium much more predictable than other, historically

used, reversal agents. Short-acting opioid medications can be used during the intraoperative course. Large open abdominal operations can lead to profound hypothermia, especially in elderly patients who have a decreased ability to shiver. Warming devices should be applied in the preoperative period and continued in the operating room.[45]

The ERAS guidelines recommend using a balanced crystalloid, like lactated Ringer's solution as opposed to normal saline. There is no distinction made between using a balanced crystalloid or colloid solution. It is emphasized that fluids should be given judiciously, according to certain targets including stroke volume, stroke volume variation, cardiac index, cardiac output, and/or pulse pressure variation. Studies have shown that the use of minimally invasive cardiac output monitors can be used to guide fluid administration.[50]

Postoperative considerations

Postoperative pain can be a huge source of perioperative morbidity in elderly patients. Thoracic epidural anesthesia is often used in the perioperative period for large open abdominal cases because this provides superior perioperative pain control and improved mental status when compared to systemic opioid administration.[52] Due to the hypotension caused by local anesthetic administration, thoracic epidurals are commonly dosed toward the end of the operation when large hemodynamic changes are unlikely.[50] Epidurals should be dosed in the operating room upon completion of the procedure and prior to emergence in order to titrate the local anesthetic dose appropriately. Some anesthesiologists and surgeons are proponents of transversus abdominis plane blocks for the smaller incisions associated with laparoscopic abdominal surgeries, however pain relief is short-acting and other modes of pain control may be required.[45]

Anesthetic considerations for orthopedic surgery

Hip fractures are the second most common reason for hospital admissions in the elderly population.[43] General surgeons are often managing these patients at trauma centers. These injuries are associated with high mortality and morbidity as well as considerable hospital costs.[43,53]

Postoperative complications occur in 20% of patients who have undergone surgery for a hip fracture and one-third of all hip fracture patients die within 6 months of their procedure.[54] This is most likely due to the increased age of this population and the associated comorbidities. The usual preoperative evaluation of elderly patients should also include a thorough investigation of the mechanism in which the patient suffered the fracture, cognitive status, medications (especially anticoagulants), and nutritional status. Due to the poor prognosis associated with hip fractures, advanced directives and code status should be discussed.[55]

Although some practice guidelines have recommended neuraxial anesthesia (NA) for patients undergoing hip fracture surgery, the subject of NA vs GA is controversial. NA advantages include decreased blood loss, decreased risk of deep venous thrombosis, decreased incidence of PONV, decreased risks of pulmonary compromise, analgesia in the immediate postoperative period, earlier mobilization, and quicker return to baseline cognitive function.[43,45,56] GA may lead to better perioperative hemodynamic stability in elderly patients.[57] Patients who are anxious about being "awake" during surgery may prefer GA. GA, however, may increase the risk of cognitive dysfunction, PONV, and delayed mobilization in elderly patients.[45] A 2018 population-based cohort study found that elderly patients having emergency hip fracture surgery at hospitals with a low proportion of neuraxial use had decreased rates of survival.[54] Other studies draw similar conclusions and show that patients fare better with NA as opposed to GA. However, another study in 2014 linked NA to a longer length of stay in elderly patients, with no decrease in mortality when compared to GA.[58] Patients with NA will have some analgesic benefit immediately postoperatively but may be given a combination of acetaminophen, NSAID, or opioid patient-controlled analgesia for long-term postoperative pain management as part of a multimodal regimen.[43,45]

Anesthetic considerations for urogynecologic surgery

Common urogynecologic procedures in the elderly include transurethral resection of the prostate (TURP), the removal of bladder tumors, ureteral obstructions, cystocele/rectocele repairs, and hysterectomies. These patients often have other comorbidities including pulmonary and cardiovascular disease, and may be on antiplatelet or anticoagulant medications. The major decisions for anesthesiologists include determining the type of anesthesia (general vs regional) and postoperative pain management.[45]

Benign prostatic hyperplasia is common in elderly patients and often requires surgical intervention. Minimally invasive techniques include transurethral microwave thermotherapy and transurethral needle ablation. Surgical interventions include transurethral incision of the prostate and TURP. Newer surgical techniques use laser therapy and are associated with decreased operating time and bleeding.[60]

Preoperative evaluation should include a detailed history of coexisting diseases, with special attention to cardiovascular and pulmonary disease, and current medications. Patients on antiplatelet medications for cardiovascular disease should be seen by their cardiologist or prescribing physician to weigh the risks and benefits of holding this medication for the procedure. If held, antiplatelet medications should be restarted as soon as possible postprocedure. Preoperative labs should include a metabolic panel, a complete blood count, coagulation studies, and a urinalysis to identify any urinary tract infection.[59]

Elderly patients have a blunted myocardial beta-receptor response secondary to decreased sympathetic tone, which can make the hemodynamic response to NA unpredictable.[61] New advances in GA and surgical techniques have decreased the need for NA for patients undergoing TURP procedures. Patients undergoing an open prostatectomy may benefit from an epidural for postoperative pain control. Due to the high risks of bleeding in these patients, 2 large bore IVs are recommended as well as a balanced salt solution for goal directed fluid therapy.

TURP syndrome is a dreaded intraoperative complication associated with conventional TURP procedures. The frequency varies between 0.18% and 10.9% in patients undergoing the procedure.[62] During the procedure nonconducting irrigating solutions like mannitol, glycine, and sorbitol are used to improve visualization in the surgical field while allowing use of the electrocautery during the procedure. These solutions are hyponatremic and are absorbed via the prostatic venous sinuses and/or via the retroperitoneal spaces. This can lead to systemic hyponatremia, intravascular volume expansion, hyperglycinemia, and hyperammonemia.[62]

Symptoms include confusion, dizziness, agitation, nausea, vomiting, visual disturbances, and seizures. TURP syndrome is associated with significant morbidity and careful attention must be paid to allow early recognition and treatment. Spinal anesthesia was the mainstay of treatment for a number of years as patients could inform the provider of any early symptoms.[59]

Following TURP, patients frequently suffer from bladder spasms, which respond well to multimodal pain control. These patients should be monitored closely for any signs of hyponatremia or fluid overload, especially cases in which resection time was greater than 1 hour. Those undergoing open prostatectomy may benefit from preoperative thoracic epidural placement with patient controlled epidural analgesia postoperatively.

In the elderly population hysterectomies are often performed for the treatment of endometrial cancer or irregular postmenopausal bleeding. Surgical interventions include open abdominal, vaginal, or laparoscopic depending on the pathology and surgeon. As with other surgical procedures in the elderly, it is important to get a detailed history of the patient's current illness as well as any coexisting diseases. A complete blood count, coagulation studies, and type and crossmatch are warranted.[61,62]

Depending on the patient and the surgical approach, a regional or general anesthetic can be used for a hysterectomy. Intraoperative concerns for elderly women undergoing hysterectomies include bleeding, volume loss for large abdominal incisions, and pain control. The use of the current ERAS guidelines and intraoperative multimodal pain management have been shown to decrease postoperative complications, like chronic pain, in this patient population. During the intraoperative period pain control should be treated pharmacologically with drugs like

ketamine, acetaminophen, and ketorolac in addition to regional techniques like transversus abdominis plane blocks or NA.[62]

Decreased perioperative opioid use decreases the risk of PONV. Intraoperative multimodal pain control techniques should be continued in the postoperative period. Patients undergoing large abdominal incisions may benefit from an epidural, which can be used both intra- and postoperatively.[62]

Conclusion

Providing anesthesia for elderly patients can be challenging due to the decrease in their overall functional reserve. It is important that prior to any surgical procedure there is a discussion between the surgeon and anesthesiologist to develop the best perioperative plan for each patient. There should also be a thorough discussion between the anesthesiologist and the patient or patient's family regarding postoperative expectations.

Anesthesiologists should use the mini cognitive exam to assess the baseline cognitive function of elderly patients as they are at an increased risk for postoperative cognitive dysfunction (POCD). Approximately 25% of all elderly patients having major surgery exhibit cognitive decline. Researchers are unsure of the exact causes of POCD but some evidence points to anticholinergic drugs, hypotension, general anesthetics (volatile gases), age, and the stress response (steroids, surgical). There is no specific treatment for POCD, although avoiding anticholinergic drugs, temperature control, pain control, and euvolemia are important.[45]

As people live longer, the number of elderly patients having surgery will continue to grow. Identifying those patients at increased risk for postoperative complications is important during the preoperative period. The use of current ERAS guidelines and a perioperative multimodal pharmacologic approach can decrease postoperative complications.

Approach to colon and rectal cancer in geriatric patients

Eric Girard, MD

Colorectal cancer (CRC) is the second leading cause of cancer deaths in the United States, with the majority of diagnoses occurring in the geriatric population. This population has been steadily growing due to the aging of the baby boomer generation. According to the United States Census Bureau, 49.2 million people are over 65 years old. CRC carries a 4.2% lifetime risk, which in 2015, meant an estimated 1.3 million people were living with CRC in the United States. The SEER Program estimates 140,250 new cases per year, which makes up 8.1% of all new cancer diagnoses. They estimate 50,630 deaths, which is 8.3% of all cancer deaths.[63]

The distribution of cancer varies by race and age. The highest incidence is seen in African Americans, American Indians, and indigenous Alaskans.[63] It is not surprising that the 65- to 74-year-old age group has the highest incidence of diagnosis of CRC. Approximately 56% of all CRC cases are in the geriatric population, however this group accounts for 69% of deaths. The overall 5-year survival of combined stages is 64.5%.[63] The magnitude of this disease is significant, as an estimated $14 billion were spent on the direct medical costs of CRC in 2010. The need for appropriate care of this specific population of patients is necessary, as geriatric patients are often excluded from clinical trials. This raises concerns about making treatment decisions for geriatric patients based on the broadly applying data from large clinical trials that may exclude a large proportion of geriatric patients.[64]

Colorectal cancer pathways

We now understand that CRC develops in a multifactorial manner. There are 3 well-defined pathways to developing CRC: chromosomal instability, microsatellite instability (MSI), and

hypermethylation. Approximately 75% of CRC is derived from chromosomal instability and it is the most common form of genomic instability.[65] Examples of chromosomal instability are physical losses of portions of chromosomes during mitosis that lead to loss of heterozygosity.[65]

The loss of heterozygosity pathway is an accumulation of a well-defined set of mutations that lead to uncontrolled proliferation, loss of response to cell signaling, and, eventually, adenocarcinoma. This mutation sequence begins with a mutation in the adenomatous polyposis coli (APC) tumor suppressor gene. The mutation in APC leads to accumulation of Beta-catenin and drives cellular proliferation. Germline mutations in the APC gene are responsible for the inherited familial adenomatous polyposis. The APC mutations tend to cause adenomatous polyps. The second gene in the sequence is the KRAS oncogene. A mutation in the KRAS oncogene causes a constantly stimulated epidermal growth factor receptor.[66] This occurs through the MAPK signaling pathway and leads to uncontrolled cell growth. This mutation is present in 40% of CRC cases. The final gene noted in the sequence is the p53 gene. This is a tumor suppressor gene that halts the cell cycle at G1/S phase to allow for repair of genetic mutations, or if unsalvageable, induce apoptosis. It is uncommonly found in adenomatous polyps (5%) but is present in 75% of colorectal adenocarcinomas.[67]

The second pathway to develop CRC is MSI. MSI occurs with a loss of DNA mismatch repair (MMR) genes. Microsatellites are repetitive noncoding sequences of DNA, usually 1-4 nucleotides that are often repeated with significant errors. When MMR genes are not working, these repetitive regions of DNA elongate and lead to unstable MSI, or MSI-high regions. These longer noncoding regions are seen on PCR and can be a harbinger of DNA replication infidelity and mutagenesis. The loss of MMR genes has been linked to Lynch syndrome. The important tumor suppressor genes BAX, TGF-Beta receptor II, and IGFR2 are known to contain microsatellites and are often rendered nonfunctional with loss of MMR genes.[68]

The third pathway is the serrated polyp pathway, which occurs through hypermethylation of DNA promoter regions. It is an example of how a loss of access to the gene, but not the genetic information itself, can occur and lead to cancerous change. When hypermethylation of the promoter region occurs, it effectively prevents transcription of DNA to mRNA. Cytosine nucleotides are common targets for methylation. These are referred to as CpG Islands (or heavily concentrated areas of cytosine nucleotides). These have been noted in the promoter regions of MLH1, a mismatch repair gene.[69] The sequence of methylation that leads to adenocarcinoma from serrated polyps begins with an initial inactivation in the BRAF gene. This causes aberrant crypt foci that can be visualized endoscopically and are often found to be hyperplastic polyps. Loss of BRAF creates a state of latency where cells no longer replicate. This is due to the protective effect of the p16 gene, but with methylation of the p16 promoter region, the serrated polyps grow in size. Eventual methylation of MLH1 leads to an adenocarcinoma. The progressive promoter region methylation of BRAF, p16, and MLH1 have been implicated in 20% of CRC and 85% of all MSI-high CRC.[70]

Screening guidelines and the aging population

The geriatric population, from ages 65-75 years, have shown significant benefits of screening for CRC with a reduction in the incidence and risk of death. The American Cancer Society and United States Preventative Task Force recommend individualized screening for patients over the age of 75.[71] The decision should be based on an individual's overall health and prior screening history. It goes on to recommend screening for people who have never had a colonoscopy, are healthy enough to undergo treatment for CRC, or do not have comorbidities that would significantly limit their lifespan. The United States Preventative Task Force does not recommend screening over the age of 85 years.[71]

For patients aged 65-75 years old, there are multiple recommended options for screening patients for colon and rectal cancer. The most logical approach is to separate the options into 2 groups: structural studies and fecal studies. Regardless of the chosen modality, if an abnormal test occurs, then a full colonoscopy is necessary. The fecal studies are useful if a positive result

is obtained, but they have limitations. The fecal immunochemical test (FIT) testing sensitivity rate for known invasive adenocarcinomas is 79%. with combined FIT-fecal DNA, the sensitivity increases to 92%. However, the specificity is worse with combined FIT-fecal DNA than regular FIT.[72] Fecal studies unfortunately fall short in detecting early adenomas. In 2017, Jean Shapiro led a study looking at polyps larger than 1 cm, sessile serrated polyps with dysplasia, villous adenomas, tubulovillous adenomas, adenomas with high grade dysplasia, or invasive carcinoma. In this study of 1006 screening colonoscopies, advanced neoplasia was found in 55 people and 2 were invasive CRC. The study found that InSure FIT and OC Fit have a sensitivity of 26% and 15% for advanced colorectal neoplasia. Hemoccult Sensa had a sensitivity of 7.4%. Patients tolerate fecal studies well since no bowel preparation is necessary.[73]

Imaging studies improve upon fecal studies in their ability to detect structural abnormalities larger than 1 cm. CT colonography has replaced the double contrast barium enema since it is more effective and better tolerated than a barium enema. It has a sensitivity of 82%-92% for detecting polyps larger than 1 cm in size. The limitations of CT colonography include needing a bowel preparation, frequent need for follow-up colonoscopy, and failure to detect flat lesions.[72]

There are multiple benefits of colonoscopy over other screening modalities. It is used to both detect and tattoo advanced neoplasms and remove polyps with malignant potential. In adults older than 55 years, there has been a recent decline in the incidence and mortality of CRC. Half of the decrease is attributable to modifications of risk factors, but 33% of the decrease can be credited to increased screening.[71] From 2005 to 2014, the incidence in colon and rectal cancer decreased by 2%-3% annually. This decline is thought to be related directly to increase in the use of colonoscopy as a screening tool, with an increase from 20% in 2000 to 60% in 2015.[63] Corley and colleagues. published a study looking at the adenoma detection rate in 314,872 colonoscopies and its direct correlation to the risk of invasive adenocarcinoma. It showed that the adenoma detection rate was inversely associated with the risk of interval CRC, advanced stage interval cancer, and fatal interval cancer. This study highlights the benefit of a thorough, high quality colonoscopy.[74]

We know that screening works to diagnose and prevent CRC, but the benefits are reduced in the geriatric population over the age of 75 Years. The framework to consider screening relies on knowing the following 3 factors of your patient: life expectancy, risk of death from cancer, and outcomes of screening.[75] The 3 tenets of screening are altered in the extreme elderly: there is a decrease in life expectancy, decrease in the risk of death from colon cancer, and an increase in adverse outcomes from screening.

Walters and Covinsky used data from the SEER database to measure the life expectancy of the top 25% and 50% quartiles from ages 70 to 95 Years in an increase in adverse outcomes in 5-year increments. Women had higher life expectancies than men. Eighty-year-old women in the top quartile of health were expected to live 13 additional years; 85-year-old woman had a life expectancy of 9.6 years, 90-year-old women had a life expectancy of 6.8 years, and 95 year olds had a life expectancy 4.8 years. They compared the life expectancy to the risk of death from CRC. They found that the risk of death from CRC decreased from 3% in an 80-year-old woman to 1.8% in a 90-year-old woman in the top quartile of health.[75] Robert Schoen makes an argument that there would be no benefit for a polypectomy in the over 80-year-old age group since the long-term benefit is negated by other causes of mortality.[76] He put it eloquently when he wrote: “As we age, various causes are in a sense competing to contribute to our mortality, including cancer and nonmalignant etiologies. However, as our life expectancy decreases, the risk that our death will be resulting from colorectal cancer decreases.”[76]

The decreasing life expectancy and risk of CRC death translates to an increase in the number of screening colonoscopies needed to prevent a cancer death in the extreme elderly. In patients aged 85-89 years, 133 people need to be screened to prevent 1 cancer death. In comparison, 70- to 74-year-old patients need 42 screening colonoscopies to prevent 1 cancer death.[71] Not only are the benefits of colonoscopy decreased, but the complication rates in the elderly are significantly higher, specifically the risk of perforation. The risk of perforation nearly quadruples from 0.75 per 1000 in patients 65-69 years old to 2.95 per 1000 in patients older than 75 years.[75]

Table 11
Screening options for colorectal cancer.

Screening Options	Timing
Colonoscopy	Every 10 y for average risk Every 5 y for positive family history, 2-3 adenomatous polyps Every 3 y for personal history of CRC, dysplastic, more than 3 polyps, polyps greater than 1 cm in size Every year for hereditary cancer syndromes
CT colonography (virtual colonoscopy)	Every 5 y
Flexible sigmoidoscopy	Every 5 y
Double contrast barium enema	Every 5 y
Guaiac fecal occult blood test	Every year
Fecal immunochemical test	Every year
Stool DNA (sDNA) test	Every 3 y

In conclusion, the decreased life expectancy and risk of death lead to a decreased screening benefit. In addition, there is an increase in adverse outcomes. It is clear that judicious use of colonoscopy in the older population is necessary (Table 11).

Preoperative evaluation

We try and approach every suspected cancer diagnosis the same way: name, stage, treat. The staging for colon and rectal cancer is no different. Colon cancer requires a carcinoembryonic antigen level, CT scan of the chest, and a CT scan of the abdomen and pelvis with intravenous contrast. Rectal cancer needs an additional evaluation of the mass with a pelvic MRI or an endorectal ultrasound. A positron emission tomography CT is not standard for staging, but can be helpful if questionable lymphadenopathy, peritoneal implants, or an unexplained elevated carcinoembryonic antigen are noted. Once the determination of a colectomy, low anterior, or abdominal peritoneal resection is indicated, the focus becomes a comprehensive assessment of the patient's comorbidities and his risk for surgery.

Choosing the right operation for the elderly patient

There is a bias that elderly patients are less likely to be offered a standard treatment for rectal cancer that stems from outdated reports demonstrating a higher perioperative mortality. Recent data suggest that elective colorectal surgery is safe for the elderly (with mortality rate as low as 4.7%). It should be noted that although operative mortality does not differ significantly between old and young populations, the overall survival for the elderly with rectal cancer is worse. This is probably due to added complexity with increasing comorbidities.[77]

Prior to having the discussion about surgical options, an assessment of fecal incontinence and decreased mobility must be made. Restoring intestinal continuity with a low anastomosis, in the setting of preoperative incontinence, will likely worsen incontinence. Mobility becomes an issue with fecal urgency and the inability to delay bowel movements past 1-2 minutes. This may progress to patients being homebound from fear of public embarrassment, worsening their QOL.[77]

It is important to note that patients who undergo either low rectal anastomosis or a colostomy have a period of initial adjustment and decreased QOL while they adapt to their new normal. In the long term, most patients return to the same or better QOL than preoperatively, but these are usually not related to their choice of anastomosis or colostomy. The most important factors for QOL were related to cancer recurrence or metastasis, radiation, complications of surgery or radiation, decreased functional status, and comorbidities.[78]

Patients with ostomies need to deal with public sounds and smells. They have difficulty using public restrooms, since they often need access to a sink to rinse a bag prior to disposal

or reattachment. The loss of the ability to control bowel function in private is a common cause for decreased QOL. In patients with sphincter sparing surgery, low anterior resection (LAR) syndrome causes impairment. This is manifested by fecal urgency, clustering of bowel movements, and incontinence episodes requiring pads, diapers, or change of clothes. Patients often complain of rectal pain, diarrhea, constipation, and incontinence. Downing and colleagues reported postoperative complete control after rectal surgery in 34.4% of patients and complete incontinence in 13% of patients.[79] Overall, 66% of patients undergoing surgery for rectal cancer did not have complete control of their bowels.[79] How and colleagues published that 53% of patients experienced nocturnal incontinence and 30% of patients were incontinent to liquid or solid stool after sphincter sparing operations. If recovery of bowel function occurs, it typically happens at 6-7 months after surgery. However, some patients may spontaneously improve in their function at 12-18 months. Either way, sphincter-sparing surgery can lead to a decrease in QOL through increased rectal pain, embarrassment from fecal incontinence, and decreased social well-being.[80]

After restoration of intestinal continuity with a low anastomosis, functional outcomes are significantly variable. These outcomes are related to preoperative function, distance from anal verge, radiation, anastomotic healing and reconstruction, but not age. Hida and colleagues looked at patients that underwent a LAR with colonic pouch within 4 cm of the anal verge and noted that they were more likely to have dysfunction when compared to an anastomosis 5-8 cm from the anal verge. No difference in function was seen when the patients were stratified into 3 groups by their ages: less than 59, 60-74, and greater than 74 Years.[81]

Certain anastomotic techniques have been shown to improve QOL in the early postoperative period. Brown and colleagues used the NSQIP database to compare 746 patients with a colonic J-pouch to 624 patients with a straight anastomosis. They found that there were fewer complications when performing colonic J-pouches, but this effect was negated if the patient had undergone radiation.[82] The other option for anastomotic technique is an end-to-side Baker's anastomosis. This showed functional outcomes equivalent to a colonic J-pouch in a Cochrane review of 4 randomized trials.[83] This would be an option if the pelvis is too narrow to accommodate the size of the colonic J-pouch or there is inadequate length of the bowel to make the 6-8 cm J-pouch. In the end, if length is an issue, the tenets of tension free anastomosis, adequate blood supply, and appropriate mesenteric orientation are essential in creating a healthy anastomosis and should not be compromised. An anastomotic leak will lead to a drastically worse QOL than LAR syndrome.

In summary, the choice of operation should be individualized based on the patient's anatomy, pelvic floor function, and preference. There is improved function for the first 2 years with a colonic J-pouch or an end-side anastomosis. It is important to reinforce that there will be a period of adjustment regardless of the chosen operation.

Geriatric considerations in adjuvant therapy

The geriatric population has specific challenges with regards to adjuvant therapy related to age-related organ dysfunction, increased frequency of comorbidities, QOL issues, and functional reserve. Age-related organ dysfunction plays a major role in the choice of chemotherapeutic agents. For example, capecitabine is cleared renally and should not be given if the glomerular filtration rate is less than 30 mL/min. Fluorouracil and capecitabine can both induce vasospasm and induce angina or heart failure. Bone marrow reserve weakens as we age, leading to a greater risk of cytopenias.

Physical function is often used to guide treatment decision. Patients who are frail with functional impairment are not appropriate candidates for chemotherapy. There is agreement that active, fit elderly patients should be offered adjuvant therapy. The Cancer Aging Research Group model helps delineate who will likely develop grade 3-5 toxicity from chemotherapy. Anemia, renal dysfunction, and frequent falls are more heavily weighted, each with a value of 3 points. If a score greater than 10 is obtained, there is an 83% chance of severe or fatal toxicity (Table 12).

There is a clear benefit to offering stage III patients adjuvant therapy. There is a 30% reduction in the risk of disease recurrence and a 22%-32% reduction in mortality with giving

Table 12
Cancer Aging Research Group (CARG) scoring system to predict grade 3-5 toxicity with chemotherapy.

