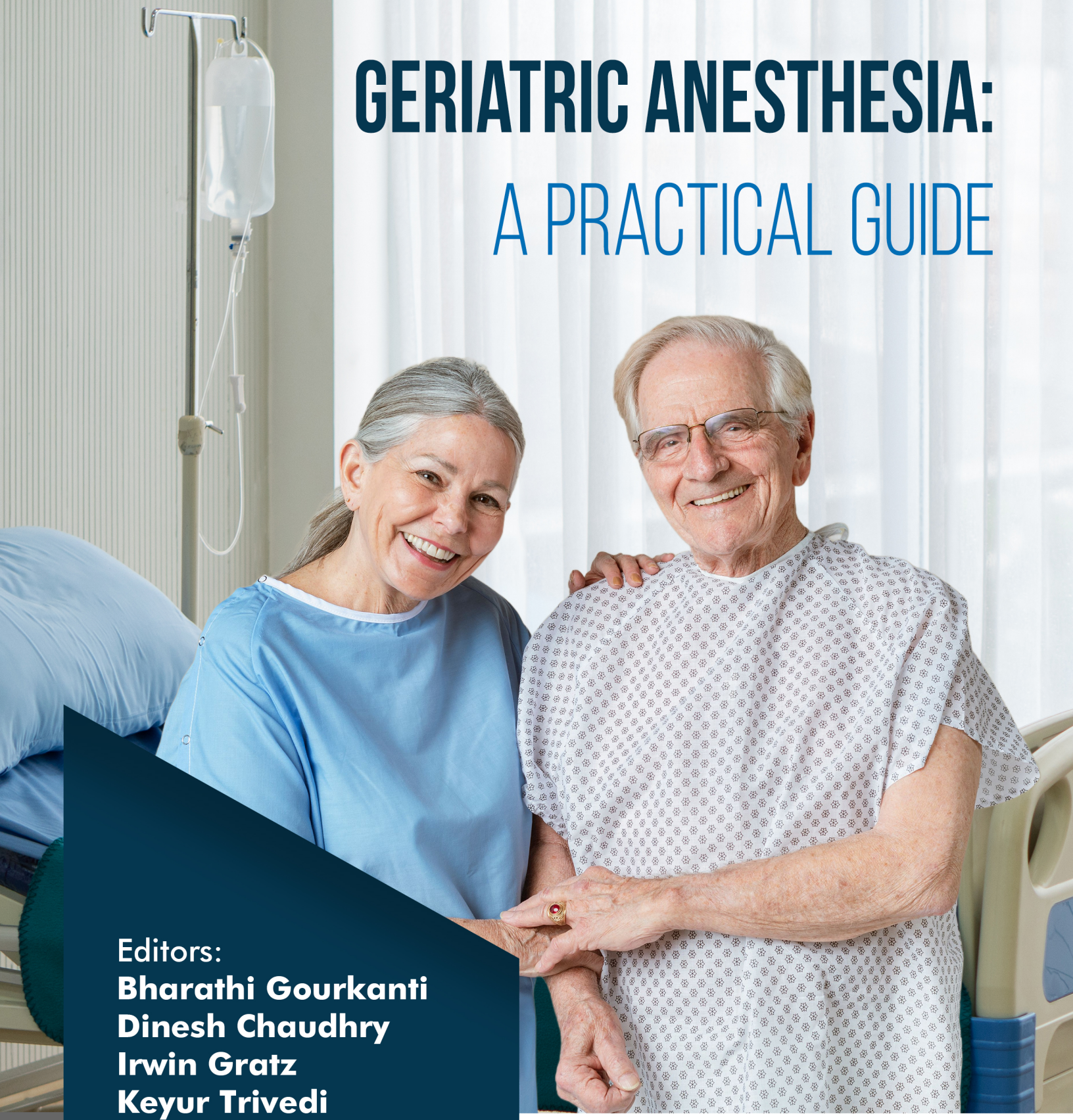
GERIATRIC ANESTHESIA:
A PRACTICAL GUIDE



Editors:
Bharathi Gourkanti
Dinesh Chaudhry
Irwin Gratz
Keyur Trivedi
Erin Pukenas

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Geriatric Anesthesia: A Practical Guide

Edited by

Bharathi Gourkanti

Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA

Dinesh Chaudhry

Department of Anesthesiology, Shriners Hospitals for Children, Philadelphia, Pennsylvania, USA

&

Irwin Gratz
Keyur Trivedi
Erin Pukenas

Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA

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Singapore
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PREFACE

As per World Health Organization (WHO) "The ageing of the world's populations is the result of the continued decline in the fertility rates and increased life expectancy. This demographic change has resulted in increasing numbers and proportions of people who are over 60. As a result, the first time in history when there will be more older people than younger people is rapidly approaching."