Risk Factor	Score
Age ≥ 72 y	2
GI or GU cancer	2
Standard dose chemotherapy	2
Number of chemotherapy drugs	2
Hemoglobin < 11 mL/min (male) < 10 g/dL (female)	3
Creatinine clearance < 34	3
Hard of hearing	2
Number of falls in 6 mo (>1)	3
IADL: taking medications, with help, unable	1
Walking 1 block, limited	2
Depression, decreased social activity	1

GI, gastrointestinal; GU, genitourinary; IALL, instrumental activities of daily living.

adjuvant therapy than with observation. High-risk stage II disease is less clear. The MOSIAC trial showed a difference of 75% vs 82% 5-year disease-free survival in observation vs 5-Fluorouracil (5-FU), leucovorin and oxaliplatin (FOLFOX), but that difference was not statistically significant. High-risk stage II disease is defined as one of the following: T4 tumor, inadequately sampled nodes, poorly differentiated tumor, perforation, obstruction, lymphovascular invasion, perineural invasion, or close margins.[83]

The current full regimen is FOLFOX due to superior results in the MOSAIC trial. If oxaliplatin is contraindicated and the tumor is microsatellite stable, then 2 regimens are available and equally effective: fluoruracil and leucovorin, or the other regimen of oral capecitabine alone.[83] Of note, MSI-High tumors are relatively resistant to fluoropyrimidines. The ACCENT database was used to analyze approximately 37,000 patients from 25 randomized trials and showed that early mortality (within 6 months of starting adjuvant therapy) was more prevalent in patients over 70 years old. Thus, 5-FU and leucovorin has become the regimen of choice for patients over 70 years of age. The pooled analysis did not show an increase in the frequency of side effects when patients were grouped by age categories.[84]

The future of geriatric care

As healthcare improves and the global population ages, we need to be prepared to care for our elders. Colon and rectal cancer are common problems surgeons will face in the community. Preoperative preparation of the geriatric patient is a key. Understanding the patients' goals and evaluating their ability to recover from a major operation are essential in having honest discussion about the risks and benefits of any resection. In the operating room, choosing an appropriate operation, whether a stoma for a patient with pre-existing incontinence, or a colonic J-pouch for a LAR, will influence the QOL. Regardless of how you approach the problem, there will always be an adjustment period requiring adaptation to a new routine. Moving forward with appropriate care for the elderly, we should incorporate a big picture perspective, specifically with regards to outcomes.

Emergency general surgery in the geriatric patient

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The United States Census Bureau estimates 15% of the population are over the age of 65 in 2017 and by 2030, more than 20% of the population will be over the age of 65. The volume of elderly patients admitted to the hospital with an emergency general surgery (EGS) diagnosis

Table 13
Top 9 emergency general surgery admission diagnoses 2010.

Diagnosis	Volume (%)	Mean cost per hospitalization ($)	Annual cost (billion US Dollars)
Soft tissue infection	451,511 (17.1)	6,990	3.16
Cholecystitis	324,897 (12.3)	12,885	4.19
Intestinal obstruction	274,044 (10.4)	9,204	2.52
Pancreatitis	237,481 (9.0)	7,218	1.71
Diverticular disease	205,013 (7.8)	8,573	1.76
Appendicitis	177,961 (6.7)	10,338	1.84
Gastrointestinal bleeding	163,307 (6.2)	12,171	1.99
Peptic ulcer disease	149,272 (5.7)	14,437	2.15
Abdominal pain	130,561 (4.9)	5,789	0.76
Total	2,114,047 (81%)		20.08

Reprinted with permission from Ogola and colleagues.[86]

Table 14
Top 7 emergency surgery procedure group and primary diagnoses.

ICD-9-CM	Procedure group	Top primary diagnosis (%)	Mortality (%)/ complication (%)	Count (%)
47.0×	Appendectomy	Acute appendicitis (71.9%)	0.08/7.27	682043 (32.48)
51.2×	Cholecystectomy	Acute cholecystitis with stone (49.5%)	0.22/8.06	619197 (29.49)
45.7×	Partial colectomy	Diverticulitis (28.5%)	5.33/42.8	138992 (6.62)
54.5×	Lysis of adhesion	Adhesion with obstruction (52.5%)	1.59/28.09	102856 (4.90)
45.6×	Small bowel resection	Adhesion with obstruction (23.6%)	6.47/46.94	78478 (3.74)
44.4×	Surgical management of peptic ulcer disease	Duodenal ulcer (42.2%); Gastric Ulcer (26.7%)	6.83/42.00	31571 (1.50)
54.1×	Laparotomy	Acute vascular insufficiency of intestine (12.3%)	23.76/40.15	9418 (0.45)

Reprinted with permission from Scott and colleagues.[87]

and those requiring surgery is also increasing. EGS admission diagnoses and procedures were poorly defined until recently. The definition of EGS allows researchers to gather data to improve risk prediction and quality improvement. In 2013 the American Association of the Surgery of Trauma published, for the first time, a list of 621 ICD-9 diagnosis codes requiring emergency surgical evaluation.[85] The list was further refined by Ogola and colleagues to produce a list of 9 EGS diagnoses that accounts for 80% of all EGS admissions and 74% of annual cost[86] (Table 13).

In 2016, Scott and colleagues published a list of 7 procedure groups that collectively accounts for 80% of all EGS procedures used to treat the EGS diagnoses as defined by AATS.[87] The 7 general surgery procedure groups also collectively accounts for 80% of deaths, complications, and inpatient costs resulting from EGS procedures (Table 14). In this study, roughly 30% of patients undergoing emergency surgery were older than 60 years. The annual estimated cost was $6 billion in 2008 and $6.6 billion in 2010. Small bowel resection had the highest complication rate (47%) while laparotomy for ischemia had the highest mortality rate (40 %).

Annually, approximately 1.5 million Americans over the age of 60 years were admitted with EGS diagnoses. Of these, over 25% required emergency surgery.[87] Ogola and colleagues analyzed 2.6 million admissions with EGS diagnoses and found an estimated cost of $28.37 billion in 2010. This is more than the cost of many common medical admissions: acute myocardial infarction (MI) ($11B), pneumonia ($10.6), COPD ($5.2B), and diabetes ($4.9B).[3] Patients 60 years or older account for more than half of the $28.37 billion.[86]

EGS admissions increased by 27% and EGS operative volume increased by 32% from 2001 to 2010.[85] By 2030, EGS admission will cost an estimated $41 billion; 60% of that cost will go toward the care of patients older than 65 years. This is likely an underestimation and also does not account for posthospital costs such as durable equipment, short term rehab, visiting nursing care, etc.[86]

EGS procedures in the geriatric patient population have higher mortality, ICU admissions, multiple organ failure, longer hospital stays, and higher rate of transfer to rehabilitative facility

after discharge. Emergency laparotomy carries a 15%-20% mortality. For patients over 80 years old, the mortality rate increases to 20%-40%. The most common cause of mortality is postoperative sepsis.[88] Almost 50% of nonagenarians are dead within a year after an EGS procedure.[88] Age alone is a predictor of increased mortality in EGS procedures that range from simple laparoscopic appendectomies to complex exploratory laparotomies.[85] Frailty is a better predictor of adverse outcome than age.[16] However, none of the frailty screens accounts for the how the acute surgical disease affects the patient's condition. There is no consensus on which frailty measurement works best for EGS.[20] ASA score and frailty combined are better at predicting outcome than each alone.[16,20] Research to define prognostic factors and development of a simple risk calculator to guide surgical decision making and counseling in geriatric EGS patients is lacking.[89]

Perioperative considerations

Preoperative

The process of diagnosis and treatment for geriatric patients is complicated by age. The history may be convoluted or difficult to obtain. Physical examination may be unreliable. All preoperative evaluations of geriatric patients should include a detailed medical/surgical history, goals of care, mental capacity, depression, delirium risk, substance abuse, and nutritional status. Up to 44% of postoperative surgical ICU patients experience delirium.[90] The prevalence of depression is as high as 10% in people over the age of 70 years. Depression is associated with increased narcotic use and increased length of stay.[28] The prevalence of alcohol abuse is as high as 14% in men older than 65 years. The rate of malnutrition in the geriatric population ranges from 5.8% in the community to 50% in rehabilitation facilities. Substance abuse or malnutrition is associated with increased morbidity, length of stay, wound infection, sepsis, and pneumonia.[28]

Goals of care discussion is essential for the geriatric EGS population. Discussion about risks of surgery should include pressure ulcers, fall risk, infection, malnutrition, functional/mental decline, and loss of independence. Palliative care specialists are especially helpful and should be involved early in this process.[1]

Patients with preoperative signs of sepsis should have broad spectrum antibiotics administered. Additionally, goal directed resuscitation to restore euvolemia, pressor support, source identification, and prompt source control, if feasible, must be initiated as outlined by the Surviving Sepsis Campaign.[90]

Intraoperative

Intraoperative considerations include proper positioning and padding to prevent pressure ulcers and nerve injury. Hypothermia is associated with increased risk of cardiac events, infection, and coagulopathy. Geriatric patients are especially prone to hypothermia due to the loss of thermoregulation, decreased muscle mass, and decreased metabolism. Any surgical procedure lasting longer than 30 minutes should include core temperature monitoring. Patients should be kept normothermic using warm saline for irrigation and infusion, heating blankets, and warm operating environments.[1]

Postoperative

The ACS have long recognized the need for research and a multidisciplinory approach to improve the outcome of geriatric EGS patients.[91] Postoperative geriatric patients have high risk

Table 15
Elements of ELPQuiC.

1. Policy for early assessment and graded escalation for senior clinical evaluation and ICU referral
2. Early broad spectrum antibiotic if sepsis or suspect spillage
3. In the operating room within 6 h, or sooner, after making the decision for surgery
4. Goal-directed resuscitation as soon as possible
5. Admit all patients to the ICU after emergency laparotomy

ICU, intensive care unit. Reprinted with permission from Eveleigh and colleagues.[92]

of multiorgan failure, ICU admission, delirium, and polypharmacy. Geriatric patients are at very high risk of postoperative delirium. Delirium risks include age older than 65 years, chronic mental decline, poor vision or hearing, severe illness, and infection. Rectifiable causes of delirium include: polypharmacy, pain, hypoxia, pneumonia, infection, electrolyte imbalance, urinary retention, fecal impaction and hypoglycemia. Preventive strategies include early physical activity, cognitive reorientation, family at the bedside, sleep hygiene, and minimizing tethers (Foley, EKG leads, IV line) and should be implemented for all geriatric patients.[91] A multidisciplinary team approach (geriatrician, cardiologist, physical therapy, nutritionist) in the management of delirium, pain control, polypharmacy, and early mobilization improves outcomes.

Implementation of a care bundle may also improve outcomes. The Emergency Laparotomy Pathway Quality Improvement Care Bundle (ELPQuiC) (Table 15) resulted in a significant decrease in 30-day mortality for emergency laparotomy without increasing hospital costs. In a multicenter study, Huddard and colleagues demonstrated a decreased 30-day mortality rate from 14% before care bundle implementation compared to 10% after.[92]

These studies did not specifically evaluate how the care bundle affects mortality in geriatric emergency laparotomy patients. Further study is necessary for proof of concept in the geriatric population.

Common general surgery emergencies

Small bowel obstruction

Small bowel obstructions (SBO) in the elderly has a variety of etiologies including adhesions, hernias, and malignancy. The demographics and presentation of geriatric patients with bowel obstructions are not significantly different from younger age cohorts.[93] Admission to a surgical service is associated with improved outcomes in both older and younger patients, and both groups of patients have similar response rates to conservative management: nothing by mouth, nasogastric decompression, and fluid resuscitation.[93]

A variety of factors have been identified as predictors of morbidity and mortality following emergent surgical management of SBO in the elderly. Age alone is associated with higher mortality following emergency laparotomy for bowel obstruction.[93] Older patients are more likely to have cardiac complications, although they are also more likely to have pre-existing cardiac conditions.[86] Other predictors of morbidity that have been identified include male gender, preoperative performance, chronic renal disease, COPD, and perioperative blood transfusion.[94] Older patients are also more likely to require discharge to a rehabilitation or other healthcare facility after laparotomy. Timing of operation is generally identical across age cohorts, with similar proportions of patients requiring an operation at time of presentation, and similar proportions failing initial medical management of SBO. Geriatric patients should have preoperative risk stratification and medical optimization at time of presentation. This allows the surgical team to appropriately counsel the patients about operative risks and have frank discussions about goals of care, particularly in elderly patients with obstruction due to malignancy.

Hernias

The relative incidence of hernia types across the population does not vary significantly with age, although patients age 65 years and older have an increased incidence of needing emergency hernia repair. The 2 most common hernias requiring emergency operative repair are inguinal hernias and femoral hernias.[85] Evidence suggests elective repair for symptomatic hernias will decrease the risk of bowel resection due to strangulated hernia. However, the proportion of patients who undergo watchful waiting of hernias increases with age due to medical comorbidities.[86]

Patients presenting for emergency hernia repair may have signs and symptoms of SBO, incarceration, or strangulation, and require swift intervention. For patients with concern for strangulation or bowel ischemia, there is often no time for medical optimization. Risk factors for postoperative morbidity and mortality include age, heart failure, decreased functional status, peripheral vascular disease, ascites, and leukocytosis.[8] Understanding the predictors of morbidity and mortality associated with emergency hernia repair can help healthcare providers counsel patients about the risks of surgery.

Acute mesenteric ischemia

Pathophysiological mechanisms of acute mesenteric ischemia, including arterial embolism, arterial or venous thrombosis, and other nonocclusive pathologies, are more prevalent with advancing age.[85] Consequently, the incidence of acute mesenteric ischemia increases exponentially with age.[95] History of weight loss, abdominal pain, and food fear may be present but difficult to illicit. Other clinical features like rising lactic acidosis, leukocytosis, and eventual hypotension are more indicative of intestinal necrosis progressing to intra-abdominal catastrophe.[95]

There is a growing body of evidence for the utility of D-dimer as a screening tool when considering acute mesenteric ischemia, with sensitivities ranging from 60% to 84.6% in select patients.[96] Elevated D-dimers in patients with a history of atrial fibrillation suggests further evaluation is necessary.[96] For geriatric patients with a high suspicion for acute mesenteric ischemia, early evaluation with early arterial and venous phase CT is paramount.[95,96] Thorough examination of the resultant images is crucial, as acute superior mesenteric artery occlusion and signs of bowel ischemia are frequently missed on the initial interpretation.[96]

The initial treatment includes hemodynamic stabilization and fluid resuscitation.[95] The approach to treatment depends entirely on the underlying pathology. For cases of arterial embolization, open surgical embolectomy is preferred, with or without resection of compromised bowel.[96] In some cases, percutaneous endovascular approaches can be utilized if identified early in the course of disease, with studies showing decreased incidence of mortality, bowel resection, and use of total parenteral nutrition (TPN).[85,96] For nonocclusive disease, correction of the underlying mechanism is the primary treatment focus. In patients with mesenteric venous thrombosis, conservative management with anticoagulation, bowel rest, antibiotics, and careful observation may be adequate.[95]

Diverticulitis

Classically, diverticular disease is a disease of the elderly. Diverticulosis is rarely present prior to the age of 40 years, and 80% of patients over 85 years old have some degree of disease. Of those with diverticulosis, only 20% will progress to diverticulitis.[97] Admissions for both uncomplicated and complicated diverticulitis are becoming increasingly common. With an ever aging population, emergency management of diverticulitis will become increasingly common.

Western populations tend to have diverticular disease present in the descending and sigmoid colon. Consequently, when inflamed, these patients present with left lower quadrant pan, fevers,

and leukocytosis. Disease progression can result in perforated viscus, generalized peritonitis, and abscess formation. Treatment can be initiated based on clinical suspicion, but the preferred imaging modality for staging purposes in the emergency setting is CT of the abdomen, which has a sensitivity and specificity of 94% and 99%, respectively.[98]

The mainstay of conservative management is antibiotics, bowel rest, fluid resuscitation, and trying to avoid surgery in an acute setting. Hemodynamically unstable patients with peritonitis or sepsis, or patients with symptoms that do not improve with antibiotics will require surgery. The geriatric patients have worse outcomes following emergency operation for acute diverticulitis, with advanced age being an independent risk factor.[98] In general, geriatric patients are at an increased risk of postoperative stroke, cardiac arrest, and renal failure.[85] For those over the age of 80 years, the mortality rate following Hartmann's procedure for acute diverticulitis is estimated to be 20%.[98] For patients over the age of 65 years with end stage renal disease, even elective surgical intervention for diverticular disease carries a significantly increased chance of postoperative morbidity and mortality.[97] These outcomes are significantly worse in the emergency setting.[97]

Elderly patients undergoing a Hartmann's procedure are unlikely to be offered reversal as the second stage of the operation can be associated with additional morbidity and mortality.[77]

Perforated peptic ulcer disease

Perforation remains the deadliest of complications of peptic ulcer disease (PUD), accounting for almost 70% of all deaths from PUD. With the advent of *H. Pylori* eradication and proton pump inhibitors, the incidence of PUD has been decreasing. Conversely, for patients over the age of 60 years, data suggest that the incidence of perforation has increased by an order of magnitude in the last decade.[50] Likewise, geriatric patients with peptic ulcer perforation also have significantly higher mortality rate when compared to their younger cohort.[99]

Prompt diagnosis and intervention is paramount. In an estimated 11% of cases, patients will have symptoms present for more than 24 hours prior to presentation.[99] This delay is a prognostic indicator of poor surgical outcomes. Approximately one-third of these patients will have a known history of PUD and approximately 20% will endorse regular NSAID use.[99]

Although laparoscopy has been studied as a comparable option, open repair via upper laparotomy remains a popular choice for the treatment of perforated PUD, especially in geriatric populations.[100] Open repair has high morbidity and mortality in geriatric populations. A review of 2784 patients with a mean age of 48 years old estimated 30-day mortality following open repair of a perforated peptic ulcer to be 5.8%.[100] In comparison, a 2017 study following a cohort of patients with a mean age of 78 years estimated the 30-day mortality following peptic ulcer perforation to be approximately 18%.[101] Other risk factors that increase elderly postoperative mortality include preoperative steroid use, decreased preoperative independence, or preexisting cardiopulmonary comorbidities.[100,101]

Conclusion

The burden of geriatric EGS on the healthcare system is immense and growing. Despite their growing presence, studies assessing geriatric patients in an EGS setting are sparse. There is a large void to fill in the early identification of at-risk patients and the development of care bundles to improve the outcome. We need to increase resource allocation for research and care of the geriatric EGS patient.

Opportunities for quality improvement in geriatric patients undergoing radical cystectomy and urinary diversion for muscle-invasive bladder cancer

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Bladder cancer is the fourth most common malignancy in men and the ninth most common in women, accounting for an estimated 81,190 new diagnoses in the United States in 2018.[102] Given the average age at diagnosis of 73 years, bladder cancer is most prevalent in geriatric patients (defined as ages 65 years and older). The majority of bladder cancers (approximately 75%) present as nonmuscle invasive disease and do not require radical cystectomy.[102] However, up to a quarter of patients with bladder cancer have de novo muscle invasive disease for which current guidelines recommend cisplatin-based neoadjuvant chemotherapy followed by surgical consolidation.[103]

Radical cystectomy and urinary diversion is a complex operation with a high risk of perioperative morbidity. When strict complications reporting criteria are used, approximately 60% of patients can expect any complication and 90-day readmission rates approach 40%.[104] Therefore, clear opportunities exist for improvement in quality of care for patients undergoing major surgery for bladder cancer. Herein, we describe current outcomes in patients undergoing cystectomy and explore areas for improvement with a focus on geriatric assessment, ERAS protocols, and the role of physician-led quality improvement collaboratives.

Radical cystectomy and urinary diversion: technique and outcomes

Radical cystectomy involves both extirpative and reconstructive components. In men, radical cystoprostatectomy involves removal of the bladder, prostate, and seminal vesicles. In women, anterior exenteration—removal of the bladder, uterus, ovaries, fallopian tubes, anterior vagina, and urethra—is the current standard of care for muscle-invasive bladder cancer. Bilateral pelvic lymphadenectomy is routine for staging purposes.[103]

Urinary diversion can be accomplished in both an incontinent and continent manner. The most common and time-tested diversion is the ileal conduit. Continent diversions including the orthotopic neobladder and the catheterizable reservoir (eg, Indiana pouch) can also be constructed via a variety of techniques. All urinary diversions require removing a segment of bowel on its mesentery, fashioning the diversion from the harvested segment, and reestablishing continuity of the gastrointestinal (GI) tract.

Radical cystectomy and urinary diversion can be accomplished in a robotic-assisted, laparoscopic, or open fashion. Regardless of approach, the morbidity associated with the operation is not trivial. Despite low perioperative mortality (less than 3%) for open cystectomy, complication rates remain high, ranging from 28% to 64% depending on fastidiousness of reporting.[103] Similarly, complication rates for robotic-assisted laparoscopic radical cystectomy and urinary diversion approach 60% with mortality rates of less than 3% at 90 days.[105] A randomized trial demonstrated no difference in 90-day morbidity between robotic-assisted laparoscopic cystectomy (66%) and open cystectomy (62%). However, these numbers likely underestimate the true incidence of postoperative morbidity given that claims data suggest readmissions following radical cystectomy are underreported by as much as 18.5% at 30 days and 23.7% at 90 days due to fragmentation of care.[104] Thus, morbidity after radical cystectomy and urinary diversion is significant and represents an opportunity to improve care.

Radical cystectomy in geriatric patients

There is some evidence to suggest increasing perioperative mortality with advancing age for patients undergoing radical cystectomy. Liberman and colleagues analyzed radical cystectomy outcomes from the SEER database.[106] Of 12,722 patients undergoing cystectomy, 4480 and 1439

were performed in patients ages 70-79 years and 80+ years, respectively. Ninety-day mortality was significantly higher in octogenarians (9.2%; odds ratio [OR] 5.02, $P < 0.001$) and septuagenarians (5.4%; OR 2.8, $P < 0.001$) compared to patients younger than 70 years of age (2%). Similarly, Haden and colleagues reported differences in outcomes among septuagenarians and octogenarians undergoing radical cystectomy from the NSQIP from 2009 to 2013.[107] Mortality rates were higher in the octogenarian group (4.3%) relative to the septuagenarian population (2.3%), although mortality rates in these patients were lower overall than those reported from SEER data.

Donat and colleagues reviewed their institutional experience with radical cystectomy and urinary diversion in 1142 patients, 117 of whom were octogenarians.[108] Octogenarians were less likely to undergo continent diversion (3% vs 40%), resulting in shorter operative times (317 vs 390 min) relative to younger patients. There was no difference in minor (55% vs 51%) or major complications (17% vs 13%) at 90 days postoperatively. However, Donat and colleagues did find a significantly higher rate of neurologic (10.3% vs 3.9%, $P = 0.01$) and cardiac (19.7% vs 9.5%, $P = 0.006$) complications among octogenarians. Although cancer-specific survival at 5 years was similar between the 2 groups (74.3% vs 75.4%), the 90-day mortality rate was again noted to be higher in octogenarians (6.8% vs 2.2%, $P < 0.01$).

A recent systematic review explored the impact of radical cystectomy and urinary diversion on patients 70 years and older.[103] The authors reported no difference in cancer-specific survival for patients 70-79 years of age compared to those younger than 60 years; however, octogenarians had worse cancer-specific survival (OR 1.56-2.54). Although few differences in perioperative complications were observed among the elderly compared to younger patients, the authors did note an increase in mortality rate with advancing age. Median overall survival for the cohort was 16 (IQR 8.8-23.2) months. For patients with muscle-invasive disease, median survival was 6 (IQR 3.3-8.7) months. However, only 11 out of 40 patients (27.5%) with muscle-invasive disease died from bladder cancer. Given the historic median survival for untreated muscle-invasive bladder cancer of 9-12 months, these data offer significant reason to pause prior to offering cystectomy with curative intent in nonagenarians with muscle-invasive bladder cancer.

Optimizing outcomes for geriatric patients undergoing cystectomy

Comprehensive geriatric assessment for patients with cancer

Age is a blunt instrument for clinical decision-making when used in isolation. In 2014, the International Society of Geriatric Oncology (SIOG) updated a CGA in older cancer patients.[109] Critical domains of a CGA include functional status, comorbidity, cognition, mental health status, nutrition, social status/support, fatigue, and polypharmacy. Similarly, the ACS has developed guidelines for optimal preoperative and perioperative care for the geriatric surgical patient.[1] Clearly, there is more to optimizing care than a singular focus on chronological age.

In most reported studies, geriatric assessment has been associated with a reduction in treatment intensity for patients with cancer.[109] However, the extent to which formal geriatric assessment adds actionable information to treatment decisions over normal clinical care has been questioned. Decoster and colleagues examined the influence of geriatric assessment on 930 patients older than 70 years with breast, ovarian, lung, prostate, colorectal, and hematologic malignancies.[110] Geriatric assessment changed treatment decisions in 4.8% (24/505) patients for whom the physicians were aware of the geriatric assessment results. Specific to surgery, only 1.2% of decisions were influenced by formal geriatric assessment. Therefore, work continues to help identify specific factors that may influence treatment intensity (in both directions) with the goal of selecting patients for optimal therapeutic benefit while minimizing harm.

Sarcopenia and albumin levels have been used as a surrogate for frailty in patients undergoing radical cystectomy and urinary diversion. Psutka and colleagues demonstrated that most patients (68.8%) undergoing radical cystectomy are sarcopenic.[111] Moreover, patients with sarcopenia have significantly worse 5-year cancer-specific survival (49% vs 72%, $P = 0.003$) and overall survival (39% vs 70%) relative to nonsarcopenic patients. On multivariable analysis,

Table 16
Components of enhanced recovery after surgery protocol.

1. Educate patients regarding perioperative expectations (preoperative)
2. Optimization of medical conditions and smoking cessation (preoperative)
3. Carbohydrate loading (preoperative)
4. Eliminate bowel prep (preoperative)
5. Reduced fasting time for clear liquids to 2 hours prior to induction (preoperative)
6. Alvimopan in opiate-naïve patients (preoperative)
7. VTE prophylaxis (preoperative)
8. Multimodal analgesia avoiding narcotics, consider epidural (intraoperative)
9. Make smaller incisions (intraoperative)
10. Goal-directed fluid resuscitation (intraoperative)
11. Eliminate nasogastric tube (postoperative)
12. Extended VTE prophylaxis (postoperative)
13. Enteric feeding early (postoperative)
14. Early ambulation (postoperative)
15. Utilize alvimopan (postoperative)
16. Multimodal pain control, avoid narcotics (postoperative)

VTE, venous thromboembolism.

the presence of sarcopenia carried a nearly 2-fold increased risk of all-cause mortality after cystectomy. Low serum albumin has also been associated with an increased risk of morbidity following radical cystectomy. Importantly, both nutritional status and frailty represent potentially modifiable factors. Jensen and colleagues randomized 107 patients to a multidisciplinary rehabilitation ("prehab") program prior to radical cystectomy.[112] The authors demonstrated improvements in postoperative mobilization and ability to perform activities of daily living in the intention to treat analysis; however, this did not translate into differences in length of stay or incidence of postoperative complications.

Geriatric assessment with a focus on modifiable preoperative risk factors may reduce the risk of morbidity following radical cystectomy and urinary diversion. Moreover, it holds the promise of improved stratification for patients who may benefit from more aggressive intervention. Continued work is both ongoing and needed to identify specific modifiable factors that would have the greatest impact on reducing morbidity and mortality after cystectomy in geriatric patients.

ERAS in patients undergoing radical cystectomy

For patients in whom a CGA does not preclude radical cystectomy and urinary diversion, ERAS protocols should be employed (Table 16). Although the exact components of ERAS protocols vary by institution, the evidence supports several themes: preoperative bowel preparation does not appear to have an influence on complications after radical cystectomy. Large and colleagues retrospectively examined 105 consecutive patients with bowel preparation and 75 consecutive patients without bowel preparation prior to radical cystectomy.[113] No difference in hospital length of stay or perioperative complications was observed between the 2 groups. Along the same lines, nasogastric tube decompression also does not influence the presence of ileus after cystectomy. Interestingly, the risk of postoperative ileus was significantly greater in patients who received preoperative polyethylene glycol bowel preparation in this study relative to those using sodium phosphate. Lastly, level 1 evidence exists supporting the efficacy of gum chewing in reducing time to flatus and bowel movement after radical cystectomy.[114] Preoperative nutritional optimization is logical for patients planning to undergo cystectomy. However, few interventions have been evaluated prospectively in bladder cancer patients. Preoperative carbohydrate loading has not been specifically considered in patients undergoing radical cystectomy.

Alvimopan is a peripherally acting μ-opioid receptor antagonist. Lee and colleagues conducted a randomized, placebo-controlled trial to determine the influence of alvimopan on a composite endpoint of time to upper (first tolerance of solid food) and lower (first bowel movement) GI recovery.[115] Patients receiving almivopan had quicker return of bowel function (5.5 vs 6.8 days, $P < 0.001$), shorter mean length of stay (7.4 vs 10.1 days, $P = 0.005$), and fewer

episodes of postoperative ileus (8.4% vs 29.1%, $P < 0.001$). Currently, almivopan is an integral part of radical cystectomy ERAS protocols.

Multimodal analgesia with a focus on avoiding narcotics is a critical component of any ERAS protocol. This is particularly true in the geriatric population which may be more susceptible to opiate-induced delirium in the perioperative period. Patients on ERAS protocols use significantly fewer narcotics, have a significantly lower median length of stay (4 vs 8 days, $P < 0.001$), and less frequent postoperative ileus (7.3% vs 22.2%, $P = 0.003$).[115]

Perioperative fluid management is important in minimizing the incidence of postoperative ileus. Pillai and colleagues conducted a randomized trial comparing the rate of GI recovery between standard care and esophageal Doppler-guided fluid resuscitation.[116] Patients in the latter group had a reduction in the incidence of ileus (7% vs 18%, $P < 0.001$) and time to first flatus (3.55 vs 5.36 days, $P < 0.01$). Wuethrich and colleagues examined the impact of reduced intraoperative fluid resuscitation and norepinephrine infusion on bladder cancer patient outcomes in the context of a randomized clinical trial.[117] The low volume group received 1.7 L intraoperatively and the control group received 4.3L ($P < 0.0001$). In-hospital complications occurred in 52% of the low volume and 73% of the control group (respiratory rate (RR) 0.70, 95% confidence interval [CI] 0.55-0.88). GI complications occurred in 6% of the low volume group compared to 37% of the control group (RR 0.16, 95% CI 0.07-0.39). The rate of any complication at 90 days was 53% for the low volume group and 77% for the control group ($P = 0.0019$). Recently, a large randomized trial of restrictive intraoperative fluid resuscitation for major abdominal surgery was published.[118] The study met its noninferiority endpoint demonstrating no difference in disability-free survival at 1 year between a restrictive vs liberal perioperative fluid management strategy. Importantly, the rate of acute kidney injury was significantly higher in the restrictive group (8.6%) compared to the liberal group (5.0%). However, the balance of data specific to radical cystectomy suggests that minimizing intraoperative fluid in a goal-directed fashion may accelerate postoperative return of bowel function.

Implementation of ERAS protocols in patients undergoing radical cystectomy has been studied prospectively. Pang and colleagues reported on the outcomes of 453 consecutive patients undergoing radical cystectomy, 393 of whom followed an ERAS protocol.[119] Components of the ERAS protocol included prehabilitation exercise, carbohydrate fluid loading, targeted intraoperative fluid resuscitation, regional local anesthesia, cessation of nasogastric tubes, lack of preoperative oral bowel preparation, avoiding drain use, early ambulation, chewing gum use, and early enteral feeding. Median length of stay was shorter with ERAS (8, IQR 6-13 days) compared to non-ERAS patients (18, IQR 6-13 days, $P = 0.002$). ERAS was associated with less blood loss (600 mL vs 1050 mL, $P < 0.001$), fewer blood transfusions (8.1% vs 25%), and fewer readmissions (15% vs 25%, $P < 0.001$). Tumor stage, nodal count, margin status, and survival outcomes did not differ based on whether ERAS was used or not. Interestingly, almovipan, a common component of most ERAS protocols, was not utilized in this study. Nonetheless, the data are convincing that ERAS protocols reduce perioperative morbidity and lead to more rapid convalescence following cystectomy.

Quality improvement initiatives for patients undergoing surgery for bladder cancer

Quality improvement collaboratives are one mechanism for tracking and improving care delivery in patients undergoing major surgery. There are at least 2 urologic, physician-led quality improvement collaboratives that have the potential to track outcomes for patients undergoing major surgery for bladder cancer.

A potential dataset for large-scale quality measurement is the American Urological Association Quality Registry. The stated goal of American Urological Association Quality Registry is to advance urologic care by providing physicians with an essential infrastructure and information, that can be used to improve clinical practice and patient outcomes. Again, the initial focus is on prostate cancer care, but it can likely be expanded to include data collection and reporting for patients with bladder cancer.

Lastly, the ACS and NSQIP have developed a joint program to improve the quality of surgical care for geriatric patients.[120] The initial pilot explored geriatric risk factors for morbidity and mortality after general-vascular and orthopedic procedures. Following risk-adjustment, surrogate

consent (OR 1.5, 95% CI 1.3-1.8) and use of a mobility aid (OR 1.3, 95% CI 1.1-1.4) increase the risk for serious morbidity or mortality in the general-vascular group. The authors concluded that surgical dataset seeking to optimize care in geriatric surgical patients should focus on cognition, decision-making, mobility, and function. The ACS/NSQIP geriatric surgery initiative could be a fourth avenue to explore quality improvement opportunities for patients undergoing radical cystectomy.

Conclusions

Geriatric patients, their families, and their multidisciplinary care teams often face difficult decisions regarding treatment intensity for muscle-invasive bladder cancer. No matter how the operation is performed, complication and readmission rates for cystectomy and urinary diversion remain high. Geriatric-focused assessment and ERAS protocols are 2 ways in which outcomes following major surgery for bladder cancer can be improved. Physician-led quality collaboratives and the ACS/NSQIP geriatric surgery program provide excellent infrastructures for data collection and analysis to optimize quality in geriatric patients undergoing radical cystectomy and urinary diversion.

Breast cancer in older women: special considerations and outcomes

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Cancer is one of the largest public health concerns in our current clinical landscape. Specifically, breast cancer is a significant contribution to the current cancer burden. Excluding skin cancer, breast cancer is the most common cancer diagnosed among women, accounting for 1 in 3 cancers. According to the American Cancer Society, approximately 253,990 new cases of breast cancer and 36,140 breast cancer deaths occurred among US women age 50 years and older in 2017.[121] Currently, 1 in 8 women in the United States will develop breast cancer in her lifetime. A special cohort of women who develop breast cancer is women older than the age of age 65 years, or the “geriatric” population. According to the National Cancer Institute’s SEER program, more than 43% of the newly diagnosed breast cancers in the United States occur in women 65 years or older.[122] This is a patient population that should have specific considerations as outlined in the following review.

Demographic disparities

The geriatric breast cancer population is a population that has not been fully outlined in the literature. Age greater than 65 years is an established parameter of this population as a result of the widely accepted definition of a geriatric to be individuals greater than 65 years or older. Similar to other patient populations, this population has not been widely studied and therefore is less well understood. The usual demographic parameters of race, socioeconomic status, and geographic distribution have also not been fully established. Racial disparities have been examined in the overall breast cancer population. The American Cancer Society overview of female breast cancer statistics in the United States in 2013 established that “breast cancer incidence rates increased slightly among African American women, decreased among Hispanic women, and were stable among whites, Asian Americans/Pacific Islanders, and American Indians/Alaska Natives from 2006 to 2010.”[123] The historical literature and studies that are widely quoted as statistics have predominantly quoted the highest incidence of breast cancer in women over 40 as occurring in the Caucasian female population.[123] This new review of statistics by the American Cancer Society portends that incidence rates in various racial

categories are changing. The data presented argue that "incidence rates are converging among white and African American women, particularly among women aged 50 STET to 59 years."[123] This shift in racial incidence is important because it can lead to important policy changes for surveillance and distribution of surveillance resources. Additionally, changes in treatment regimens can be linked to demographics of the patient population. The American Cancer Society also demonstrated "incidence rates increased for estrogen receptor-positive breast cancers in the youngest white women, Hispanic women aged 60-69 years, and all but the oldest African American women." Additionally, the number of estrogen receptor negative cancers declined across the board in all age and racial groups.[8] This study also revealed an overall decrease in breast cancer deaths in all races except for American Indians and African American women having the overall "poorest breast cancer survival of any racial/ethnic group."[123] A retrospective study published in the Journal of Health Disparities Research and Practice looked at women in Missouri and demonstrated that the odds of late stage disease were higher in African American women and in areas with the majority of citizens living below the poverty line.[124]

Both of these studies examined women in general without specific considerations for age. One specific study has been done with respect to specific age restrictions. A 2015 report looked at treatment and survival outcome differences between "poor, older black and white women with breast cancer" and found that "there was no significant difference between older black and white women in surgical treatment, radiation therapy, chemotherapy, or hormone therapy over the study period."[125]

The conclusions from these and other studies demonstrate that there are potential significant disparities in demographic categories, however there is a lack of concrete evidence. The impact of these disparities could have potential to drive surveillance, treatment, and outcomes and therefore it is important to examine the geriatric breast cancer population in regards to the demographic makeup of the population.

An often-overlooked segment of the breast cancer population is the male patient. It is known that male breast cancer patients often present later with more aggressive disease that affects their outcomes. It is unknown if this trend continues with the geriatric male breast cancer patient. The lack of knowledge about this specific sector of the geriatric breast cancer population is also an area that should be further considered since it may affect clinical outcomes.

Risk factors

There has been significant research done on the risk factors for breast cancer. Most of these are linked to hormonal influences. With increased age, it is presumed that elderly women would have increased hormonal exposure. A population-based cohort study, the Iowa Women's Health Study, looked at this specifically and found specific risk factors for women over the age of 75 years. Increased BMI was shown to have an increased risk at age 75 or more years. Additionally, family history of breast cancer, an older age at menopause, and obesity conferred an increased risk whereas a high number of live births was protective.[123] This study was specific in terms of incidence of breast cancer in this population. Although this population is slightly older than the focus of this review, these are important outcomes that should be considered.

Additional studies have looked at the impact of these risk factors in terms of clinical outcomes. In a retrospective review of 1659 patients in the Breast Cancer Registry, investigators found that in patients 65 years and older, tobacco use had a significant and detrimental impact on both overall survival and disease-free survival. Additionally, they examined alcohol consumption and BMI and found that neither of these had an impact on survival.[126] Therefore, further research should focus on age-specific risk factors, especially those that are modifiable. Such risk factors should be considered when designing surveillance and treatment protocols.

Surveillance

Another important clinical avenue that needs to be addressed is breast cancer surveillance. It is known that breast cancer increases the risk of subsequent breast cancer, both ipsilateral and

contralateral. The current literature states that this risk is approximately 4%-5% higher in the 5 years following diagnosis.[123] Therefore, increased surveillance is recommended. With respect to the screening regimen, the recommendations for elderly women are different than those for younger women. The benefits of mammograms are maximized in those who have a longer life expectancy and improved QOL. The elderly breast cancer population is different in this regard because they may have an altered QOL that is affected by increased age and adverse health. Additionally, older women may defer screening mammography as they may refuse intervention if malignancy is found due to concerns regarding their QOL and/or life expectancy. A study presented at the San Antonio Breast Cancer Symposium in 2017 argued that there was an overuse of screening mammography in patients older than 50 years, which is causing an inappropriate use of healthcare resources.[127] A recent report demonstrated that there was a strong resistance to discontinuation of screening mammography in older women, which demonstrates that there is an entrenched paradigm in our society. A significant culture change will be necessary to change both the thoughts of the scientific community and the public.[128]

Treatment and outcome variations

The age-specific population of geriatric breast cancer patients emerged into the clinical arena in the 1980s. The American Cancer Society released a study in 1989 stating that "over 43% of the newly diagnosed breast cancers in the US occur in women 65 years or older."[122] An important statistic that this study and the National Cancer Institute's SEER program noted was that "women who present initially with distant disease are more likely to be elderly."[122] Additionally, this study demonstrated that some operations were less frequent in the older population, however there were no differences in survival time.[4] These findings have been extrapolated further in the literature since the late 1980s.

Surgery

Recommendations from the National Comprehensive Cancer Network (NCCN) of surgical options for geriatric breast cancer patients is nearly the same as for younger patients. The NCCN notes that women who do not undergo the optimal treatment including sentinel lymph node (SLN) biopsy (SLNB), axillary lymph node dissection, if indicated, and postoperative axillary radiation may be at increased risk of ipsilateral lymph node recurrence.[129] One important difference is the role of the SLNB. The NCCN notes that there is no definitive evidence for the role of SLNB in certain select groups. Their recommendation is that for patients who are 65 years or older with no palpable axillary lymph nodes, SLNB may be considered optional in terms of patients with favorable tumors, patients for whom the choice of adjuvant systemic therapy is unaffected, and patients with serious comorbidities. The NCCN extends this to axillary lymph node dissection and states that even these dissections may not be beneficial in this select group of geriatric breast cancer patients. A 2017 report looked at data from the National Cancer Database and the Mayo Clinic with regards to the use of SLNB in women age 70 years or older. This study recommended that in women with a low risk of node positivity and with hormone positive receptor disease, routine SLNB should be discontinued. The authors did agree that nodal status continues to be an important prognostic indicator and is necessary for determining radiation and systemic treatment and "chronological age alone may not be the optimal algorithm for exclusion of SLN biopsy." They recommended that "further research be performed for proper individualization of SLN surgery for women age 70 years or older with hormone receptor positive disease before it is eliminated altogether."[130]

The comorbidities in the geriatric patient can seriously confound the concerns related to operative intervention. An SIOG surgical task force prospective study in 2008 looked at solid organ tumors in the elderly and found that preoperative assessment of cancer in the elderly

could be optimized using validated instruments including the CGA, fatigue, and performance status tools and anesthesiologists apostrophe evaluation.[131] This study looked at mortality, postoperative complications, and length of hospital stay. Ultimately, the outcomes demonstrated that "preoperative assessment of cancer in the elderly represents a valuable tool in enhancing the decision process concerning the candidacy of elderly cancer patients for surgical intervention and can reduce inappropriate age-related inequity in access to surgical intervention."[131] If the geriatric breast cancer patient can appropriately be risk-stratified for surgical intervention, the appropriate surgical treatment may still be an option for geriatric patients.

Another consideration for surgical options is the concept of breast conservation surgery. Patients that are candidates for this type of surgery are subjected to a smaller surgical procedure based on the stipulation that they would be amenable to consequent radiotherapy and/or chemotherapy.[132] The PRIME II study in 2015 was a randomized controlled trial that looked at postoperative whole breast radiotherapy and adjuvant chemotherapy and found that there was a "significant but modest" reduction in local recurrence for women 65 years and older, however "the 5-year rate of ipsilateral recurrence was probably low enough for omission of radiotherapy to be considered for some patients."[133] This raises the question of a change in treatment protocol for these patients and the possibility that postoperative radiation and its concurrent morbidity could be avoided in early stage geriatric breast cancer patients. This may mean that a greater number of patients may undergo breast conservation surgery, which is a smaller surgical procedure with less morbidity and mortality compared to mastectomy. Another landmark study, the Cancer and Leukemia Group B CALGB 9343 randomized phase 3 trial further verified the recommendations to exclude radiotherapy. This study "established lumpectomy and adjuvant therapy with tamoxifen alone, rather than both radiotherapy and tamoxifen, as a reasonable treatment course for women aged older than 70 years with clinical stage I estrogen receptor-positive breast cancer."[127]

Chemotherapy and endocrine therapy

Although chemotherapy regimens have led to significantly improved outcomes, there is a significant morbidity that arises with chemotherapy and endocrine therapy. A 2017 study in *Current Geriatrics Reports* states that "older women are less likely to receive standard of care treatments relative to breast reconstruction, postoperative radiation, and adjuvant chemotherapy" and the reason cited for this is often "frailty."[134] It is not clear what the exact definition of "frailty" is, and this may be a significant element of bias in the treatment of these patients that is not evidence-based. Other studies support that older breast cancer patients should be treated equally as aggressively in terms of chemotherapy as young cancer patients. The CALGB 369901 Alliance in 2017 found that "most older breast cancer patients are robust and could consider chemotherapy where otherwise indicated."[135] They did address the role of frailty in treatment options and recommended that "frailty indices could be useful for treatment decision-making and care planning with older patients."[135]

Another consideration about the medical treatment of breast cancer is the impact of the use of pharmaceutical agents in elderly patients. Studies have looked at potentially inappropriate medication use in elderly patients with cancer. In patients with breast cancer, they "support a correlation between polypharmacy and adverse outcomes for cancer patients."[135] This may coincide with "an increased risk of death in patients with breast cancer."[135]

One specific type of therapy that should be discussed is endocrine therapy. The NCCN notes that primary and sole endocrine therapy should be reserved for patients who are deemed as not suitable for surgery or are not surgical candidates (life expectancy less than 5 years).[129]

The timing of intervention, both surgical and for chemotherapy, is also linked to outcomes. Delay to the time of diagnosis is known to be associated with a worse stage at diagnosis as well as decreased overall survival.[134] Analysis of the SEER-Medicare database has demonstrated that there are moderate delays of up to 3 months in the initiation of adjuvant chemotherapy for

elderly breast cancer patients.[135] This raises the concern that there may be suboptimal clinical outcomes for these patients as a result.

There is a paucity of data about specific chemotherapeutic agents in the geriatric age group. A recent observational study in Germany looked at trastuzumab. This study found that the "beneficial long-term results were comparable to those in the younger cohorts" and although there is a significant side effect of cardiotoxicity this was "manageable in older patients."[136] This study demonstrates that certain chemotherapeutic agents should not be precluded in the geriatric population based on age alone. This is important to note as there are multiple chemotherapeutic agents that have been shown to have a significant impact on survival. The above discussion again further demonstrates that the breast cancer population older than 65 years should not be treated differently solely based on age, but this warrants further scientific investigation.

Future research

There is increasing evidence that geriatric patients are underrepresented in clinical trials. A *JAMA* article on cancer clinical trials in 2004 demonstrated that "there was a strong relationship between age and enrollment fraction, with trial participants 30-64 years of age representing 3.0% of incident cancer patients in that age group, in comparison to 1.3% of 65- to 74-year-old patients and 0.5% of patients 75 years of age and older."[136] Other authors have reinforced this notion of lack of representation of this patient population. An article in *Current Oncology Reports* states that "accrual of older cancer patients to clinical trials has been stagnant, and consequently, evidence-based recommendations are often limited by a lack of prospective data to inform decisions."[126] Additionally this article states "improving enrollment of older patients onto clinical trials should be a national priority; it is only through prospective assessment that we can improve our approaches to treating our older patients with cancer."[126] This is an important consideration in future avenues in order to maximize efficacy and efficiency in specific patient populations.

With an increased awareness of unique patient populations such as geriatric breast cancer patients, and the special considerations that coincide with these patient populations, there is hope for improved patient care and enhanced outcomes. A better understanding of the specifics of these patients will lead to better and more effective strategies for treatment of postmenopausal breast cancer patients. Additionally, with increased awareness, there are opportunities for specialized patient care models. For example, the SIOG created a model for a CGA in cancer patients in 2005.[136] This could be translated to specific geriatric patient populations including those with breast cancer.

Conclusions

Geriatrics is a subspecialty of medicine that is relatively recent in its inception in the medical arena however has significant impact both on the patients included in this category as well as the healthcare sector. This patient population of individuals age 65 years and older is growing in number as the population of the United States ages. Additionally, with the advent of medical technology and the change in the average patient, this sector of patients will continue to grow into the future. Hence, it is important and necessary to pay more attention to this patient population. The incidence of breast cancer is also increasing. Therefore, the conjunction of these 2 patient populations—geriatrics and breast cancer—will undoubtedly become increasingly more important. The literature about these patients is evolving but is far from robust. Therefore, further healthcare and scientific resources should be dedicated to a better understanding and increased evidence based clinical regimens for breast cancer patients older than 65 years in order to lead to better clinical outcomes for the current patient population as well as future patients.

Urinary order and disorder in the geriatric surgical patient

Cara Hardy, Iman Al-Naggar, PhD, Phillip P. Smith, MD

For most of adult life, urinary control is taken for granted. The endless cycling of bladder filling with the occasional and manageable call to void the bladder brings minimal attention to itself. The bladder and urinary control consequently receive little attention among personal, popular, and medical concerns. However, unlike homeostatic failures in other systems (eg, appendicitis, cancer, hypertension, pneumonia), loss of normal urinary control carries significant social stigmata, significantly degrades QOL, and may be evidence of deeper and more significant pathophysiologies (eg, multiple sclerosis or cognitive declines). Personal embarrassment and rationalization ("don't all women leak a little?")[137] frequently delay attention-seeking for urinary control disorders, often complicating evaluation and management of these common and distressing problems. With advancing age comes an increasing prevalence of urinary control problems. Urinary control disorders in the geriatric patient are associated with morbidities such as falls and fractures, immobilization, and institutionalization. Although death may not be strongly linked with urinary symptoms, urinary incontinence is feared more than death by hospitalized patients.[138] Especially for the surgeon, seeming iatrogenic failure of urinary control following surgery is a risk that must be considered when contemplating procedural interventions.

Despite a geriatric understanding of urinary dysfunction in older people as syndromic, current clinical approaches to urinary dysfunction continue to emphasize disorders of bladder pressure creation and competence of the urinary sphincter. Terms such as "overactive bladder" (OAB), "underactive bladder" (UAB), and concepts such as "the type of incontinence" all assume a relatively simplistic linkage of symptoms to objective dysfunction, and by extension, pathophysiology. This conception is demonstrably untrue,[139] and current therapeutics derived from the equation of symptoms and function are notably suboptimal, especially in the aged. Clinical and laboratory evidence support the hypothesis that urinary dysfunction has origins well beyond just the bladder. Geriatrics research linking cognition and mobility to urinary function suggest a more effective approach to prevention and management of clinical bladder control disorders, and requires a reconsideration of the traditional bladder-centric paradigm.

Urinary symptoms are the perception of disordered bladder volume management. Excluding central perceptual disorders associated with delusions or delirium, urinary symptoms result from volume hypo- or hypersensitivity, structural and/or neuromuscular disorders of the bladder outlet, and/or structural failures of the bladder as a urinary reservoir.

Symptoms are readily classified into a few basic categories. Most common are those associated with disordered bladder volume management: irritative symptoms, disorders of urine storage, generally covered by the term "overactive bladder" (OAB, frequency, urgency, nocturia); voiding symptoms, generally corresponding to the term "underactive bladder" (UAB, hesitancy, straining to void, reduced flow, intermittent stream, or a sensation of incomplete emptying); and incontinence. The older adult experiences any or all of these symptoms in response to a wider variety of challenges to urinary control physiology, and with a greater prevalence and worsening symptom impact,[139] compared to younger individuals. Attempting to understand the etiology of the symptoms in the physiological and social contexts of the aging patient should be the cornerstone of management strategies. Realistic therapeutic goals must be identified prior to devising strategies aimed at symptom management. Priorities such as ensuring low pressure urine storage, managing the urinary reservoir and its emptying, and understanding how the control of urine storage and evacuation must be addressed in every case regardless of apparent simplicity.

Physiology

The urinary bladder is a muscular reservoir located behind the anteroventral bony pelvis. Urine produced in the kidneys travels to the bladder through the ureters. The urethra is the small duct through which urine is excreted. Urine is expelled through the urethra upon simultaneous contraction of the bladder muscle and relaxation of the sphincter muscle. Its

complementary hydraulic functions of storage and excretion of urine waste are managed by the autonomic nervous system with a unique binary voluntary control overlay. The unidirectional arrangement of the ureterovesical and vesico-urethral urine flow allows the bladder to act as an isolation chamber to prevent the access of the biologically hazardous external world to the renal pelvis and thus bloodstream.

The bladder wall is comprised of 3 main layers: detrusor smooth muscle, lamina propria, and urothelium. The detrusor smooth muscle is the dominant layer. The lamina propria is a layer of connective tissue that contains afferent and efferent nerve endings and vasculature; it is hypothesized that the lamina propria is integral in relaying paracrine and neuronal signaling and determining bladder volume sensing and detrusor responsiveness. The urothelium is a specialized epithelial layer separating the lumen from the basal bladder wall. It plays an important role in paracrine signaling in response to mechanical stress (ie, bladder distension). Although fewer in number than in the lamina propria, the urothelium contains sensory afferent nerve terminals. The pelvic nerve afferents of the bladder project to the Diagnosis Related Group (DRG) of the sacral spinal cord (S2-S4) in humans, and to the DRG of the lumbosacral spinal cord (L5, L6, S1) in mice. The afferents of the bladder can be divided into 2 populations: myelinated Aδ fibers and unmyelinated C-fibers. Aδ fibers respond to lower intravesical pressures such as those occurring during bladder filling, whereas C-fibers exhibit higher intravesical thresholds and are involved in the transduction of pain. The distribution of these fibers in the DRG is roughly 2:1, favoring a larger population of C-fibers. Interneurons in the spinal cord project to the periaqueductal gray and an area in the rostral pons known as the pontine micturition center (PMC).[140] The PMC is by default activated by pressure/volume-induced periaqueductal gray activation, and is "hardwired" to autonomic and somatic control to facilitate detrusor contraction and sphincteric relaxation ("synergic voiding"). The PMC is normally held in a suppressed state during consciousness, pending recognition of a full bladder and the decision to void in a socially acceptable time and place. Release of PMC inhibition, whether voluntary or due to pathology, results in synergic bladder emptying. Inhibition of PMC is a requirement for successful urine storage.

Urinary control is predicated on central recognition and processing of sensory information about bladder content. Detrusor smooth muscle myocytes show spontaneous activity.[140] However, as the bladder continues to fill this muscular activity causes a net tension to be generated. These tensions, clinically assessed as the product of volume and bladder-wall generated pressure, result in afferent sensory nerve activity. Under normal physiological conditions, sympathetic suppression of detrusor myocyte activity suppresses volume-induced tensions, and therefore facilitates low intravesicular pressures relative to intra-abdominal pressure. This is a necessary condition, as the downside of the hydrostatic gradient across the glomerular membrane reflects the pressure differential between the bladder lumen and intra-abdominal pressures. Loss of this gradient due to high pressure urine storage within the bladder compromises renal filtration, and can lead to renal failure.[141] Sympathetic suppression of myocyte activity reduces sensory afferent sensitivity to bladder volume, permitting relatively large volumes of urine to be stored without intrusive sensations.[141]

Lower urinary tract function is also dependent on structural integrity. The bladder is emptied via the urethra, which passes through the striated muscular levator pelvic floor. If expulsive pressures inside the bladder exceed the closure forces of the urethra, urine is voided. Both urethra and bladder have strong smooth muscle components under autonomic control. Normal bladder filling/voiding requires that the urinary reservoir is covered in its entirety by detrusor smooth muscle. Vesicoureteral reflux and bladder diverticula are examples of the urinary reservoir exceeding the boundary of the detrusor, resulting in a reservoir that cannot be fully emptied by normal detrusor contraction. The urethral smooth muscle provides closure forces that can resist gravity-induced intra-abdominal pressures, but requires augmentation by the striated muscle of the pelvic floor, anchored to anterior and posterior bony pelvis and laterally to the arcus tendinous levator ani/fascia pelvis internus, working against pubourethral connections to provide closure in response to stronger forces induced by increases in intra-abdominal pressure.[141] The dynamics of voiding represent an equilibrium state between expulsive pressure needed to open the urethra and urethral distensibility. Urodynamic quantitation of voiding

pressures and flow rates are required to assess the strength of detrusor voiding contraction and/or the presence of bladder outlet obstruction. Urine storage is the result of urethral closure forces exceeding expulsive pressures. Expulsive pressures are readily measured with an intravesical catheter, however quantifying urethral closure forces especially in cases of suspected sphincteric failure remains controversial in technique and interpretation. All of these mechanisms are subject to compromise by injury, age, and disease. Surgical approaches to urinary symptoms derive from attempts to restore these structural aspects. Unfortunately, pelvic surgical impacts include disruption of microvasculature and neural supply, dysregulated spinal signaling following activation of nociceptive pathways, altered structural tissue connections, and changes in tissue biomechanical properties, all of which conspire to an inevitable risk of undesirable outcomes in the short and long terms.[142]

The aging bladder

As with all tissues and systems, the lower urinary tract undergoes change with age. Most of the available human data is derived from symptomatic patients and therefore is representative of the experience of aging, which includes disease processes overlain on the physiology of aging. Nerve tissue, especially afferent neurons, diminishes with aging.[143] Declines in cognition associated with brain degeneration in older adults are accompanied by an increased prevalence of urinary and mobility disorders and worsening impact of symptoms.[144]

An adaptive paradigm

The functional impact of age-associated changes in the bladder cannot be considered in isolation as they occur in the context of an aging system. Many groups, including our own, have challenged the idea that the bladder is old and thus tends toward dysfunction; Most 90 year olds have 90-year-old bladders yet are asymptomatic and often recover from surgical stress without iatrogenic urinary dysfunction. Growing evidence supports an adaptive systemic model, in which peripheral modulation of afferent activity by central processes permits central adaptive responses to accommodate age-related changes in mechanisms involved in urinary control responses.[137,138]

One can consider this brain-bladder system as arranged to cope with 2 worlds: the external circumstances and the internal environment. The state of the internal world is dependent upon its ability to process the inputs it is receiving from the outside, such as water intake and lifestyle, and is most directly affected by aging and disease. Cortical control integrates information about the external world, internal demands, memory, emotions, and bladder volume, generating ever greater conscious intrusion of bladder sensations into consciousness as the bladder fills. This perception of bladder filling status (“do I need to go?”) underlies the possibility for appropriate behavioral responses—hold it, or find a restroom. Feedback mechanisms such as forward control over the detrusor tonus, and therefore volume sensitivity, provide the opportunity to optimize cortical control to available end-organ capabilities. Structural changes, such as age-induced changes like increased fibrosis and denervation, can undermine response to stimuli and the efficacy of signal transduction to the bladder, respectively.[142] Cognitive losses, in combination with increasing internal stressors, further complicate central adaptive control. Hence, the impact of aging on the human organism is better considered a progressive loss of adaptability to a range of internal and external physiological stressors. In the older patient, the additive effect of relatively innocuous challenges can become significant. The identification of addressable stressors and the avoidance of excessive physiological challenge as preventive measures is probably a more effective approach than managing urinary dysfunction in the elderly by applying the relatively drastic single-target measures useful in younger, more resilient adults.

Origins of urinary symptoms

The fundamental feature of well-functioning (homeostatic) urinary control is the low-pressure storage of renal output and periodic voiding of urine under voluntary control with a minimal perception of bother. Typically, the bladder is not consciously sensed during most of urine storage. Normal sensations originate with volume-induced tensions in the bladder wall, and signal bladder volume status. Generally not reaching consciousness, perceptions of bladder volume become increasingly intrusive onto consciousness as bladder capacity is approached; brain imaging shows cortical activations associated with volumes associated with a desire to void.[144] Although moderately reproducible, sensations are subject to patient expectations.[145] In general, under cystometric conditions a "first sensation" of bladder filling is often reported at about 30-50 mL of filling; this is about when the unexpanded bladder volume is filled out. "First desire" to void typically is reported around 200 mL, with "normal desire" at approximately 250-350 mL, and "strong desire" at 300-400 mL. Aging is associated with diminished sensitivity to bladder volume in asymptomatic women and symptomatic older men and women.[145] The impact of aging on detrusor muscle voiding strength is less clear; while the older detrusor muscle is often regarded as weak (relative to young), the evidence in asymptomatic humans and in animals suggests that loss in voiding contraction strength is not a feature of aging per se.[146] Normal voiding from typical normal volumes results in nearly complete bladder emptying regardless of age, although postvoid residual volumes are larger in symptomatic older patients than young symptomatic individuals. Finally, colorectal function can cause or contribute to urinary symptoms. Fecal impaction may be a cause of urinary retention in older patients. Due to extensive neurologic crosstalk between bowel and bladder, addressing urinary symptoms in older patients requires inquiry into bowel dysfunction.

The clinical entity "overactive bladder" (OAB) constitutes the constellation of irritative bladder symptoms including urinary frequency, urge, urgency, and perhaps urge incontinence. The term and the associated symptom complex imply volume hypersensitivity and even detrusor muscle "spasm." Yet, neither is necessarily true. The patient with volume hypersensitivity has low-volume thresholds for a desire to void, and may or may not have an elevated postvoid residual volume. Urinary frequency is the predictable result. The presence of unsuppressed waves of detrusor-generated pressure and/or impaired central executive function associated with poor attentional biasing can contribute to a distressing sense of urgency to void, sometimes overpowering the ability to suppress the flow of urine resulting in "urge incontinence." UAB symptoms may be reported; patients with volume hypersensitivity often still sense the presence of a desire to continue to void despite an objectively empty bladder.

Similarly, volume hyposensitivity can also result in OAB. Large postvoid residual volumes may not be sensed, but only small increases in volume on top of a large postvoid volume can produce rapid onset of a desire to void, urgency, and even urge incontinence. Stress urinary incontinence may be evident, not because of an inadequate sphincter mechanism but rather because of an otherwise-adequate sphincter which is being overchallenged but huge bladder volumes. Especially in older patients, diminished volume sensitivity can become pathologic, resulting in bladder volumes sufficient to impair bladder wall perfusion. In older individuals, more susceptible to compromised tissue metabolic functions, this can magnify the volume hyposensitivity to the point of preventing a voiding reflex. Urinary retention is the not-infrequent result.[145]

Bladder outlet obstruction should always be included in the differential diagnosis of symptomatic older males (prostate) and females having a history of anterior vaginal wall and/or incontinence surgery. The diagnosis of obstruction requires knowledge of both expulsive pressure and voiding flow rates; obstruction cannot be diagnosed by poor and/or intermittent urine flow or elevated postvoid residual volumes. The evaluations are the domain of urodynamic testing, and consultation should be considered.

Incontinence is often assigned a "type," although the clinical usefulness of that classification is questionable. Urine comes out when expulsive pressures exceed urethral closure forces. Incontinence implies the patient does not desire this to happen; in the patient who does

not recognize the inappropriate loss of urine, one can manage wetness (even to the point of dryness via prompted voiding), but one cannot "treat incontinence" in this patient. Incontinence can happen due to poor suppression of the PMC/voiding reflex (eg, dementia, stroke), or vast overfilling of the bladder resulting in high storage pressures. Overwhelming increases in expulsive pressure due to detrusor overactivity create waves of pressure, which can overwhelm urethral closure, or provoke a voiding reflex via urethral stimulation. Other sources of increased expulsive pressure include a noncompliant bladder, obesity, or neurologic disease impairing the generation, transmission, and processing of volume-based sensory signals. Failures of urethral closure forces can happen due to neuromuscular compromise (eg, pelvic floor dysfunction relating to childbirth or injury) or structural damage (eg, vaginal prolapse). These are a few examples; we believe the patient is better served by considering all possible contributors to the undesired imbalance of intravesical expulsive and urethral closure forces resulting in the passage of urine, and render those contributors as the treatable diagnosis rather than resorting to conceptual shorthand of "types" of incontinence.

Management suggestions

We can offer 11 important management suggestions:

1. "Normal function" is relative, and pertains to the well-adapted mature healthy adult. Deviations from "normal" could represent adaptive changes in older individuals and should be considered in the context of the patient's symptoms (if any).
2. Polypharmacy is not rare in the older patient, and tremendously complicates the assessment and management of urinary dysfunction. The prescribing physicians should be notified and implored to eliminate this situation as a first line of treatment.
3. In evaluating the symptomatic older patient, treatment goals should be an early consideration. If preservation of renal function is desired, maintenance of low pressure urine storage must be the first priority.
4. The urinary reservoir must be understood. Although pharmacology should be approached cautiously in the elderly, the hypersensitive or poorly compliant bladder may respond to antimuscarinics or a $\beta 3$ agonist (mirabegron). Intradetrusor injection of botulinum toxin and other neuromodulatory techniques are available if oral medications are insufficient.
5. How the urinary reservoir is emptied must be considered. Normally the detrusor muscle surrounds the urinary reservoir, and creates expulsive pressure opening the outlet. If this mechanism is not feasible, due to neurologic, muscular, or structural concerns, alternative emptying via intermittent catheterization or diversionary procedures may be required.
6. The origins of the symptoms of OAB, UAB, and incontinence should be understood in a context of reservoir storage/emptying volume management. Symptoms do not correlate well with function. Patients want relief of these symptoms, but diagnosis and management must focus on the pathophysiology underlying volume mismanagement.
7. A suprapubic tube or indwelling Foley should generally be avoided if possible, primarily due to the infectious risk and the limitations placed on patient mobility. However, an indwelling catheter offers the advantage of exteriorizing the urinary reservoir and offering simple control over emptying. Especially in infirm older patients these advantages may outweigh the disadvantages.
8. If an indwelling catheter is desirable, transurethral or suprapubic approaches are equivalent in men. However, chronic use of a transurethral Foley catheter in women can be associated with urethral dilation resulting in total incontinence, and should therefore be avoided.
9. Neither urinary retention nor the presence of a foreign body (catheter) are per se large infectious risks. However, great attention to detail is required to ensure continuous bladder drainage with an indwelling catheter, meaning that the combination of retained urine and foreign body is often present in the chronically catheterized patient.

10. There is no strong evidence that preoperative urodynamic assessment predicts postoperative bladder function in older adults. However, the operating surgeon should have some understanding of the urinary reservoir, emptying mechanism, and adequacy of control between storage and voiding prior to imposing surgical stress on the older patient.
11. We view postoperative urinary retention in older surgical patients as generally the result of exceeding an already tenuous threshold of adaptive reserve. Common postoperative factors such as opioid use and impaired defecatory function can compound this problem. Early efforts to address physiological stressors might contribute to earlier return of urinary function. Early data that suggest neuromodulation may be useful in addressing postoperative urinary retention in children is consistent with our own anecdotal experience in older women undergoing pelvic surgery.

Hepatopancreaticobiliary surgery in the elderly patient

Lindsay A. Bliss, MD, Brian D. Shames, MD

Patients older than 80 years represent a rising portion of the worldwide population and a significant number of patients with hepatopancreatobiliary disease. Here, we review the existing literature regarding surgical care and outcomes of elderly patients with hepatopancreatobiliary diseases. The definition of what is elderly varies between studies and appears to be a moving target with some emphasis placed on the physiological and outcome differences between the elderly and the extremely elderly populations. Given the complexity of establishing liver transplantation criteria, we do not address this topic but acknowledge that comprehensive surgical management of hepatopancreatobiliary disease should involve consideration of transplantation, when appropriate.

Pancreatectomy

Pancreatectomy is a morbid procedure with high perioperative morbidity and mortality rates. Large registry data suggest that the dangers associated with pancreatectomy increase with increasing age. In a population of all pancreatectomies performed in Texas from 1999 to 2005, postoperative mortality rates, length of stay, and total hospital costs increased with rising age. In this comprehensive study, the investigators concluded that increased age was associated with worse clinical and financial outcomes following pancreatectomy.[147]

A meta-analysis of single institution studies comparing pancreatectomy outcomes based on age reported similar outcomes. The analysis from Sukharamwala and colleagues, included 5186 patients from 11 studies and found increased odds of postoperative morbidity and mortality among patients older than 80 years as well as over the younger cutoff of age of 80 years or older. Among specific complications, only pulmonary complications were associated with the older age categories in this pooled dataset.[148]

Registry data suggest that patients aged 66 years or greater are not undergoing surgical resection of early stage pancreatic malignancies even when eligible. Although resection rates rose from 2001 to 2009, the final resection rate was only 30% in all older patients. Of those not undergoing operative intervention, 50% received chemotherapy or radiotherapy while 50% received no cancer treatment. As the age at diagnosis increased, the likelihood of undergoing surgical resection decreased. With multivariate analysis, age was the only factor that was not a tumor characteristic that remained a statistically significant predictor of resection. Those patients who underwent resection enjoyed significantly longer survival, with median survival time of 24.3 months compared to 5.8 months. This suggests that patients who could be enjoying extended lifespan due to surgical resection may not be receiving the option due to age alone.[149] Similarly, among those who undergo resection, there are decreased rates of adjuvant chemotherapy delivery in the elderly population, which is associated with decreased median survival.[150]

When restricted to only patients undergoing pancreaticoduodenectomy, elderly patients generally experience similar outcomes to nonelderly patients. Tani and colleagues compared patients resected at a single institution with nearly half of all patients over the age of 70 years. Patients were divided into septuagenarians and elderly (age 80 years or greater); older age was associated with higher median ASA class and higher performance status score, as well as lower preoperative albumin and higher preoperative creatinine. Other than an increased rate of delayed gastric emptying in the elderly group compared to the septuagenarian group, there were no statistically significant differences in postoperative outcomes suggesting that pancreaticoduodenectomy in the setting of periampullary tumor is no riskier for older patients.[151]

The extremes of age lead to further questions about the safety of proceeding with highly morbid pancreatic resections. Numerous studies attempt to address this concern by comparing patients up to age 79 years against those aged 80 years and older, with generally positive results.[152,153]

Melis and colleagues noted their octogenarian population undergoing pancreatectomy primarily differed from younger patients on Eastern Cooperative Oncology Group Performance Status (performance status greater than or equal to 1, 90% vs 51%, $P < 0.01$) and ASA class (class 3 or greater, 71% vs 47%, $P < 0.01$). Octogenarian patients in this study had a longer length of stay and higher morbidity.[154] Belyaev and colleagues reviewed local data at a single high-volume center comparing the 4.4% of pancreatectomy patients aged 80 years or older. Overall morbidity rates were higher in the octogenarian population (72.4% vs 42.0%, $P<0.05$); when divided into medical and surgical complications, octogenarians suffered from significantly more medical complications, albeit with comparable rates of surgical complications. Octogenarians had a nearly 4-fold increase in mortality in the postoperative period.[155]

By reviewing the Healthcare Cost and Utilization Project Nationwide Inpatient Sample and the SEER Medicare linked database, Finlayson and colleagues were able to compare both inpatient and long-term outcomes for octogenarians and older relative to younger elderly patients (age 65-69 years old) undergoing pancreatectomy for malignancy alone. Perioperative mortality for pancreatectomy was significantly higher in the extremely elderly population. The likelihood of being discharged home dropped dramatically in the octogenarian population. The presence of 2 of more comorbid conditions was associated with lower likelihood of long-term survival. Ultimately, the 5-year survival rate among the extremely elderly population was low at 11%.[152] Median survival times can be considerably longer when pancreatectomy in the octogenarian population is performed for benign or premalignant reasons. Patients undergoing resection for premalignant or benign conditions had a median survival time of 103 months.[152]

In the extremely elderly pancreatic cancer population, chemotherapy may represent a viable alternative to surgical resection given the considerable morbidity and mortality associated with pancreatectomy. Kinoshita and colleagues compared cohorts of octogenarians who underwent upfront surgical resection with intent for adjuvant chemotherapy or chemotherapy alone. More than half of the chemotherapy alone population was considered unresectable due to distant metastatic disease or locally advanced status, while the remainder were technically able to be resected but declined surgery. Only half of the surgical patients were able to receive any adjuvant chemotherapy and only a quarter completed their planned chemotherapy. Competing risk did not appear to be a significant factor despite the advanced age of the study population as there was only 1 death not attributed to the malignancy. The 1-year survival rate of surgery and chemotherapy groups were similar (50% vs 45%), with no significant difference in median survival time (12.4 vs 11.7 months, $P>0.05$).[156] This raises the strong possibility that surgical intervention for pancreatic malignancy in the extremely elderly, while feasible, may not help patients achieve life prolongation.

Despite significant perioperative morbidity, pancreatectomy for malignancy in the elderly population does not necessarily lead to long-term worsened QOL among patients with prolonged survival. Gertenhaber and colleagues administered the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-Core 36 (QLC-C30) to elderly Israeli patients 3, 6, and 12 months after pancreatectomy for malignant or premalignant disease. When compared to a matched cohort of patients who underwent laparoscopic cholecystectomy,

patients undergoing pancreatectomy had significantly worse scores at 3 months postoperatively. However, over the following 3 months the scores improved progressively with no statistically significant difference found between the pancreatectomy and cholecystectomy groups at 6-month follow-up. Furthermore, at 6 months there was no significant difference in QOL scores for patients who underwent pancreatectomy for malignant conditions compared to those with premalignant or benign processes.[157] This suggests the negative perioperative aspects of pancreatectomy in the elderly population may not transform into be long-standing debility.

Cholecystectomy

Elderly patients with gallstone disease who undergo cholecystectomy differ from younger populations beyond mere chronological age. A large cross-sectional study of the Health Care Utilization Project Nationwide Inpatient Sample reviewed elderly patients (age 65 years and greater) hospitalized for cholecystectomy between 1999 and 2006 as well as a comparison group of patients aged 50-64 years. The number of comorbid conditions increased as age category increased. Older patients had a longer average time to surgery and were more likely to undergo operation at rural, nonteaching facilities. Older patients had increased complexity of disease processes as evidenced by high numbers of individual biliary diagnoses and were more likely to have cholangitis or biliary pancreatitis. The likelihood of undergoing an open surgical approach also increased with age, as was undergoing other biliary procedures in the same hospital stay. The outcomes associated with advanced age were worse compared to middle-aged individuals. Mortality rates were increased with older age, as were morbidity, length of stay, and hospital costs.[158]

Single-institution studies demonstrate the safety of attempting laparoscopic cholecystectomy in the elderly population, with complication rates between 5.7% and 36.4% and early postoperative mortality rates between 0% and 3.2%.[158] Meta-analysis of 13 studies demonstrates significant advantages to a laparoscopic approach in the elderly population. The mortality rate was 1.0% in the laparoscopic population compared to 4.4% in the open population ($P < 0.00001$) and morbidity was lower as well (11.5% vs 21.3%, $P < 0.00001$).[159] Advanced age (greater than 70 years) demonstrates an association with higher rates of conversation to an open surgical approach. It is similarly associated with increased rates of postoperative complications; however, these data may be skewed by the extremely elderly population, rather than septuagenarians.[158] Furthermore, the rate of complex biliary disease is higher as the patient age rises, potentially worsening perceived clinical outcomes in this age population. In a single institution study of elderly patients (age 65 years or older), complicated biliary disease (acute cholecystitis, emphysematous cholecystitis, gangrenous cholecystitis, perforated cholecystitis, gallbladder empyema, pericholecystic abscess, biliary pancreatitis, and cholangitis) was associated with increased complication rates (9.8% vs 3.1%, $P < 0.05$) as well as increased length of stay (7.9 vs 5.0 days, $P < 0.01$).[160]

When examining the extremely elderly populations (octogenarians and nonagenarians), advanced age appears associated with increased postoperative morbidity as well as increased length of stay.[160] In a comparison between elderly patients (65-79 years old) and extremely elderly patients (80 years of age or older) undergoing laparoscopic cholecystectomy, Brunt and colleagues demonstrated both significant differences in the patient population and in overall outcomes. This single-institution study conducted in the early era of laparoscopy (prior to 2000) noted that extremely elderly patients had higher ASA classes and included more patients with complicated biliary disease, including acute cholecystitis, gallstone pancreatitis, and emergent surgical intervention. Worse outcomes among the extreme elderly population included total complication rate, a higher rate of conversion to an open surgical approach, and increased length of stay.[161]

The consequences of failure to perform cholecystectomies in elderly patients are not trivial. In a 2010 study, Riall and colleagues used Medicare claims data to examine elderly patients (66 years of age or older) admitted with cholecystitis. On the index admission, 25% of patients did not receive a cholecystectomy, with only 1.7% of that group undergoing percutaneous

cholecystostomy tube placement on the index admission. Index admission mortality rates were higher among patients not receiving cholecystectomy (2.7% vs 2.1%, $P<0.03$), but length of stay was longer among those undergoing cholecystectomy (5 vs 4 days, $P < 0.0001$). In multivariate modeling, patients were less likely to undergo cholecystectomy if older, nonwhite, female, admitted emergently, admitted to a general medicine physician, evaluated by a gastroenterologist, had common bile duct stones, or had select comorbid conditions. Among those patients without cholecystectomy, 27% of those who survived the index admission went on to require further admission related to gallstone disease and 9.6% underwent outpatient cholecystectomy. The population that underwent cholecystectomy during the index admission had a 4.2% gallstone-related readmission rate, with most readmissions occurring for surgical complications. In a multivariate model of survival, having no cholecystectomy during the index admission was associated with the 2-year mortality rate (HR 1.56 [1.47-1.65]).[162] This suggests that there are significant long-term implications of treating acute cholecystitis in a nonoperative fashion in the elderly population and age alone should not dissuade surgeons from offering cholecystectomy.

Hepatectomy

Patients over the age of 75 years represent a relatively small percentage of liver resections. A review of elective hepatectomies from 2005 to 2010 included in the NSQIP database demonstrated that only 11.7% were performed in the elderly population. When compared to patients under 75 years old, the elderly population was more likely to have an ASA class of 3 or greater. However, they were more likely to undergo partial hepatectomies rather than anatomical resections.[163] These resections were more likely to be performed for malignant disease compared to younger patients.

Among elderly patients who underwent resection in the study by Tzeng and colleagues the rates of severe complications were significantly higher for elderly patients (23.9% vs 18.4%, $P < 0.001$). This remained true regardless of the magnitude of the resection, with elderly still at higher risk even with only partial hepatectomies (20.0% vs 15.1%, $P < 0.001$). Mortality rates were also significantly higher in the elderly population undergoing resection, with a 3-fold increase in mortality rate among elderly patients undergoing right hepatectomy. Furthermore, among patients with serious complications, elderly patients fared worse, with increased failure to rescue rates after 1, 2, and 3 serious complications.[163] A similar single-institution study from Ruzzente and colleagues included 803 patients with more than half over the age of 65 years. Their data implicated extent of hepatectomy, presence of bile duct resection, need for transfusion of 3 or more units of packed red blood cells, preoperative ischemic heart disease, and cirrhosis as risk factors for severe mobility and mortality. These factors alone did not mitigate the increased risk associated with rising age.[164] This suggests that the elderly population is at significant risk when compared to younger patients when undergoing hepatectomy.

When examining patients undergoing hepatectomy for primary malignancy, the data appears more favorable for resection in elderly patients. A review article by Oishi and colleagues examined hepatocellular carcinoma in the elderly population.[165] Compared to younger patients, elderly patients are resected at lower rates (0%-14% vs 12%-28%) with women being disproportionately represented among resected elderly patients in Asian studies. Among those resected, liver function appeared similar compared to younger patients undergoing resection, suggesting that there is aggressive patient selection involved in the elderly population. Although early studies in their review saw postoperative mortality rates between 0% and 42.9%, more recent studies have lower mortality rates reflecting overall improvements in perioperative care. Morbidity rates tend to align more closely with younger patients, ranging from 9% to 51% in an elderly hepatocellular carcinoma population. Long-term outcomes were slightly worse among elderly patients with resected hepatocellular carcinomas.[166] With the additional diagnosis of portal hypertension, elderly patients have significantly worse outcomes compared to younger patients with similar portal hypertension in the preoperative setting. In particular, these patients are more likely to die (81% vs 44%) and those deaths are more likely to occur as a result of liver

failure (38% vs 21%) rather than hepatocellular carcinoma recurrence (46% vs 72%). A similar time to recurrence of hepatocellular carcinoma after resection was observed in this population.

Hepatocellular carcinoma may be approached without resection in several capacities. Due to limited organ availability, transplantation is largely unavailable as a treatment of hepatocellular carcinoma in the elderly population. A review of ablative therapies for elderly patients demonstrates radiofrequency ablation may be a viable alternative for elderly patients considered too high risk for resection. However, in these studies, advanced age remains a risk factor for in-hospital mortality compared to younger patients with lower overall survival as well. Hepatic artery embolization demonstrated comparable prognosis for young and elderly patients, with the exception of cardiopulmonary complication which appear associated with cardiovascular comorbidities in the elderly population. Transarterial chemoembolization appears equally safe for elderly patients, with comparable efficacy and tolerability in all but 1 published series. Finally, radioembolization with yttrium-90 also demonstrated comparable tolerability and median survival when used in an elderly population.

The evidence regarding resection of metastatic hepatic lesions is largely dominated by colorectal metastectomies. In a single high-volume center study, acceptable rates of postoperative morbidity and mortality were achieved for both initial and repeat hepatic resection for metastatic disease in patients older than 70 years. In this population, the investigators reported mortality rates of 0% and 7% and morbidity rates of 41% and 38% for first and subsequent resections, respectively. Overall survival was 28 months among all patients following the first resection, which rose to 33 months when analyzing patients with R0 resections achieved.[167]

A study by Orcut and colleagues attempted to address these outcomes questions on a population level using the Healthcare Cost and Utilization Project Nationwide Inpatient Sample by examining all patients undergoing hepatectomy for liver metastases from 2005 to 2008. Of the 4026 hepatectomies identified, 36.6% in this population were in patients age 65 years or older. Patients were divided into cohorts of young (age less than 65 years), old (age 65-74 years) and older (age 75 years or greater). In-hospital mortality was significantly increased with rising age category. The likelihood of discharge to a facility vs home strongly increases with rising age category.[168]

The ability to predict liver function after hepatectomy is intuitively influenced by age, but data to support this age-related bias is limited. In the early postoperative period following major intra-abdominal surgery, advanced age (greater than 65 years) reduces the postoperative hepatic acute phase response even if older patients' baseline levels of hepatic acute phase proteins were similar to those of younger patients.[167] When adjusting for objective measures of posthepatectomy liver function, age greater than 65 years remains a predictor of early postoperative mortality (OR 4.83 [1.24-18.85]).[168] Similarly, age has been inversely correlated with early liver regeneration after partial hepatectomy even when corrected for preoperative predicted liver remnant, suggesting functional liver remnant assessment alone may be inadequate in the older population.[167]

Gastric adenocarcinoma in the elderly

David W. McFadden, MD

Gastric surgery for benign and malignant diseases has decreased significantly over the last few decades, but the multimodal management of gastric cancer requires that the surgeon be well versed in the medical and surgical facets of care. Our purpose here is to provide an overview of the management of gastric cancer with specific emphasis on the geriatric patient. The American Cancer Society estimated that in the United States 26,370 people will be diagnosed with gastric cancer, with 10,730 deaths in 2016.[168] Worldwide, however, gastric cancer remains the fifth most common cancer and a leading cause of cancer mortality. The average age of diagnosis in the United States is 69 years of age. Men are more likely to have gastric cancer

than women, and Hispanic Americans, African Americans, and Asian/Pacific Islanders are more frequently affected than non-Hispanic whites. Individuals with lower socioeconomic status are more likely to be affected both in the United States and in developing countries.[168]

Since 1930, the incidence of gastric cancer has decreased significantly. Concurrently, a trend of decreased tumors located distally within the stomach and an increase in more proximal gastric tumors has been noted. Despite the decreasing incidence, gastric cancer remains highly lethal in the United States with an anticipated overall 5-year survival rate of 29%.[168]

Pathology

More than 90% of malignant gastric tumors are adenocarcinoma with 2 distinct histologic subtypes: intestinal (well differentiated) and diffuse (poorly differentiated). The former is more frequently seen in high-risk populations and older patients. It tends to form glands and the tumors appear as masses. There is a strong association with *H. Pylori* infection. The diffuse type is more common in inherited syndromes and behaves more aggressively. It is associated with E-Cadherin mutations and loss of cellular adhesion. These tumors infiltrate the gastric wall without forming glands.

In recent years, proximally located and diffuse type tumors have been increasing in incidence in Western cultures, while there has been a substantial decrease in intestinal and more distal tumors. Distal lesions, however, continue to predominate in Japan and other parts of the world.[2] The etiology for this trend is unknown and likely multifactorial.

Diagnosis and staging

Unfortunately, the symptoms of gastric cancer are vague and in many cases mimic those of benign GI disorders (ie, epigastric pain, nausea). Screening for gastric carcinoma is commonly performed in the East, but not recommended in Western countries due to the rarity of the disease. Thus, the majority of tumors in the United States are diagnosed at advanced stages. Often, physical examination is unremarkable, except in stage IV disease. Endoscopy is the diagnostic examination of choice. Endoscopic ultrasound is employed as an adjunctive test to determine the depth of the tumor (T stage) or lymph node involvement (N stage), with accuracies of more than 75% and 60%, respectively.[169] Traditionally, CT is used primarily for detection of metastatic disease, however with newer technologies this modality may provide a level of accuracy for locoregional staging similar to that of endoscopic ultrasound. Diagnostic laparoscopy can aid in the detection of unresectable disease, as it identifies metastatic disease in up to 40% of patients with negative cross-sectional imaging. Peritoneal washings can be collected during these procedures and offer further prognostic information. This can be particularly relevant in patients who are scheduled to undergo neoadjuvant treatment. Positive peritoneal cytology is an independent predictor of poor survival. As it carries a similar prognosis to other forms of stage IV gastric cancers, it has been classified as M1 disease in the seventh edition of the AJCC staging manual. The American Joint Committee on Cancer and International Union against Cancer (AJCC / UICC) system remains the most commonly used pathologic staging criteria. The following guidelines apply to tumors more than 5 cm from and those that do not cross the GE junction: the depth of gastric wall invasion defines tumor (T) stage. T1a lesions invade into the lamina propria or muscularis mucosa, while T1b lesions invade the submucosa. T2 tumors penetrate into the muscularis propria. T3 lesions invade the subserosa but not the visceral peritoneum or adjacent structures. Finally, T4 lesions are characterized by invasion of the visceral peritoneum or adjacent organs. Nodal (N) status is determined by the number of lymph nodes involved. N1 involves metastases in up to 2 regional nodes, N2 from 3-6, and N3 7 or more regional nodes. Regional nodes include the perigastric nodes as well as the celiac, left gastric, splenic, and common hepatic artery nodes. The surgical specimen should contain a minimum of 15 lymph nodes for examination.[169]

A recent study evaluated the specific features of gastric cancer in elderly patients. The records of 1107 patients who had radical gastrectomy for gastric cancer between were reviewed. They were divided into young (younger than 65 years, n = 676), young-old (65-74 years, n = 332), and old-old age group (older than or equal to 75 years, n = 99). Increased CA 19-9, advanced diseases, and node metastasis were more common in the young-old and old-old age groups. There were no significant differences in *H. pylori* status. Surgery-related complication rates were similar in the 3 groups (5.3%, 5.1%, 8.1%, $P = 0.497$). The elderly group had more synchronous tumors (7.5%, 10.2%, 17.2%; $P = 0.006$). The authors concluded that surgery can be applied to elderly gastric cancer patients without significant risk of complications. However, considering the more advanced disease and synchronous tumors among the elderly, they cautioned that care should be taken while deciding the extent of surgery for elderly gastric cancer.[170]

Surgery

Regardless of age, surgical excision remains the cornerstone of curative therapy for gastric cancer. The objective is to perform a complete resection with negative margins (R0 resection). This can be accomplished via subtotal or total gastrectomy, as randomized controlled trials have shown no difference in survival when comparing these operations. Due to the high propensity of gastric cancer to spread in the submucosa, gross margins of at least 5 cm are preferable. The management of microscopically positive margins (R1 resection) is a contentious issue. A number of studies have demonstrated a poor prognosis in patients with microscopically positive margins. More recent studies have shown that this is predominantly true only in patients with T1 or T2 tumors and limited nodal involvement.[169] Thus, the decision to reoperate should be considered carefully based on the patient's overall condition and treatment goals, as well as on regional pathologic staging. NCCN guidelines do not currently recommend reoperation after R1 resection.

Access to care was recently reviewed from the SEER database of nearly 6000 elderly patients (aged older than 65 years, median age 78 years) with regional gastric adenocarcinoma. The review showed that 26.5% received no treatment. The lack of treatment was associated with age over 80 years old, black race, lower education levels, and diagnosis before 2007. The treated patients had significantly improved median survival and 5-year survival.[171] As with many diseases, sarcopenia and frailty have significant adverse relationships with the occurrence of postoperative outcomes. However, in a Japanese study of 108 colectomy and gastrectomy patients over the age of 80 years, there were no operative deaths, and the morbidity rate was 27.9%. Impressively, only 6% of the patients showed a decrease in activities of daily living at the sixth postoperative month. Patient QOL showed recovery to an extent equal to or better than average preoperative scores. The authors concluded that surgical treatment should therefore be considered, whenever needed, for elderly patients 80 years of age or older with gastric or colorectal cancer.[172] A large Korean study revealed similar data over a 10-year period showing that outcomes for the elderly after gastric resection for cancer are similar as for the younger cohort.[173]

Lymphadenectomy

The extent of lymphadenectomy continues to be controversial. Historically, nodal resection has been defined by the proximity of the specimen to the stomach. A D0 dissection is when no effort is made to resect nodes, typically during palliative resection. D1 lymphadenectomy refers to excision of perigastric nodes, while D2 dissection includes nodes located along the main trunks of the celiac axis. The Japanese Society for Research in Gastric Cancer standardized the extent of resection and lymphadenectomy in the early 1980s. Retrospective studies from Japan have demonstrated significant survival advantage with extended D2 resection. However, prospective randomized trials in Western countries could not reproduce these findings. Notably, the Dutch Gastric Cancer Group trial comparing D1 and D2 lymphadenectomy, performed under the tutelage of an experienced Japanese surgeon, did not show improvement in survival but was

associated with higher postoperative morbidity. Similarly, the British Medical Research Council investigation of D1 and D2 lymphadenectomy showed a significant increase in postoperative morbidity without improvement in either overall or recurrence-free survival. Distal pancreatectomy and splenectomy were included in D2 resection and subgroup analyses suggested that these procedures contributed to the morbidity of patients undergoing extended lymph node dissection.[169] D1 and D2 resections without pancreatosplenectomy have subsequently been compared in nonrandomized, single-center trials that demonstrated comparable morbidity and improved survival after D2 resection.[168] Aggressive lymphadenectomy is also beneficial as it allows for accurate staging.[173] The collective literature indicates that survival is improved with an increased number of resected nodes.

The use of minimally invasive techniques in gastrectomy for gastric cancer remains controversial but is increasing in its utilization. Laparoscopic resections once yielded a lower number of nodes due to technical issues with the procedure, but standardization of operative technique has recently shown comparable nodal harvests and overall survival. Nevertheless, there is a steep learning curve for this operation and surgeons should seek adequate training at high-volume centers before embarking on this route. Robotic procedures may alleviate this problem, but are more expensive and take significantly longer to perform. Further studies are needed before these techniques can be widely implemented.[174]

Short-term and long-term outcomes of elderly patients who underwent gastric resection for gastric cancer were recently reviewed. There were 222 patients who underwent gastrectomy and were divided into 2 groups: younger than or equal to 75 years old (group A) and older than 75 years (group B). The groups were homogeneous except for more advanced pathological stage ($P = 0.011$) and higher number of comorbidities in group B and a higher rate of neoadjuvant or adjuvant complementary therapy in group A. Perioperative morbidity rates were 38.7 and 65.5% ($P = 0.001$), and mortality rates were 2.5 and 7.9% ($P =$ ns), respectively. The independent negative prognostic factors for morbidity were age older than 75 years, multiple organ resection, and male gender. The 36-month survival rates were 76.1% and 42.1% ($P = 0.002$) and disease-free survival rates were 85% and 76.3% ($P = 0.017$), respectively. The authors concluded that surgical indications should not be limited by age.[175]

Combined modality therapy

Adjuvant therapy

Unfortunately, even patients who undergo curative R0 resection have a high rate of recurrent disease following surgery. Locoregional and distant recurrences happen with comparable frequencies, with most recurrences occurring within 2 years of surgery. In 2001 the Intergroup 0116 prospective randomized controlled trial comparing 5-FU and leucovorin plus external beam radiation to observation after curative resection of gastric cancer demonstrated improvement in both overall and relapse-free survival in the treatment group.[176] More recent data have shown that the survival benefit of this therapy is maintained on long-term follow-up. Ongoing studies are also currently evaluating the addition of targeted therapies such as trastuzumab, a targeted HER2 monoclonal antibody, to chemotherapy in the adjuvant setting.

Adjuvant chemotherapy in the elderly was evaluated in a study of 406 patients with nonmetastatic gastric cancer that consisted of 283 patients younger than 65 years (range: 23-64 years) and 123 patients 65 years of age or older (range: 65-75 years). There were no significant differences in gender, tumor localization in the stomach (cardia/noncardia), tumor histology, perineural invasion, lymphovascular invasion, histopathological characteristics of the tumor, or tumor stage between groups. No significant difference was detected in survival between groups. The median survivals were 20.8 months in patients younger than 65 years and 19.5 months in patients 65 years of age or older ($P = 0.9$). The authors concluded that adjuvant chemotherapy in elderly patients with gastric cancer has the same effectiveness as nonelderly patients.[177]

Neoadjuvant therapy

Likely benefits of preoperative administration include improved patient tolerance, ability to assess disease response in vivo, and tumor downstaging, which may improve R0 resection rate. There has therefore been significant interest in developing effective neoadjuvant or perioperative therapy regimens for gastric cancer. The British Medical Research Council's MAGIC trial comparing perioperative epirubicin, cisplatin, and 5-FU to surgery alone demonstrated improved overall and progression-free survival in addition to improved resectability. In addition, a significantly higher proportion of patients were able to tolerate the preoperative therapy. This study, however, has also has been criticized for the low rate of D2 dissection. More recent studies in the United States and Europe have also demonstrated improved survival and R0 resection rate with preoperative chemoradiotherapy. The RTOG 9904 trial, which was a phase II trial of neoadjuvant chemoradiotherapy, demonstrated a pathologic complete response in 26% of patients, with improved short-term survival in these patients. Presently, neoadjuvant therapy is recommended for patients with locoregionally advanced disease, regardless of age.[178]

Palliation

Due to the grim prognosis of advanced gastric cancer and inability to complete curative resection in approximately half of patients, understanding palliation is imperative when treating patients with gastric cancer. The utility of surgical therapy in palliation is controversial. Palliative gastrectomy is associated with significant morbidity (more than 50%) and mortality. Although this is presumably due to the deconditioned state of patients with advanced gastric cancers, this procedure cannot be justified universally for the prevention of symptoms. Follow-up studies of patients in whom elective gastrectomy was aborted due to detection of metastases at the time of operation found that only half required intervention for symptoms of advanced tumors and just over 10% needed operative interventions. The development of newer chemotherapeutic regimens and the implementation of targeted therapies may also improve the ability to palliate patients with advanced gastric cancer.

Summary

Even though the incidence of gastric adenocarcinoma has declined significantly in the United States over the last century, there is a trend toward more proximal and biologically aggressive tumors. Surgical excision continues to be the foundation of curative therapy for patients with operable disease, regardless of age. R0 resection optimizes outcomes while extended lymphadenectomy enhances staging accuracy and may provide marginal survival benefit.

Geriatric trauma

Ryan Millea, MD, Irfan Ali, MD

Surgeons and emergency physicians who treat injured patients are facing a new paradigm in trauma care. Over the next decade and beyond, the aging population will continue to increase, as will its need for emergency medical care, which has been colloquially termed the "silver tsunami." According to the US Census Bureau's 2017 National Population Projections, by the year 2030 all members of the "baby boom" generation will be older than age 65. By the year 2035, for the first time in the history of the United States, the elderly population will outnumber children, so that 1 in every 5 residents will be retirement age.[179]

During 1975 to 2015, life expectancy at birth in the United States increased from 68.8 to 76.3 years for men and from 76.6 to 81.2 years for female.[179] Given that the geriatric population is

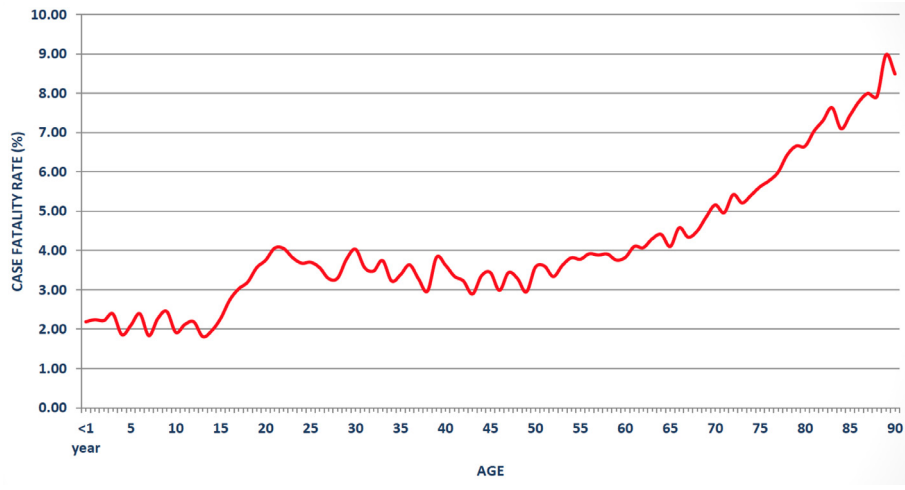

Fig. 2. Case fatality rate by age, NCHS Data Brief No. 199, May 2015.

living longer and leading more independent and active lifestyles than ever before, this population will be at an increased risk for unintentional injuries. Thus, there will be an expectant rise in the number of elderly patients presenting injured and, as recent reports suggest, they are indeed the fastest growing population admitted to trauma centers.[180] The 2016 National Trauma Data Bank reports that more than 30% of the recorded injuries occur in patients 65 years old or greater, accounting for more than 20% of the total fatalities.[180] In fact, the highest case fatality rates occurred in patients 75 years old and over (Fig 2). Overall in 2015, unintentional injury was the third leading cause of death and the seventh leading cause of death in patients greater than 65 years old, with more than 51,000 deaths reported (Fig 3).[178] The economic impact of trauma care in the elderly cannot be understated. Patients older than 65 years currently use more than 30% of all healthcare dollars allocated for trauma care and expenditures will continue to rise.

Although the literature currently lacks consensus on an age cutoff in trauma for a patient to be considered elderly, it has become customary to describe patients older than the age of 65 years to as elderly. Increasing age has been shown to be independently associated with an increased risk of death.[181] However, age alone may not be the only contributing factor to poorer outcomes; a patient's frailty may be even more predictive. In addition to frailty, pre-existing medical conditions have substantial influence on poorer outcomes in these patients.[182] Advancing age is associated with increasing medical comorbidities, different injury risk factors, poly-pharmacy, and overall loss of functional reserve and resiliency to injury. Due to the combination of these and other physiological deteriorations, elderly patients have an increased likelihood of substantial morbidity and mortality. Geriatric trauma patients have longer hospital lengths of stay, increased number of admissions to ICUs, develop more complications, and have higher mortality rates compared to younger patients with similar injuries.[182]

Physiological changes of aging

Aging

The fundamental concept in dealing with the elderly trauma patient is that the aging process exerts a progressive decrease of function in organ systems. Aging, also termed senescence,

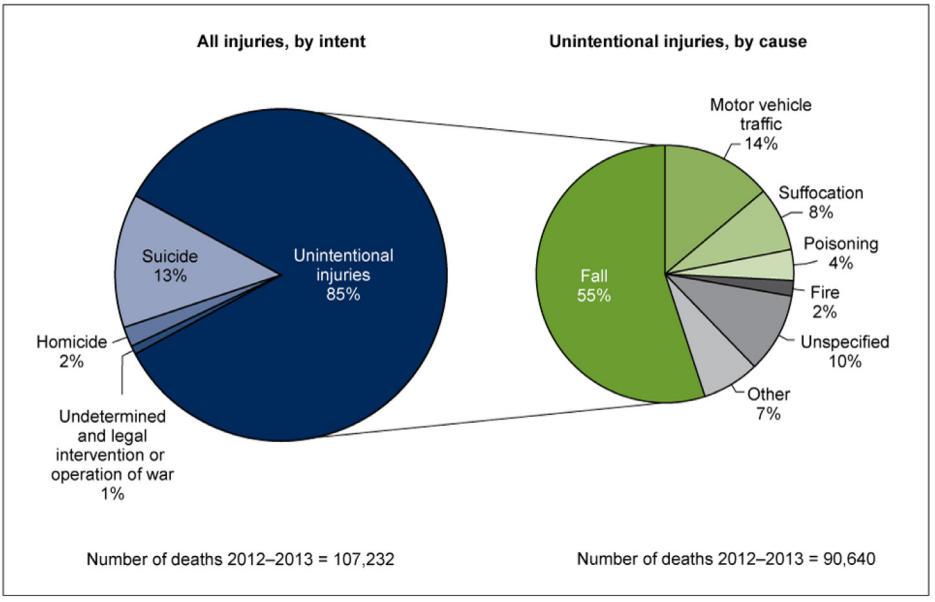

Fig. 3. Percent distribution of injury deaths, by intent and cause among adult aged 65 years and over: United States, 2012-2013. Note: Percents may not total 100% due to rounding. Source: CDC/NCHS, National Vital Statistics System, Mortality.

results from complex and multifactorial biological processes that are only beginning to be understood. A wide host of factors, external and internal, exert influence on this process. A sufficient definition is that aging is a progressive cellular decline that results in gradual deterioration of organ function. The physiological deteriorations of aging are intrinsic, inevitable, and irreversible, and lead to loss of viability and increase in vulnerability to disease and eventual death. It is also useful to understand the impact of aging by discussing the resulting changes that occur in the different organ systems.

Functional reserve

The ability to maintain homeostasis in the face of stress or injury decreases as we age. Functional reserve refers to the ability of an organ to successfully return to its original physiological state following repeated episodes of stress. Pre-existing comorbidities may further inhibit normal physiological responses needed to overcome injury. It has been shown that older patients do not fare as well following injuries, as do younger patients with similar injuries.[180] In a normal nonstressed state, the senescent changes in any particular organ system may not produce any meaningful functional impairment. Upon the introduction of stress in the form of injury, however elderly patients lack the ability to achieve maximal organ function, which may result in significant complications or increased mortality. The negative impact of diminished homeostatic function and pre-existing disease states on the outcomes of injured elderly patients may be offset by more aggressive management strategies compared to healthy younger patients. Increasingly in trauma and other medical subspecialties, the concept of frailty is being used to identify the subset of elderly patients with diminished functional reserve. The concept of frailty and how it is commonly assessed is discussed below.[20]

Outcomes and mortality

Comorbidities

Management and assessment of the geriatric trauma patient has multiple physiological challenges in the prehospital setting, acute trauma evaluation, and subsequent hospital course. A study conducted by Grossman and colleagues in 2002 sought to measure the impact of pre-existing medical conditions on mortality by analyzing a statewide trauma registry. Over a 13-year review, 33,781 geriatric trauma patients over the age of 65 years were included. Patients presenting with Glascow Coma Scale (GCS) of less than 3 were excluded. Pre-existing medical conditions universally prolonged inpatient care and demonstrated a significant increase in mortality as compared to the geriatric patient that had a single or no pre-existing medical conditions.[182]

Many clinical factors make geriatric patients more susceptible to serious complications from relatively minor trauma and make it more difficult to evaluate and treat these patients.[20] The advent of tailored pharmaceuticals for chronic medical conditions, as well as the availability of healthcare to an aging American population warrants careful consideration as to how these medical comorbidities can affect the contemporary effective geriatric trauma care. Part of these principles involves understanding how cardiac and pulmonary conditions affect overall morbidity and survival within the geriatric trauma population.[9,10]

Nearly half of evaluated geriatric patients have hypertension and associated heart disease that require cardiac-specific or systemic medication.[9] Twenty to thirty percent of these patients have a degree of pulmonary compromise ranging from medication-controlled COPD to oxygen requirements as an outpatient.[10,12] Examination of the remaining geriatric trauma population demonstrates that 10%-15% have concomitant diabetes, renal impairment, or cognitive impairment in the form of pre-existing dementia or prior stroke.[13,15,18] It has been shown that the highest rates of mortality within the geriatric population are in patients with liver, renal, or malignant conditions that are otherwise unknown at the time of initial presentation.[18] Gathering an appropriate medical history and addressing the most common clinical scenarios encountered in the trauma bay will benefit every geriatric trauma evaluation.

Cardiac

It has been well documented that beta blockers mask changes in vital signs in the setting of hemorrhagic shock. It is important to evaluate for occult hypoperfusion by obtaining base deficit and serum lactate values. Geriatric patients are more sensitive to changes in vital signs than are younger patients because of decreased physiological reserve, and they more commonly have baseline hypertension.[183] Thresholds for shock intervention in geriatric patients are more conservative than those in younger patients (systolic blood pressure $<$ 110 mm Hg vs $<$ 90 mm Hg in younger patients; heart rate $>$ 90 beats per minute vs $>$ 100 beats per minute in younger patients).[9]

Previous studies have shown that arrhythmias account for 25% of falls in the geriatric population.[184] Unwitnessed syncopal events warrant diligent cardiac evaluation and closer examination of a patient's medical history. Elderly patients are commonly anticoagulated, and anticoagulation is a therapeutically reversible risk factor. Considering the increasing number of indications for and prevalence of anticoagulation, the low cost of an INR and the potential reduction in costs associated with traumatic brain injury (TBI), several prospective studies have provided evidence to support the need for assessment of coagulation profiles in elderly trauma patients to promptly identify those in need of closer monitoring and a more aggressive reversal of their anticoagulation.[185] The use of anticoagulation in these patients warrants an individual examination and assessment for reversal for each patient. On a related note, no significant differences in overall morbidity and mortality have been noted between geriatric patients with and without major indications for antiplatelet therapy.[184] Geriatric trauma patients on outpatient anticoagulation have a higher likelihood of developing or exacerbating cardiac complications, needing packed red blood cell transfusions, worsening TBI, and sustaining more extensive solid organ injury.[186] The advent of newer anticoagulant therapies is of interest to the

trauma community. Of the novel anti-Xa anticoagulants, only dabigatran currently has a reversal agent commercially available. To date, rivaroxaban and edoxaban have no commercial agents that reverse either. Multiple studies have tested the efficacy of using 4-factor pro-thrombin complex (KCentra) for reversal of these novel agents, but no study has shown a mortality or even functional benefit.[187] Andexanet has recently been approved by the FDA as a modified factor Xa that binds all anti-Xa agents without conferring a procoagulant profile by itself.

Permanent pacemakers have improved upon cardiac function in this population as well. Pacemaker malfunction or cessation of function is a rare event but has been shown to severely limit resuscitative efforts in the geriatric trauma patient, leading to suboptimal care simply due to concerns of causing or exacerbating a cardiac event. Having a cardiologist involved early in the patient's care may limit delay in definitive care while appropriately restarting needed maintenance therapy, maintaining needed medical prosthetics, and perhaps eliminating unnecessary polypharmacy.

Pulmonary

COPD accounts for most of pulmonary disease encountered in the geriatric trauma patient. Pulmonary compromise as well as associated injuries can lead to a further complication such as pneumonia, sympathetic pleural effusions, and nonresolution of pneumothorax.[10,12] Complications of lower and upper airway disease has become a topic of research and aggressive inpatient management. Multicenter studies have shown that up to 40% of the current generation of geriatric trauma patients have had a significant smoking history of 5 years or more.[188]

Atelectasis and the rapid progression to pneumonia in rib fracture patients has been noted in multiple retrospective studies, identifying those with concurrent pulmonary disease as patients who are prone to longer ICU stays and mortality. ICU stays, and subsequent mechanical ventilator dependence, have been shown to be extended by as long as 4 days compared to those patients without significant pulmonary disease.[188] The most significant deterrent toward early rehabilitation has unfortunately been attributed to the amount of time these patients are immobile.[182] Early mobility protocols have improved these historical trends, but further studies and formal system-based practice changes are needed.

Endocrine and renal

Diabetes has been shown to delay wound healing, worsen cardiac function, and lead to electrolyte derangements that affect cardiopulmonary balance as well as cardiorenal balance.[42] Diabetic control and electrolyte imbalance is an area of interest for larger trauma centers. Aggressive repletion of magnesium and phosphate has been shown to have significant mortality benefit, while strict blood glucose control has shown to help in management of overall nutrition and rehabilitative efforts.[183] Management of fluid and electrolyte imbalances has shown to be a critical factor in appropriately resuscitating patients in the convalescent phase of care. Prior studies have shown that under-resuscitation is seen in smaller centers not familiar with appropriate management of impaired renal function. Under-resuscitation has been shown to decrease overall survival and worsen chronic renal failure.[183] Geriatric trauma patients that present with acute kidney injury as a result of either dehydration or metabolic insult tend to progress to mild chronic impairment simply as a function of not identifying and treating the underlying nidus.[24] Due diligence in resuscitating and accounting for metabolic and electrolyte derangements in the elderly can have a significant survival benefit in this population of trauma patients. Taken together, the maintenance of physiological capacity within the geriatric trauma patient requires attention to detail.[183] Chronic conditions that are otherwise well controlled before traumatic injury are not always at the front of triage assessments. Keeping endocrine and renal factors aligned with overall resuscitative goals will be an attainable challenge for optimal geriatric care in the trauma setting.

Neurocognitive

Previous studies have indicated that cognitive impairment on admission leads to a 3-fold increase in time spent as an inpatient and an extended stay within rehabilitation facilities.[13,15,42]

Patients' cognitive impairment may limit the use of mental status examinations and the Glasgow Coma Scale. Early intensive monitoring, evaluation, and resuscitation of elderly patients improve survival after trauma. This costly medical support is justified with few requiring nursing home care on discharge and the majority returning home. It has been suggested that effective care of the elderly should involve a geriatric consultation service.[46] This was confirmed by Fallon and colleagues who demonstrated improved medical care in elderly patients after review by a physician, addressing new and existing medical issues and reducing hospital acquired complications, such as functional decline, falls, delirium, and death.[189]

Frailty

Frailty has been previously defined as a clinical state of low physiological capacity and increased susceptibility to disability because of age-related loss of physical, cognitive, social, and psychological functioning.[20,42,46] The frailty syndrome is broadly considered to be decreased physiological reserve across multiple organ systems leading to an impaired ability to withstand physiological stress. Previous sections have described known physiological changes in the geriatric patient and are discussed elsewhere in this monograph.

Mechanism of injury

Falls

Falls are the most common mechanism of both fatal and nonfatal injuries in older adults. According to the National Vital Statistics system, in 2012-2013, 55% of all unintentional injury deaths among adults aged 65 years and over were due to falls. In 2014, approximately 30% of older adults reported falling at least once in the preceding 12 months, resulting in an estimated 29.0 million falls.[181] Of the individuals who reported a fall, 37.5% reported at least 1 fall that required medical treatment or restricted activity for at least 1 day, resulting in more than 7.0 million fall injuries. From 2000 through 2013, the age-adjusted fall injury death rate among adults aged 65 years and over nearly doubled from 29.6 per 100,000-56.7 per 100,000 (NVS). In 2015, the medical costs associated with fatal and nonfatal falls was approximately $50 billion.

Older patients are at risk of significant injury because of low altitude or ground level falls because of factors discussed previously. Physiological changes contributing to the severity of these injuries may include osteopenia, sarcopenia, and poor functional reserve capacity. Patients who may live alone or have a pre-existing diminished functional capacity who sustain an injury resulting from a fall may not be able to get up off the ground or call for help. In the event the patients remains incapacitated, secondary complications such as hemorrhage, dehydration, rhabdomyolysis, or pressure wounds to the skin may arise. Also, an increasing number of patients are being prescribed anticoagulation medications.[187] These medications are directly associated with a higher mortality, complication rate, and length of ICU stay in patients who sustain a fall.[187] Upon presentation, trauma providers must be at heightened awareness for patients who may be taking these medications, so that early and aggressive reversal may be considered and implemented.

There have been numerous studies regarding identifying risk factors in the geriatric population. Both intrinsic and extrinsic factors have been found to be associated with increased risk of falls and a higher associated mortality. These studies report mixed results for identifying the major risk factors, but all have many similar findings. In a review of 12 fall risk factor studies, it was determined that older age, history of previous falls, functional impairment, impaired mobility or use of walking assist device, dementia, low activity level, and balance impairment carried the highest risk of fall events.[190] There are a host of intrinsic physiological factors and medical comorbidities that also increase the chance of fall, such as hypotension, antihypertensive medications, vision problems, depression, and polypharmacy. Environmental risk factors range from footwear, such as slippers, bare-feet, or socks, to poor lighting and objects such as rugs or ground level obstacles within the home.

Falls should not be an inevitable part of aging. One example of a successful program aimed at the reduction of falls is the Stopping Elderly Accidents, Deaths and Injuries, which was developed by the Centers for Disease Control and Prevention (CDC). The Stopping Elderly Accidents, Deaths and Injuries program was established based on guidelines by the American and British Geriatric Societies in 2012. The tools in this algorithmic assessment include screening questions such as "do you feel unsteady when standing or walking" and then if positively screened, proceeds to assessment with timed walking and balance testing. After determining a patient's risk, successful interventions include thorough review and adjustment of disease and pharmacologic treatments, exercise programs, footwear modification, using calcium and vitamin D supplementation, correcting vision impairments, environmental inspection, and hazard reduction.[30] Given the success and validation of this program, its utilization is becoming more widespread and is being adopted to prevent in-hospital falls.

Geriatric patients who require hospitalization following fall related injury have poor outcomes. A retrospective cohort study conducted by Ayoung-Chee and colleagues included 1352 patients older than 65 years admitted to a regional level I trauma center from 2005 to 2008 demonstrated that there is significant morbidity and mortality associated with fall events. Of this cohort, 48% had an Injury Severity Score (ISS) greater than 15, and 12% died during admission. For the patients who survived hospitalization, 51% were discharged to a skilled nursing facility, 33% to home without assistance, 6% to home with assistance, and 5% to inpatient rehabilitation facilities. Within 1 year of the index injury, 44.6% of the patients were readmitted. The cumulative 1-year mortality rate for this cohort was 33% and for the patients who were discharged alive, the 1-year mortality rate was 24%.[190] Given the scope of this problem, multidisciplinary assessment while the patient is in hospital is paramount. To improve outcomes, initiation of early physical therapy, consultation with a pharmacist, and involvement of a geriatric consultation service have been shown to be helpful.[189]

Motor vehicle collisions

According to the National Trauma Databank, motor vehicle collisions (MVC) are the second most common mechanism of injury in the elderly population. Although the elderly driver is not always at fault, studies have revealed risk factors associated with these collisions and predictors of poor outcomes. Elderly drivers may be at increased risk for MVC due to previously discussed conditions. MVCs have been attributed to visual disturbances, hearing impairments, physical disabilities, medications, cognitive impairments including difficulties in managing sensory input and chronic diseases.[191] It has been shown that age is a positive predictor of serious injury from motor vehicle trauma, the risk of which increases in nonlinear fashion as age increases.[191]

Several studies have shown that elderly drivers are less likely to be appropriately triaged to designated trauma centers.[192] Geriatric patients involved in MVCs have been shown to fare better when assessed at a designated trauma center. The New York Statewide Planning and Research Cooperative Systems database was analyzed for trauma admissions to level I and II trauma centers from 1996 to 2003 to determine the volume of patients older than 65 years involved in MVC. There were 5365 geriatric MVC victims. Of these patients, 91% were discharged alive. The volume of geriatric MVC patients at the center where the patient was treated was an independent significant predictor of survival (OR, 32.6; 95% CI, 2.8-377.0; $P = 0.005$),[192] suggesting that there may be a risk-adjusted survival advantage for elderly involved in MVC treated at trauma centers with higher volume of geriatric MVC trauma.

Elderly drivers have more fatal crashes per mile driven than any other group except teenage males.[192] Given the increasing geriatric population and number of aged drivers, we can expect the number of MVC will also continue to increase. Therefore, maximizing the safety for older drivers is crucial. Reducing risk factors, similar to falls, may be beneficial. Also, driver license renewal policies and/or restrictions were found to reduce the crash risk.

Triage of the geriatric trauma patient

Geriatric trauma patients are at high risk for undertriage both in the prehospital setting and upon arrival to a hospital. Due to the consequence of physiological age associated changes,

elderly patients may present with subtle changes in baseline vital signs that may not be perceived by either Emergency Medical Service (EMS) or Emergency Department (ED) personnel. Additionally, patients who are seemingly stable may rapidly deteriorate due to decreased functional reserve. The combination of these factors may place the elderly population at risk for error in triage, either by diversion from a dedicated trauma center, or inappropriate level of trauma team activation. The 2011 Nationwide Emergency Department Sample for more than 4 million emergency department visits for patients older than or equal to 55 years old with new injury severity score injury severity score of more than or equal to 9 determined that 61.3% were treated at a lower level or nontrauma center.[185]

Appropriate triage to a designated trauma center may improve outcomes. Although there are some data to suggest that there may not be a demonstrable improvement in mortality between designated and nondesignated trauma centers, there does appear to be a cost discrepancy. In a population-based retrospective cohort study by Staudenmayer and colleagues, there were 244 patients included with an ISS greater than 15. The undertriage rate was 32.8% (n = 80) and the overall 60-day mortality rate for patients with an ISS greater than 15 was found to be 17%, with no difference between trauma and nontrauma centers in unadjusted or adjusted analyses. Of note, however, the median per-patient costs were $21,000 higher for severely injured patients taken to trauma centers.[193] Further studies may aid in developing predictive models of early mortality and identification of the subset of elderly patients, if not all, who would benefit from trauma center admission.

Geriatric patients that were prehospital triaged to trauma centers have been found to have underutilization of trauma service activation. Lehmann and colleagues found that elderly trauma patients were significantly less likely to have trauma team activation (14% vs 29%, $P < 0.01$), despite a similar percentage of severe injuries (injury severity score > 15). Also, they more frequently required urgent craniotomy (10% vs 6%, $P < 0.01$) and orthopedic procedures (67% vs 51%, $P < 0.01$) compared to younger patients. This study also showed that heart rate and blood pressure were not predictive of severe injury in patients older than 65 years of age. Undertriaged elderly patients had 4 times the mortality rate and discharge disability of the younger cohort in this study (both $P < 0.001$).[194]

The results of these studies reveal that the undertriage of geriatric trauma patients is a national phenomenon, even at designated trauma hospitals. It may be necessary to alter trauma activation criteria for elderly patients to offset the negative impact of undertriage. Indeed, it has been shown that by adjusting for age as a factor for highest tier trauma activation improves the outcomes for these patients. One study included 336 patients aged 70 years or more with an ISS greater than 15 using age older than or equal to 70 years as trauma team activation criteria. Two groups were compared before (group 1) and after (group 2) the new activation protocol with regard to survival, functional status on discharge, and hospital charges. The investigators found that the mortality rate for group 1 was 53.8% and for group 2 was 34.2% ($P = 0.003$). The incidence of permanent disability in the 2 groups was 16.7% and 12.0%, respectively. In subgroups of patients with an ISS of more than 20 the mortality rate was 68.4% and 46.9% in groups 1 and 2, respectively ($P = 0.01$). The date also showed a reduction in permanent disability, with 12 of 49 survivors in group 1 and 2 of 26 in group 2 who suffered permanent disability ($P = 0.12$).[195] Based on the results of this and similar studies, the ACS Trauma Quality Improvement Project (TQIP) Geriatric Trauma Management guidelines recommend lowering the threshold for trauma team activation for elderly patients. The current recommendation is for trauma centers to elevate the level of activation by 1 tier based on age.

Common injuries

Pelvic and hip fractures

Pelvic and proximal femur fractures are common injuries in the geriatric trauma patient. In an analysis of 5953 fractures distribution reviewed from a single orthopedic trauma unit, 75% had an increased incidence in older patients. Analysis of these data indicates that 14 different

fractures are likely attributable to osteoporosis. Approximately 30% of fractures in men, 66% of fractures in women, and 70% of inpatient fractures are potentially osteoporotic.[188]

Pelvic fractures are associated with significant morbidity, poor functional outcomes, and high mortality both acutely and following discharge in the elderly. Recent advances in operative management of pelvic fractures have improved outcomes and patient survival. Buller and colleagues provided the largest and most comprehensive epidemiologic analysis of pelvic ring fractures in the United States. In this study, the National Hospital Discharge Survey was used to estimate the incidence and to evaluate risk factors for mortality and inpatient complications following pelvic ring fractures. The investigators found that the incidence of pelvic ring fractures increased from 27.24 to 34.30 per 100,000 capita ($P < 0.001$) over the 17- year study period. Mortality declined from 4.2% to 2.8% ($P < 0.001$) paralleling an increase in the proportion of patients treated with surgical fixation (7.22%-10.36%).[188] They postulate that the decrease in mortality and in length of stay are likely due to improved surgical techniques and the implementation of early surgical intervention, hemorrhage control, and earlier ambulation.

Each year more than 300,000 patients 65 years and older are hospitalized for hip fractures, mostly due to falls. Women account for 3 quarters of all hip fractures, due to increased risk of osteoporosis. Delay in operative intervention for hip fracture is associated with a significant increase in mortality. A multicenter study of 4633 patients, investigated the impact of delays in surgery for hip fracture on short- and long-term outcomes in patients older than 65 years. Patients who had surgery within 2 days had lower in-hospital, 1-month, and 1-year mortality rates compared to those who waited for surgery for more than 4 days (2.9%, 4.0%, 17.4% vs 4.6%, 6.1%, 26.2%, respectively). The length of operation delay has the largest effect on increasing mortality (less than 2 days-reference group, 2-4 days-OR = 1.20, 5 days or longer, OR = 1.50). The patients who did not receive an operation suffered the highest 1-year mortality, at 36.2%.[196]

Rib fractures

Rib fractures in elderly trauma patients are associated with significant mortality and morbidity. The most common complications associated with geriatric rib fractures included respiratory failure, poor pain control, atelectasis, prolonged mechanical ventilation, and pneumonia. A 13-year statewide database analysis of 8648 elderly patients admitted to a trauma center with more than 1 rib fracture was used to examine the relationship between the number of rib fractures and associated morbidity and mortality. The mortality for elderly patients with rib fractures was greater than for patients younger than age 65 years (20.1% vs 11.4%, $P < 0.001$). Mortality rates increased linearly with increasing numbers of fractures for both age groups and were always significantly higher in elderly trauma patients. Seven of 10 complications were more common in elderly patients despite a lower mean ISS. Of the pulmonary complications, acute respiratory failure, pneumonia, and pleural effusion were more common in elderly patients ($P < 0.05$).[188] Similarly, a study showed that elderly patients who sustain rib fractures have twice the mortality and thoracic morbidity of younger patients with similar injuries and that for each additional rib fracture, the mortality rate increases by 19% and the risk of pneumonia by 27%.[188]

In an initiative to reduce pulmonary complications associated with multiple rib fractures in the elderly, Pyke and colleagues recommended direct intensive care unit admission of nonmechanically ventilated elderly patients with clinically important thoracic trauma, primarily multiple rib fractures. After this intervention, they had decreased unplanned ICU admissions (8.5% vs 13.0%, $P < 0.001$), complications (14.3% vs 28.2%, $P = 0.001$), and ICU length of stay (4 vs 6 day, $P = 0.05$). Additionally, more patients of the post-ICU intervention group were discharged to home (41.1% vs 27.5%, $P = 0.008$). The post group demonstrated a decrease of in-hospital mortality (2.9% vs 15.2%, $P = 0.004$).[197] This intervention shows that early and aggressive management of geriatric patients who sustain multiple rib fracture may have far reaching benefit to morbidity and mortality.

Aggressive pain control strategies and chest physiotherapy are the mainstay interventions to decrease the risk of significant pulmonary complications. Treatment options such as

narcotics, local rib blocks, paravertebral blocks or infusion pump systems, pleural infusion catheters, and epidural catheter directed analgesia are often employed. Each strategy has its own unique advantages and disadvantages. Intravenous opioid narcotics should be used with caution in elderly patients and administration should be monitored closely, such as with end-tidal CO_2 monitor or patient-controlled analgesia pumps. The Eastern Association of the Surgery of Trauma recommends epidural analgesia as the preferred and optimal modality of pain relief for patients with blunt thoracic trauma. Epidural catheter analgesia is associated with less respiratory depression, somnolence, and GI symptoms when compared to narcotics. Ullman and colleagues demonstrated a decreased incidence of tracheostomy, length of ICU and total hospital stay, and duration of ventilator support with epidural analgesia.[198] Given the likely benefits of aggressive pain control and chest physiotherapy strategies, the authors' practice is to admit older patients with 2 or more rib fractures to the ICU for at least a short duration, to assess and trend pulmonary function, and to utilize epidural analgesia if possible.

Traumatic brain injury

The incidence of TBI and associated mortality is rapidly rising in the population of elderly patients in the United States.[73] More than 100,000 TBI related deaths occurred among adults aged 65 years or older from 2000 to 2010. The most common mechanism of injury causing TBI in the elderly is falls. Mortality from TBI in elderly patients is higher compared to younger adults and the elderly have worse functional outcomes. In a study to mortality in nearly 12,000 TBI patients, of which nearly 30% were elderly, the mortality for patients older than 64 years was almost twice that of the younger group. Also, the surviving patients had lower GCS upon discharge than the younger group despite better admission GCS scores and lower ISS upon admission.[199] The fact that elderly patients with TBI present less injured and with higher initial GCS scores warrants close consideration by the trauma surgeon. Due to decreased brain volume and increased intracranial space associated with aging, it may take longer for blood to accumulate before it becomes clinically apparent. It is necessary to have a high index of suspicion for these injuries based on mechanism, so that early surgical intervention can be initiated if warranted, as this has been shown to have mortality and functional outcome benefit.

Special considerations

Elder abuse

Unfortunately, geriatric patients triaged by a trauma surgeon may be victims of elder abuse, although it may not be clear at the time. The CDC defines elder abuse as any abuse and neglect of persons age 60 years and older by a caregiver or another person in a relationship involving an expectation of trust. Consensus has been established about the inclusion of 5 major types of elder abuse including physical, psychological, sexual, financial, and neglect. In 2010, 1 in 10 people older than 60 years experienced some form of mistreatment.[200] However, this incidence is likely underestimated since studies that rely on self-reported information exclude patients with dementia, which has been shown to place older persons at greater risk for mistreatment. An estimated 4 of 5 cases are not reported because of shame, ignorance of rights, self-blame, and fear of a loss of independence. The CDC reported that more than 500,000 older adults are abused or neglected each year. Elderly adults who are victims of abuse have a 3-fold increase in all-cause mortality compared to nonabused cohorts. In another study, patients who are victims of abuse had statistically significant increases in 5-year mortality risks between abuse types and across gender.[201]

Abuse occurs in institutions as well, as almost one-third of elders in an assisted living or nursing home experienced abuse. Measures to reduce or prevent elder abuse must begin with mandatory reporting. Practitioners must be educated in the signs of abuse and the methodology for reporting such events. The National Center on Elder Abuse maintains a website with

resources, contact numbers, and a directory in each state for reporting and investigating elder abuse.

End of life and palliative care

In severely injured geriatric trauma patients, end-of-life decisions and aggressiveness of treatment must be always considered. Often in this population there will be written advanced directives, living wills, or appointed healthcare proxies or surrogates that can assist in guiding treatment decisions. Opinions regarding clinical outcomes may differ between physicians and healthcare proxies and/or advanced directives. Therefore, it is important for the physician to provide care in agreement with the patient's previous directives or with the person designated to make decisions on behalf of the patient if incapacitated to the point where he cannot make his current wishes known. According to the ACS Guidelines for Geriatric Trauma, more than 40% of elderly trauma patients require decision-making near the end-of-life, with 70% of those patients lacking decision-making capacity. It has been found that patient's wishes via living wills or advanced directives "in a terminal condition" and fulfillment of these directives is often not observed.[22]

Elderly trauma patients experience more complications, have higher mortality rates, and are more likely to be discharged to long-term care facilities with poor recovery of function. It can be especially challenging to determine the futility of ongoing treatment in severely injured elderly patients and when withdrawal of care should be considered. It has been shown that pre-existing medical comorbidities and injury severity do not always accurately predict futility of care of elderly trauma patients.[189] Survivability may not be the sole factor in determination of care withdrawal. Often perceptions of QOL or disposition to long-term care facilities are factors that determine care withdrawal.

Due to the complexity of end-of-life decisions in geriatric trauma, early consultation with a palliative care consultant has been shown to be beneficial. Patients who received an early palliative care consultation were significantly more likely to have a documented advance directive discussion (93.1% vs 6.9%; $P < 0.001$) and a code status update or change. They also experienced both reduced ICU and hospital length of stays and had had better symptom management.[39] Another study demonstrated that patients who received palliative care consultations were less likely to undergo tracheostomy and feeding tube placement.[202] It is clear that palliative consultation services can assist in navigating the difficult decisions that must be made for severely injured trauma patients and these services should be incorporated into a multidisciplinary team approach for these patients.

Conclusion

As the elderly population of the United States continues to grow, more geriatric patients than ever before will be treated for traumatic injury. Because treating geriatric trauma patients is becoming common practice, it is necessary for trauma and general surgeons to come equipped with a firm understanding of the special considerations in the management of their injuries, medical comorbidities, and the underlying age-associated physiological changes that may contribute to poor outcomes. Older patients fare worse with similar injury severity to younger cohorts. Mechanism of injury and survival are not necessarily as straightforward an association in the elderly as in younger patients. Seemingly innocuous injuries can have devastating consequences on healthcare efficacy and longer term rehabilitative needs. Age is an important delineator of many of the topics covered in this chapter, but it cannot be understated that age alone is not the only factor that must be considered when treating elderly patients. Pre-existing medical conditions and the assessment of the patient's physiological functional reserve in the form of frailty are strong predictors of mortality and independence upon discharge. Because the degree of functional reserve differs among patients, it is necessary to individualize treatment considerations for each patient, including potentially more aggressive strategies, management by critical care specialists, involvement of geriatricians, and palliative care consultations.

References

1. Mohanty S, Rosenthal RA, Russell MM, et al. Optimal perioperative management of the geriatric patient: a best practices guideline from the American College of Surgeons NSQIP and the American Geriatrics Society. *J Am Coll Surg*. 2016;222:930–947.
2. Chow WB, Rosenthal RA, Merkow RP, et al. Optimal preoperative assessment of the geriatric surgical patient: A best practices guideline from the American College of Surgeons National Surgical Quality Improvement Program and the American Geriatrics Society. J Am Coll Surg, Vol. 215, 453-466.
3. Polanczyk CA, Marcantonio E, Goldman L, et al. Impact of age on perioperative complications and length of stay in patients undergoing noncardia surgery. *Ann Intern Med*. 2001;134:637–643.
4. Hamel MB, Henderson WG, Khuri SF, Daley J. Surgical outcomes for patients aged 80 and older: morbidity and mortality from major noncardiac surgery. *J Am Geriatr Soc*. 2005;53:424–429.
5. Perry R, Scott LJ, Haase AM, et al. Pre-admission interventions to improve outcome after elective surgery—protocol for a systematic review. *Syst Rev*. 2016;5:88.
6. Kaplan EB, Sheiner LB, Boeckmann AJ, et al. The usefulness of preoperative laboratory screening. *JAMA*. 1985;253:3576–3581.
7. Benarroch-Gampel J, Sheffield KM, Duncan CB, et al. Preoperative laboratory testing in patients undergoing elective, low-risk ambulatory surgery. *Ann Surg*. 2012;256:518–528.
8. Chen AF, Wessel CB, Rao N. *Clin Orthop Relat Res*. 2013;471:2383. https://doi.org/10.1007/s11999-013-2875-0.
9. Fleisher LA, Fleischmann KE, Auerbach AD, et al. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing non cardiac surgery: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2014;130:2215.
10. Gupta H, Gupta P, Xiang F, et al. Development and validation of a risk calculator predicting postoperative respiratory failure. *Chest*. 2011;140:1207–1215.
11. Nakhaie M, Tsai A. Preoperative assessment of geriatric patients. *Anesth Clin*. 2015;33:471–480.
12. Qaseem A, Snow V, Fitterman ER, et al. Risk assessment for strategies to reduce perioperative pulmonary complications for patients undergoing noncardiothoracic surgery: a guidelines from the american college of physicians. *Am Int Med*. 2006;144:575–580.
13. Borson S, Scanlan JM, Chen P, Ganguli M. The Mini-Cog as a screen for dementia: validation in a population-based sample. *J Am Geriatr Soc*. 2003;51:1451–1454.
14. Kroenke K, Spitzer RL, Williams JB. The patient health questionnaire-2: validity of a two-item depression screener. *Med Care*. 2003;41:1284–1292.
15. Rinaldi P, Mecocci P, Benedetti C, et al. Validation of the five-item geriatric depression scale in elderly subjects in three different settings. *J Am Geriatr Soc*. 2003;51:694–698.
16. Lachs MS, Feinstein AR, Cooney Jr LM, et al. A simple procedure for general screening for functional disability in elderly patients. *Ann Intern Med*. 1990;112:699–706.
17. Afilalo J, Eisenberg MJ, Morin J-F, et al. Gait speed as an incremental predictor of mortality and major morbidity in elderly patients undergoing cardiac surgery. *J Am Coll Cardiol*. 2010;56:1668–1676.
18. Colburn JL, Mohanty S, Burton JR. Surgical guidelines for perioperative management of older adults: what geriatricians need to know. *J Am Geriatr Soc*. 2017;65:1339–1346. doi:10.1111/jgs.14877.
19. Alvarez-Nebreda M, Bentov N, Urman R, et al. Recommendations for preoperative management of frailty from the society for perioperative assessment and quality improvement (SPAQI). *J Clin Anesth*. 2018;47(June):33–42.
20. Joseph B, Pandit V, Zangbar B, et al. Superiority of frailty over age in predicting outcomes among geriatric trauma patientsa prospective analysis. *JAMA Surg*. 2014;149:766–772. doi:10.1001/jamasurg.2014.296.
21. Searle SD, Mitnitski A, Gahbauer EA, Gill TM, Rockwood K. A standard procedure for creating a frailty index. *BMC Geriatr*. 2008;8:24. doi:10.1186/1471-2318-8-24.
22. Taylor LJ, Nabozny MJ, Steffens NM, et al. A framework to improve surgeon communication in high-stakes surgical decisionsbest case/worst case. *JAMA Surg*. 2017;152:531–538. doi:10.1001/jamasurg.2016.5674.
23. Nabozny MJ, Kruser JM, Steffens NM, et al. Constructing high-stakes surgical decisions: it's better to die trying. *Ann Surg*. 2016;263:64.
24. Smith T, Pelpola K, Ball M, Ong A, Myint PK. Pre-operative indicators for mortality following hip fracture surgery: a systematic review and meta-analysis. *Age Ageing*. 2014;43:464–471.
25. Palmquist CL, Arivaratnam R, Watters DA, et al. Monitoring and evaluating surgical care: defining perioperative mortality rate and standardizing data collection. *Lancet*. 2015;385(Suppl 2):S27. doi:10.1016/S0140-6736(15)60822-4.
26. Liu Y, Cohen M, Hall B, et al. Evaluation and enhancement of calibration in the American College of Surgeons NSQUIP surgical risk calculator. *J Am Coll Surg*. 2016;223:231–239.
27. Fong TG, Tulebaev SR, Inouye SK. Delirium in elderly adults: diagnosis, prevention and treatment. *Nat Rev Neurol*. 2009;5:210–220. doi:10.1038/nrneurol.2009.24.
28. Marcantonio ER, Goldman L, Mangione CM, et al. A clinical predicition rule for delirium after elective noncardiac surgery. *JAMA*. 1994;271:134–139.
29. Bakker, Osse RJ, Tulen JH, Kappetein AP, Bogers AJ. Preoperative and operative predictors of delirium after cardiac surgery in elderly patients. *Eur J Cardiothorac Surg*. 2012;41:544–549.
30. Jeong YM, Lee E, Kim K-I, et al. Association of pre-operative medication use with post-operative delirium in surgical oncology patients receiving comprehensive geriatric assessment. *BMC Geriatr*. 2016;16:134. doi:10.1186/s12877-016-0311-5.
31. Regan DW, Kashiwagi D, Dougan B, Sundsted K, Mauck K. Update in perioperative medicine: practice changing evidence published in 2016. *Hosp Pract*. 2017;45:158–164. doi:10.1080/21548331.2017.1359060.
32. Amador LF, Goodwin JS. Postoperative delirium in the older patient. *J Am Coll Surg*. 2005;200(May):767–773.
33. Hastings SN, Sloane R, Morey MC, et al. Assisted early mobility for hospitalized older veterans: preliminary data from the STRIDE program. *J Am Geriatr Soc*. 2014;62:2180–2184 Epub 2014 Oct 30. doi:10.1111/jgs.13095.

34. Kalisch BJ, Lee S, Dabney BW. Outcomes of inpatient mobilization: a literature review. *J Clin Nurs*. 2014;23:1486–1501. doi:10.1111/jocn.12315.
35. Lawrence VA, Cornell JE, Smetana GWAmerican College of Physicians. Strategies to reduce postoperative pulmonary complications after noncardiothoracic surgery: systematic review for the American College of Physicians. *Ann Intern Med*. 2006;144:596–608.
36. Walton- Geer PS. Prevention of pressure ulcers in the surgical patient. *AORN J*. 2009;89:538–548.
37. Collard RM, Boter H, Schoevers RA, Oude Voshaar RC. Prevalence of frailty in community-dwelling older persons: a systematic review. *J Am Geriatr Soc*. 2012;60:1487–1492.
38. Golladay GJ, Satpathy J, Jiranek WA. Patient optimization—strategies that work: malnutrition. *J Arthroplasty*. 2016;31:1631–1634.
39. McDonald SR, Heflin MT, Whitson HE, et al. Association of integrated care coordination with postsurgical outcomes in high-risk older adults: the perioperative optimization of senior health (POSH) initiative. *JAMA Surg*. 2018;153:454–462.
40. Eamer G, Taheri A, Chen SS, et al. Comprehensive geriatric assessment for older people admitted to a surgical service. *Cochrane Database Syst Rev*. 2018(1) Art. No.: CD012485. doi:10.1002/14651858.CD012485.pub2.
41. Balentine CJ, Naik AD, Berger DH, Chen H, Anaya DA, Kennedy GD. Postacute care after major abdominal surgery in elderly patients. *JAMA Surgery*. 2016;151:8. 759. http://doi.org/10.1001/jamasurg.2016.0717 .
42. Deiner S, Westlake B, Dutton RP. Patterns of surgical care and complications in elderly adults. *J Am Geriatr Soc*. 2014;62:829–835. http://doi.org/10.1111/jgs.12794.
43. Lester L. Anesthetic considerations for common procedures in geriatric patients. *Anesthesiol Clin*. 2015;33:491–503. http://doi.org/10.1016/j.anclin.2015.05.006.
44. Barnett SR. Elderly patients. In: Miller RD, Pardo M, eds. *Basics of Anesthesia*. Elsevier; 2011:581–590.
45. Dodds C, Kumar CM, Servin F. *Anaesthesia for the Elderly Patient*. Oxford: Oxford University Press; 2007.
46. American Society of Anesthesiologists. ASA physical status classification system. https://www.asahq.org/resources/clinical-information/asa-physical-status-classification-system. Accessed 2 March 2018.
47. Culley DJ, Flaherty D, Fahey MC, et al. Poor performance on a preoperative cognitive screening test predicts postoperative complications in older orthopedic surgical patients. *Anesthesiology*. 2017;127:765–774. http://doi.org/10.1097/aln.0000000000001859.
48. Lindenauer PK, Pekow P, Wang K, Mamidi DK, Gutierrez B, Benjamin EM. Perioperative beta-blocker therapy and mortality after major noncardiac surgery. *N Engl J Med*. 2005;353:349–361 http//doi:10.1056/nejmoa041895.
49. Roshanov PS, Rochberg B, Patel A. Withholding versus continuing angiotensin II receptor blockers before noncardiac surgery. *Anesthesiology*. 2017;126:16–27.
50. Gustafsson UO, Scott MJ, Schwenk W, et al. Guidelines for perioperative care in elective colonic surgery: enhanced recovery after surgery (ERAS®) society recommendations. *Clin Nutr*. 2012;31:783–800. http://doi.org/10.1016/j.clnu.2012.08.013.
51. . Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration. *Anesthesiology*. 2017;126:376–393. http://doi.org/10.1097/aln.0000000000001452.
52. Mann C, Pouzeratte Y, Boccara G, et al. Comparison of intravenous or epidural patient-controlled analgesia in the elderly after major abdominal surgery. *Anesthesiology*. 2000;92:433. http://doi.org/10.1097/00000542-200002000-00025.
53. McIsaac DI, Wijeysundera DN, Huang A, Bryson GL, Walraven CV. Association of hospital-level neuraxial anesthesia use for hip fracture surgery with outcomes. *Anesthesiology*. 2018;128:480–491. http://doi.org/10.1097/aln.0000000000001899.
54. Koso RE, Sheets C, Richardson WJ, Galanos AN. Hip fracture in the elderly patients: a sentinel event. *Am J Hosp Palliat Med*. 2017;35:612–619. http://doi.org/10.1177/1049909117725057.
55. Beaupre LA, Jones CA, Saunders LD, Johnston DWC, Buckingham J, Majumdar SR. Best practices for elderly hip fracture patients. *J Gen Intern Med*. 2005;20:1019–1025. http://doi.org/10.1111/j.1525-1497.2005.00219.x.
56. Luger T, Kammerlander C, Luger M, Kammerlander-Knauer U, Gosch M. Mode of anesthesia, mortality and outcome in geriatric patients. *Zeitschrift für Gerontologie und Geriatrie*. 2014;47:110–124. http://doi.org/10.1007/s00391-014-0611-3.
57. Neuman MD, Silber JH, Elkassabany NM, Ludwig JM, Fleisher LA. Comparative effectiveness of regional versus general anesthesia for hip fracture surgery in adults. *Anesthesiology*. 2012;117:72–92. http://doi.org/10.1097/aln.0b013e3182545e7c.
58. Holt NF. Renal disease. In: Stoelting RL, ed. *Anesthesia & Co-Existing Disease*. New York, N.Y.: Churchill; 2012:53–355.
59. Abdelmonem A. Low dose hyperbaric bupivicaine injected at T12–L1 provides adequate anesthesia with stable hemodynamics for elderly patients undergoing TURP. *Egypt J Anaesth*. 2011;27:95–100. http://doi.org/10.1016/j.egja.2011.04.001.
60. Nakahira J, Sawai T, Fujiwara A, Minami T. Transurethral resection syndrome in elderly patients: a retrospective observational study. *BMC Anesthesiol*. 2014;14. http://doi.org/10.1186/1471-2253-14-30.
61. Holt NF. Cancer. In: Stoelting RL, ed. *Anesthesia & Co-Existing Disease*. New York, N.Y.: Churchill; 2012:511–512.
62. Munro A, Sjaus A, George RB. Anesthesia and analgesia for gynecological surgery. *Curr Opin Anaesthesiol*. 2018;31:274–279. http://doi.org/10.1097/aco.0000000000000584.
63. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2018. *CA Cancer J Clin*. 2018;68:7–30.
64. Jafari MD, Jafari F, Halabi WJ, et al. Colorectal cancer resections in the aging US population: a trend toward decreasing rates and improved outcomes. *JAMA Surg*. 2014;149:557–564.
65. Ogino S, Goel A. Molecular classification and correlates in colorectal cancer. *J Mol Diagn*. 2008;10:13–27.
66. Dahabreh IJ, Terasawa T, Castaldi PJ, Trikalinos TA. Systematic review: anti-epidermal growth factor receptor treatment effect modification by KRAS mutations in advanced colorectal cancer. *Ann Intern Med*. 2011;154:37–49.
67. Bahnassy AA, Zekri AR, Salem SE, et al. Differential expression of p53 family proteins in colorectal adenomas and carcinomas: prognostic and predictive values. *Histol Histopathol*. 2014;29:207–216.

68. Sanchez JA, Krumroy L, Plummer S, et al. Genetic and epigenetic classifications define clinical phenotypes and determine patient outcomes in colorectal cancer. *Br J Surg*. 2009;96:1196–1204.
69. Weisenberger DJ, Siegmund KD, Campan M, et al. CpG island methylator phenotype underlies sporadic microsatellite instability and is tightly associated with BRAF mutation in colorectal cancer. *Nat Genet*. 2006;38:787–793.
70. Bettington M, Walker N, Clouston A, Brown I, Leggett B, Whitehall V. The serrated pathway to colorectal carcinoma: current concepts and challenges. *Histopathology*. 2013;62:367–386.
71. Wolf AMD, Fontham ETH, Church TR, et al. Colorectal cancer screening for average-risk adults: 2018 guideline update from the American Cancer Society. *CA Cancer J Clin*. 2018:250–281.
72. Rex DK, Boland CR, Dominitz JA, et al. Colorectal cancer screening: recommendations for physicians and patients from the US multi-society task force on colorectal cancer. *Gastrointest Endosc*. 2017;86:18–33.
73. Shapiro JA, Bobo JK, Church TR, et al. A comparison of fecal immunochemical and high-sensitivity guaiac tests for colorectal cancer screening. *Am J Gastroenterol*. 2017;112:1728–1735.
74. Corley DA, Jensen CD, Marks AR, et al. Adenoma detection rate and risk of colorectal cancer and death. *N Engl J Med*. 2014;370:1298–1306.
75. Walter LC, Covinsky KE. Cancer screening in elderly patients: a framework for individualized decision making. *JAMA*. 2001;285:2750–2756.
76. Schoen RE. Pro: should screening colonoscopy be performed on an 88-yr-old healthy patient? *Am J Gastroenterol*. 2006;101:1713–1715 discussion 7-8.
77. Kasrten KRF. *T.D. Considerations for Geriatric Patients Undergoing Colorectal Surgery*. New York, NY: Springer Science+Business Media; 2016 pages cm p.
78. Herrinton LJ, Altschuler A, McMullen CK, et al. Conversations for providers caring for patients with rectal cancer: comparison of long-term patient-centered outcomes for patients with low rectal cancer facing ostomy or sphincter-sparing surgery. *CA Cancer J Clin*. 2016;66:387–397.
79. Downing A, Morris EJ, Richards M, et al. Health-related quality of life after colorectal cancer in England: a patient-reported outcomes study of individuals 12 to 36 months after diagnosis. *J Clin Oncol*. 2015;33:616–624.
80. How P, Stelzner S, Branagan G, et al. Comparative quality of life in patients following abdominoperineal excision and low anterior resection for low rectal cancer. *Dis Colon Rectum*. 2012;55:400–406.
81. Hida J, Yoshifuji T, Okuno K, et al. Long-term functional outcome of colonic J-pouch reconstruction after low anterior resection for rectal cancer. *Surg Today*. 2006;36:441–449.
82. Brown S, Margolin DA, Altom LK, et al. Morbidity following coloanal anastomosis: a comparison of colonic j-pouch vs straight anastomosis. *Dis Colon Rectum*. 2018;61:156–161.
83. Andre T, Boni C, Navarro M, et al. Improved overall survival with oxaliplatin, fluorouracil, and leucovorin as adjuvant treatment in stage II or III colon cancer in the MOSAIC trial. *J Clin Oncol*. 2009;27:3109–3116.
84. McCleary NJ, Meyerhardt JA, Green E, et al. Impact of age on the efficacy of newer adjuvant therapies in patients with stage II/III colon cancer: findings from the ACCENT database. *J Clin Oncol*. 2013;31:2600–2606.
85. Shafi S, Aboutanos MB, Agarwal Jr S, et al. Emergency general surgery: definition and estimated burden of disease. *J Trauma Acute Care Surg*. 2013;74:1092–1097. doi:10.1097/TA.0b013e31827e1bc7.
86. Ogola GO, Shafi S. Cost of specific emergency general surgery diseases and factors associated with high-cost patients. *J Trauma Acute Care Surg*. 2016;80:265–271. doi:10.1097/TA.0000000000000911.
87. Scott JW, Olufajo OA, Brat GA, et al. Use of national burden to define operative emergency general surgery. *JAMA Surg*. 2016;151. doi:10.1001/jamasurg.2016.0480.
88. Green G, Shaikh I, Fernandes R, Wegstapel H. Emergency laparotomy in octogenarians: a 5-year study of morbidity and mortality. *World J Gastrointest Surg*. 2013;5:216–221. doi:10.4240/wjgs.v5.i7.216.
89. Davis P, Hayden J, Springer J, Bailey J, Molinari M, Johnson P. Prognostic factors for morbidity and mortality in elderly patients undergoing acute gastrointestinal surgery: A systematic review. *Can J Surg*. 2014;57:E44–E52. doi:10.1503/cjs.006413.
90. Dellinger RP, Levy MM, Rhodes A, et al. Surviving sepsis campaign: international guidelines for management of severe sepsis and septic shock: 2012. *Crit Care Med*. 2013;41:580–637 [doi]. doi:10.1097/CCM.0b013e31827e83af.
91. Russell MM, Berian JR, Rosenthal RA, Ko CY. Improving quality in geriatric surgery: a blueprint from the american college of surgeons. *Bull Am Coll Surg*. 2016;101:22–28.
92. Eveleigh MO, Howes TE, Peden CJ, Cook TM. Estimated costs before, during and after the introduction of the emergency laparotomy pathway quality improvement care (ELPQuIC) bundle. *Anaesthesia*. 2016;71:1291–1295 [doi]. doi:10.1111/anae.13623.
93. Krause WR, Webb TP. Geriatric small bowel obstruction: an analysis of treatment and outcomes compared with a younger cohort. *Am J Surg*. 2015;209:347–351 [doi]. doi:10.1016/j.amjsurg.2014.04.008.
94. Jeppesen MH, Tolstrup MB, Kehlet Watt S, Gogenur I. Risk factors affecting morbidity and mortality following emergency laparotomy for small bowel obstruction: a retrospective cohort study. *Int J Surg*. 2016;28:63–68 [doi]. doi:10.1016/j.ijsu.2016.02.059.
95. Karkkainen JM, Lehtimaki TT, Manninen H, Paajanen H. Acute mesenteric ischemia is a more common cause than expected of acute abdomen in the elderly. *J Gastrointest Surg*. 2015;19:1407–1414 [doi]. doi:10.1007/s11605-015-2830-3.
96. Gun B, Yolcu S, Degerli V, et al. Multi-detector angio-CT and the use of D-dimer for the diagnosis of acute mesenteric ischemia in geriatric patients. *Ulus Travma Acil Cerrahi Derg*. 2014;20:376–381 [doi]. doi:10.5505/tjtes.2014.57639.
97. Hupfeld L, Pommergaard HC, Burcharth J, Rosenberg J. Emergency admissions for complicated colonic diverticulitis are increasing: a nationwide register-based cohort study. *Int J Colorectal Dis*. 2018 [doi]. doi:10.1007/s00384-018-3078-7.
98. Lameris W, van Randen A, Bipat S, Bossuyt PM, Boermeester MA, Stoker J. Graded compression ultrasonography and computed tomography in acute colonic diverticulitis: meta-analysis of test accuracy. *Eur Radiol*. 2008;18:2498–2511 [doi]. doi:10.1007/s00330-008-1018-6.

99. Thorsen K, Soreide JA, Kvaloy JT, Glomsaker T, Soreide K. Epidemiology of perforated peptic ulcer: age- and gender-adjusted analysis of incidence and mortality. *World J Gastroenterol*. 2013;19:347–354 [doi]. doi:10.3748/wjg.v19.i3.347.
100. Uccheddu A, Floris G, Altana ML, Pisanu A, Cois A, Farci SL. Surgery for perforated peptic ulcer in the elderly. evaluation of factors influencing prognosis. *Hepatogastroenterology*. 2003;50:1956–1958.
101. Thorsen K, Soreide JA, Soreide K. Long-term mortality in patients operated for perforated peptic ulcer: factors limiting longevity are dominated by older age, comorbidity burden and severe postoperative complications. *World J Surg*. 2017;41:410–418 [doi]. doi:10.1007/s00268-016-3747-z.
102. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2018. *CA Cancer J Clin*. 2018;68:7.
103. Chang SS, Bochner BH, Chou R, et al. Treatment of non-metastatic muscle-invasive bladder cancer: AUA/ASCO/ASTRO/SUO guideline. *J Urol*. 2017;198:552.
104. Chappidi MR, Kates M, Stimson CJ, et al. Quantifying nonindex hospital readmissions and care fragmentation after major urological oncology surgeries in a nationally representative sample. *J Urol*. 2017;197:235.
105. Novara G, Catto JW, Wilson T, et al. Systematic review and cumulative analysis of perioperative outcomes and complications after robot-assisted radical cystectomy. *Eur Urol*. 2015;67:376.
106. Liberman D, Lughezzani G, Sun M, et al. Perioperative mortality is significantly greater in septuagenarian and octogenarian patients treated with radical cystectomy for urothelial carcinoma of the bladder. *Urology*. 2011;77:660.
107. Haden TD, Prunty MC, Jones AB, et al. Comparative perioperative outcomes in septuagenarians and octogenarians undergoing radical cystectomy for bladder cancer-do outcomes differ? *Eur Urol Focus*. 2017:895–899.
108. Donat SM, Siegrist T, Cronin A, et al. Radical cystectomy in octogenarians–does morbidity outweigh the potential survival benefits? *J Urol*. 2010;183:2171.
109. Wildiers H, Heeren P, Puts M, et al. International Society of Geriatric Oncology consensus on geriatric assessment in older patients with cancer. *J Clin Oncol*. 2014;32:2595.
110. Decoster L, Kenis C, Van Puyvelde K, et al. The influence of clinical assessment (including age) and geriatric assessment on treatment decisions in older patients with cancer. *J Geriatr Oncol*. 2013;4:235.
111. Psutka SP, Carrasco A, Schmit GD, et al. Sarcopenia in patients with bladder cancer undergoing radical cystectomy: impact on cancer-specific and all-cause mortality. *Cancer*. 2014;120:2910.
112. Jensen BT, Petersen AK, Jensen JB, et al. Efficacy of a multiprofessional rehabilitation programme in radical cystectomy pathways: a prospective randomized controlled trial. *Scand J Urol*. 2015;49:133.
113. Large MC, Kiriluk KJ, DeCastro GJ, et al. The impact of mechanical bowel preparation on postoperative complications for patients undergoing cystectomy and urinary diversion. *J Urol*. 2012;188:1801.
114. Choi H, Kang SH, Yoon DK, et al. Chewing gum has a stimulatory effect on bowel motility in patients after open or robotic radical cystectomy for bladder cancer: a prospective randomized comparative study. *Urology*. 2011;77:884.
115. Lee CT, Chang SS, Kamat AM, et al. Alvimopan accelerates gastrointestinal recovery after radical cystectomy: a multicenter randomized placebo-controlled trial. *Eur Urol*. 2014;66:265.
116. Pillai P, McEleavy I, Gaughan M, et al. A double-blind randomized controlled clinical trial to assess the effect of Doppler optimized intraoperative fluid management on outcome following radical cystectomy. *J Urol*. 2011;186:2201.
117. Wuethrich PY, Burkhard FC, Thalmann GN, et al. Restrictive deferred hydration combined with preemptive norepinephrine infusion during radical cystectomy reduces postoperative complications and hospitalization time: a randomized clinical trial. *Anesthesiology*. 2014;120:365.
118. Myles PS, Bellomo R, Corcoran T, et al. Restrictive versus liberal fluid therapy for major abdominal surgery. *N Engl J Med*. 2018;379:1283.
119. Auffenberg GB, Ghani KR, Ye Z, et al. Comparing publicly reported surgical outcomes with quality measures from a statewide improvement collaborative. *JAMA Surg*. 2016;151:680.
120. Berian JR, Zhou L, Hornor MA, et al. Optimizing surgical quality datasets to care for older adults: lessons from the American College of Surgeons NSQIP geriatric surgery pilot. *J Am Coll Surg*. 2017;225:702.
121. Cancer.Org, 2018, https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/breast-cancer-facts-and-figures/breast-cancer-facts-and-figures-2017-2018.pdf. Accessed 30 May 2018.
122. Yancik R, Rosemary TG. Breast cancer in aging women. a population-based study of contrasts in stage, surgery, and survival. *Cancer*. 1989;63:976–981 Wiley. doi:10.1002/1097-0142(19890301)63:5⟨976::aid-cncr2820630532⟩3.0.co;2-a.
123. DeSantis C, Ma J, Brian L, et al. Breast cancer statistics, 2013. *CA Cancer J Clin*. 2013;64:52–62 American Cancer Society. doi:10.3322/caac.21203.
124. Yu XQ. Socioeconomic disparities in breast cancer survival: relation to stage at diagnosis, treatment and race. *BMC Cancer*. 2009;9 Springer Nature. doi:10.1186/1471-2407-9-364.
125. Aggarwal H, Callahan CM, Miller KD, et al. Are there differences in treatment and survival between poor, older black and white women with breast cancer? *J Am Geriatr Soc*. 2015;63:2008–2013 Wiley. doi:10.1111/jgs.13669.
126. Manthri S, Iqbal M, Desai MR, Mocharnuk RS, Robinson K. Impact of modifiable risk factors on clinical outcomes in geriatric patients with breast cancer. *J Clin Oncol*. 2017;35(15_suppl):e21546.
127. Kunkler IH, Williams LJ, Jack WS, et al. Breast-conserving surgery with or without irradiation in women aged 65 years or older with early breast cancer (PRIME II): a randomised controlled trial. *Lancet Oncol*. 2015;16:266–273 Elsevier BV. doi:10.1016/s1470-2045(14)71221-5.
128. Mandelblatt J, Cai L, Luta G, et al. Frailty and long-term mortality of older breast cancer patients: CALGB 369901 (Alliance). *Breast Cancer Res Treat*. 2017;164:107–117.
129. Koroukian S, Warner D, Schiltz N, et al. Abstract P6-02-01: perceived life expectancy, multimorbidity, and breast cancer screening in older women. *Cancer Research*. 2018;78(4 Supplement) P6-02-01-P6-02-01.
130. Housten A, Pappadis M, Krishnan S, et al. Resistance to discontinuing breast cancer screening in older women: a qualitative study. *Psycho Oncology*. 2018;27:1634–1641.
131. NCCN. https://www.nccn.org/professionals/physician_gls/default.asp.

132. "Shall we operate? Preoperative assessment in elderly cancer patients (PACE) can help". Vol. 65, no. , 2008, 156-163. Elsevier BV, doi:10.1016/j.critrevonc.2007.11.001.
133. Morgan J, Reed M, Wyld L. Primary endocrine therapy as a treatment for older women with operable breast cancer—a comparison of randomized controlled trial and cohort study findings. *Eur J Surg Oncol*. 2014;40:676–684.
134. Palta M, Palta P, Bhavsar NA, et al. The use of adjuvant radiotherapy in elderly patients with early-stage breast cancer: changes in practice patterns after publication of cancer and leukemia group B 9343. *Cancer*. 2014;121:188–193 Wiley. doi:10.1002/cncr.28937.
135. Martin G, Shaughnessy E. Breast cancer care in the elderly patient. *Curr Geriatr Rep*. 2017;6:139–148.
136. Dall P, Lenzen G, Göhler T, et al. Trastuzumab in the treatment of elderly patients with early breast cancer: results from an observational study in Germany. *J Geriatr Oncol*. 2015;6:462–469.
137. Leung KS, Ng MF, Pang FC, Au SY. Urinary incontinence: an ignored problem in elderly patients. *Hong Kong Med J*. 1997;3:27–33.
138. Rubin EB, Buehler AE, Halpern SD. States worse than death among hospitalized patients with serious illnesses. *JAMA Intern Med*. 2016;176:1557–1559.
139. Blaivas JG. The bladder is an unreliable witness. *Neurourol Urodyn*. 1996;15:443–445.
140. le Feber J, van Asselt E, van Mastrigt R. Afferent bladder nerve activity in the rat: a mechanism for starting and stopping voiding contractions. *Urol Res*. 2004;32:395–405.
141. Petros PE, Ulmsten U. Urethral and bladder neck closure mechanisms. *Am J Obstet Gynecol*. 1995;173:346–348.
142. Smith PP, DeAngelis A, Kuchel GA. Detrusor expulsive strength is preserved, but responsiveness to bladder filling and urinary sensitivity is diminished in the aging mouse. *Am J Physiol Regul Integr Comp Physiol*. 2012;302:R577–R586.
143. Yoshida M, Homma Y, Inadome A, et al. Age-related changes in cholinergic and purinergic neurotransmission in human isolated bladder smooth muscles. *Exp Gerontol*. 2001;36:99–109.
144. Tadic SD, Tannenbaum C, Resnick NM, Griffiths D. Brain responses to bladder filling in older women without urgency incontinence. *Neurourol Urodyn*. 2013;32:435–440.
145. Pfisterer MH, Griffiths DJ, Schaefer W, Resnick NM. The effect of age on lower urinary tract function: a study in women. *J Am Geriatr Soc*. 2006;54:405–412.
146. Kubota M, Okuyama N, Kobayashi K, Tsukada M, Nakaya K, Ishikawa M. Effects of neuromodulation with sacral magnetic stimulation for intractable bowel or bladder dysfunction in postoperative patients with anorectal malformation: a preliminary report. *Pediatr Surgery Int*. 2011;27:599–603.
147. Riall TS, Reddy DM, Nealon WH, Goodwin JS. The effect of age on short-term outcomes after pancreatic resection: a population-based study. *Ann Surg*. 2008;248:459–467.
148. Sukharamwala P, Thoens J, Szuchmacher M, Smith J, DeVito P. Advanced age is a risk factor for post-operative complications and mortality after a pancreaticoduodenectomy: a meta-analysis and systematic review. *HPB*. 2012;14:649–657.
149. He W, Zhao H, Chan W, Lopez D, Shroff RT, Giordano SH. Underuse of surgical resection among elderly patients with early-stage pancreatic cancer. *Surgery*. 2015;158:1226–1234.
150. Nagrial AM, Chang DK, Nguyen NQ, et al. Adjuvant chemotherapy in elderly patients with pancreatic cancer. *Br J Cancer*. 2014;110:313–319.
151. Tani M, Kawai M, Hirono S, et al. A pancreaticoduodenectomy is acceptable for periampullary tumors in the elderly, even in patients over 80 years of age. *J Hepatobiliary Pancreat Surg*. 2009;16:675–680.
152. Finlayson E, Fan Z, Birkmeyer JD. Outcomes in octogenarians undergoing high-risk cancer operation: a national study. *J Am Coll Surg*. 2007;205:729–734.
153. Lee MK, Dinorcia J, Reavey PL, et al. Pancreaticoduodenectomy can be performed safely in patients aged 80 years and older. *J Gastrointest Surg*. 2010;14:1838–1846.
154. Melis M, Marcon F, Masi A, et al. The safety of a pancreaticoduodenectomy in patients older than 80 years: risk vs. benefits. *HPB*. 2012;14:583–588.
155. Belyaev O, Herzog T, Kaya G, et al. Pancreatic surgery in the very old: face to face with a challenge of the near future. *World J Surg*. 2013;37:1013–1020.
156. Kinoshita S, Sho M, Yanagimoto H, et al. Potential role of surgical resection for pancreatic cancer in the very elderly. *Pancreatology*. 2015;15:240–246.
157. Gerstenhaber F, Grossman J, Lubezky N, et al. Pancreaticoduodenectomy in elderly adults: is it justified in terms of mortality, long-term morbidity, and quality of life. *J Am Geriatr Soc*. 2013;61:1351–1357.
158. Kuy S, Sosa JA, Roman SA, et al. Age matters: a study of clinical and economic outcomes following cholecystectomy in elderly Americans. *Am J Surg*. 2011;201:789–796.
159. Antoniou SA, Antoniou GA, Koch OO, Pointner R, Granderath FA. Meta-analysis of laparoscopic vs open cholecystectomy in elderly patients. *World J Gastroenterol*. 2014;20:17626–17634.
160. Pavlidis TF, Marakis GN, Symeonidis N, et al. Considerations concerning laparoscopic cholecystectomy in the extremely elderly. *J Laparoendosc Adv Tech A*. 2008;18:56–60.
161. Brunt LM, Quasebarth MA, Dunnegan DL, Soper NJ. Outcomes analysis of laparoscopic cholecystectomy in the extremely elderly. *Surg Endosc*. 2001;15:700–705.
162. Riall TS, Zhang D, Townsend Jr CM, Kuo YF, Goodwin JS. Failure to perform cholecystectomy for acute cholecystitis in elderly patients is associated with increased morbidity, mortality, and cost. *J Am Coll Surg*. 2010;210:668–679.
163. Tzeng CW, Cooper AB, Vauthey JN, Curley SA, Aloia TA. Predictors of morbidity and mortality after hepatectomy in elderly patients: analysis of 7621 NSQIP patients. *HPB*. 2013;16:459–468.
164. Ruzzenente A., Conci S., Ciangherotti A., et al. Impact of age on short-term outcomes of liver surgery: lessons learned in 10-years' experience in a tertiary referral hepato-pancreato-biliary center.
165. Oishi K, Itamoto T, Kohashi T, Matsugu Y, Nakahara H, Kitamoto M. Safety of hepatectomy for elderly patients with hepatocellular carcinoma. *World J Gastroenterol*. 2014;20:15028–15036.

166. Orcutt ST, Artinyan A, Li LT, et al. Postoperative mortality and need for transitional care following liver resection for metastatic disease in elderly patients: a population-level analysis of 4026 patients. *HPB*. 2012;14:863–870.
167. Suttner SW, Sürder C, Lang K, Piper SN, Kumle B, Boldt J. Does age affect liver function and the hepatic acute phase response after major abdominal surgery. *Intensive Care Med*. 2001;27:17.
168. Knight G, Earle CC, Cosby R, et al.Gastrointestinal Cancer Disease Site Group Neoadjuvant or adjuvant therapy for resectable gastric cancer: a systematic review and practice guideline for North America. *Gastric Cancer*. 2013 Jan;16:28–40.
169. Santoro R, Ettorre GM, Santoro E. Subtotal gastrectomy for gastric cancer. *World J Gastroenterol*. 2014;20:13667–13680.
170. Lim JH, Lee DH, Shin CM, et al. Clinicopathological features and surgical safety of gastric cancer in elderly patients. *J Korean Med Sci*. 2014;29:1639–1645.
171. Liu N, Molena D, Stem M, Blackford AL, Sewell DB, Lidor AO. Underutilization of treatment for regional gastric cancer among the elderly in the USA. *J Gastrointest Surg*. 2018;22:955–963.
172. Fukata S, Ando M, Amemiya T, Kuroiwa K, Oda K. Postoperative function following radical surgery in gastric and colorectal cancer patients over 80 years of age–an objection to "ageism". *Nagoya J Med Sci*. 2012;74:241–251.
173. de Pascale S, Belotti D, Celotti A, et al. Prognostic factors for short-term and long-term outcomes of gastric cancer surgery for elderly patients: 10 years of experience at a single tertiary care center. *Updates Surg*. 2018. doi:10.1007/s13304-018-0548.
174. Lianos GD, Rausei S, Ruspi L, et al. Evidences. *Int J Surg*. 2014;12:136–143.
175. Roberto M, Botticelli A, Strigari L, et al. Prognosis of elderly gastric cancer patients after surgery: a nomogram to predict survival. *Med Oncol*. 2018;35:111.
176. Karaca M, Tural D, Kocoglu H, Selcukbiricik F, Bilgetekin I, Özet A. Adjuvant chemotherapy for gastric cancer in elderly patients has same benefits as in younger patients. *J Cancer Res Ther*. 2018;14:593–596.
177. Smalley SR, Benedetti JK, Haller DG, et al. Updated analysis of SWOG-directed intergroup study 0116: a phase III trial of adjuvant radiochemotherapy versus observation after curative gastric cancer resection. *J Clin Oncol*. 2012;30:2327–2333.
178. Newton AD, Datta J, Loaiza-Bonilla A, Karakousis GC, Roses RE. Neoadjuvant therapy for gastric cancer: current evidence and future directions. *J Gastrointest Oncol*. 2015;6:534–543.
179. Bureau USC: Demographic turning points points for the United States: populationprojections for 2020 to 2060. In. Edited by Vespa J.A.D., Medina L.; 2018.
180. Mann NC, Cahn RM, Mullins RJ, Brand DM, Jurkovich GJ. Survival among injured geriatric patients during construction of a statewide trauma system. *J Trauma*. 2001;50:1111.
181. American College of Surgeons CoT: National trauma data bank report 2016. In. Edited by Bank NTD; 2016.
182. Grossman DM, Miller WD, Scaff WD, Arcona WS. When is an elder old? Effect of preexisting conditions on mortality in geriatric trauma. *J Trauma*. 2002;52:242–246.
183. Woll MM, Maerz LL. Surgical critical care for the trauma patient with cardiac disease. *Anesthesiol Clin*. 2016;34:669–680.
184. Wallace ER, Siscovick DS, Sitlani CM, et al. Incident atrial fibrillation and the risk of fracture in the cardiovascular health study. *Osteoporos Int*. 2017;28:719–725.
185. Casey CM, Parker EM, Winkler G, Liu X, Lambert GH, Eckstrom E. Lessons Learned From Implementing CDC's STEADI Falls Prevention Algorithm in Primary Care. *Gerontologist*. 2016;57:787–796.
186. Shah SP, Penn K, Kaplan SJ, et al. Comparison of bedside screening methods for frailty assessment in older adult trauma patients in the emergency department. *Am J Emerg Med*. 2018;37:12–18.
187. Barnes GD, Lucas E, Alexander GC, Goldberger ZD. National trends in ambulatory oral anticoagulant use. *Am J Med*. 2015;128:1300–1305 e1302.
188. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. *Injury*. 2006;37:691–697.
189. Fallon FW, Rader FE, Zyzanski FS, et al. Geriatric outcomes are improved by a geriatric trauma consultation service. *J Trauma*. 2006;61:1040–1046.
190. Ayoung-Chee P, McIntyre L, Ebel BE, Mack CD, McCormick W, Maier RV. Long-term outcomes of ground-level falls in the elderly. *J Trauma Acute Care Surg*. 2014;76:498.
191. Zhang J, Lindsay J, Clarke K, Robbins G, Mao Y. Factors affecting the severity of motor vehicle traffic crashes involving elderly drivers in Ontario. *Accid Anal Prev*. 2000;32:117–125.
192. Lane P, Sorondo B, Kelly JJ. Geriatric trauma patients—are they receiving trauma center care? *Acad Emerg Med*. 2003;10:244–250.
193. Staudenmayer KL, Hsia RY, Mann NC, Spain DA, Newgard CD. Triage of elderly trauma patients: a population-based perspective. *J Am Coll Surg*. 2013;217:569–576.
194. Lehmann R, Beekley A, Casey L, Salim A, Martin M. The impact of advanced age on trauma triage decisions and outcomes: a statewide analysis. *Am J Surg*. 2009;197:571–575.
195. Demetriades D, Karaiskakis M, Velmahos G, et al. Effect on outcome of early intensive management of geriatric trauma patients. *Br J Surg*. 2002;89:1319.
196. Novack V, Jotkowitz A, Etzion O, Porath A. Does delay in surgery after hip fracture lead to worse outcomes? A multicenter survey. *Int J Qual Health Care*. 2007;19:170–176.
197. Pyke OJ, Rubano JA, Vosswinkel JA, et al. Admission of elderly blunt thoracic trauma patients directly to the intensive care unit improves outcomes. *J Surg Res*. 2017;219:334–340.
198. Ullman DA, Fortune JB, Greenhouse BB, Wimpy RE, Kennedy TM. The treatment of patients with multiple rib fractures using continuous thoracic epidural narcotic infusion. *Reg Anesth*. 1989;14:43.
199. Susman MM, Dirusso MS, Sullivan MT, et al. Traumatic brain injury in the elderly: increased mortality and worse functional outcome at discharge despite lower injury severity. *J Trauma*. 2002;53:219–224.

200. Acierno R, Hernandez MA, Amstadter AB. Prevalence and correlates of emotional, physical, sexual, and financial abuse and potential neglect in the United States: the National Elder Mistreatment Study. *Am J Public Health*. 2010;100:292.
201. Burnett J, Jackson SL, Sinha AK, et al. Five-year all-cause mortality rates across five categories of substantiated elder abuse occurring in the community. *J Elder Abuse Negl*. 2016;28:1–17.
202. Emerick E, Kupensky D, Hileman B, Chance E. Impact of palliative medicine consultation on geriatric trauma service patients. *Gerontologist*. 2016;56(Suppl3):77.