Aging increases the risk of chronic diseases such as dementias, heart disease, type 2 diabetes, arthritis, and cancer. For this segment of elderly people, the increase in longevity is also characterized by the emergence of several complex health states and complications which present a cascade of healthcare needs including procedure based and surgical interventions.

WHY THIS BOOK?

The geriatric population of the world is increasing rapidly due to advances in medical knowledge, technology, research, awareness of and early diagnosis and treatment of diseases. With the increase in the numbers of patients of advanced age, the rate of surgical procedures requiring anesthesia services has also increased. Our effort is to present a comprehensive, evidence based resource for Anesthesia Practitioners.

WHAT IS IN THE BOOK?

In this text we present awareness about ageing demographics and associated health care costs, and discuss the anatomical and physiological changes that occurs in the human body in the geriatric population. We present the pharmacokinetic and pharmacodynamics change in the geriatric population and these impacts on the care the anesthesia provider must perform in order to decrease and prevent adverse effects to decrease mortality and morbidity.

The anesthesia care of the geriatric patient involves many areas of medical care including, special cardiac conditions, chronic and acute pain management, trauma, critical care, neurological care and management, postoperative cognitive dysfunction (POCD), ambulatory surgery and care, special needs of the female geriatric patient. Anesthesia care of the COVID-19 geriatric patient is given special attention.

WHO CONTRIBUTED TO THIS BOOK?

We believe it is important to have input from every level of anesthesiology field for best patient care outcomes. We include input from medical students, certified nurse anesthetists, anesthesia residents, practicing anesthesiologists in the writing of this manuscript.

WHO BENEFITS FROM THIS BOOK?

This is an educational and learning resource for medical students, student nurse anesthetists, anesthesia residents, anesthesia practitioners. Hopefully this book will provide solutions for certain dilemmas, latest improvements in anesthesia field enabling anesthesia providers to give the best possible anesthesia care to geriatric patients.

My grateful acknowledgement.

I wish to express my heartfelt thanks and deep gratitude to all the authors, co editors for the countless hours of their untiring efforts to put together this book. My special thanks to Brian McEniry, Anesthesia Clinical Research Coordinator and Dr. Andrea Villa for their technical support. My sincere thanks to Bentham Science Publishers for providing me with an opportunity to write this book. I deeply appreciate the support of the Bentham Books team of Dr. Obaid Sadiq, Manager Bentham Books, Fariya Zulfiqar, Manager Bentham Books Publications, Urwa Rehan, QA Manager Bentham Books, Sumaiya Azhar, Editorial Manager Bentham Books, Ibad Arshad, Assisant Manager Bentham Books Cross Verification Department, and Humaira Hashmi in making this book a reality.

Bharathi Gourkanti
Department of Anesthesiology
Cooper Medical School of Rowan University
Cooper University Health Care
Camden, NJ
USA

List of Contributors

Akhil Patel	George Washington University School of Medicine and Health Sciences, Washington, D.C., USA
Aakash K. Patel	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, New Jersey, USA
Abhishek Patel	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Andrea Villa	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Anthony Hikes	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Afrin Sagir	Department of Anesthesiology and Critical Care, Hospital of the University of Pennsylvania, Perelman School of Medicine, Philadelphia, PA19104, USA Penn Center for Perioperative Outcomes Research and Transformation, University of Pennsylvania, Perelman School of Medicine, Philadelphia, PA19104, USA
Anil Bhatnagar	Cooper Medical School of Rowan University, Camden, NJ, USA
Bharathi Gourkanti	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Christopher Mahrous	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Christopher J. Mahrous	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Christopher Potestio	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Dejan Vuckovic	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Dave Shah	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Dhaval Rana	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Ershad Khan	Philadelphia College of Osteopathic Medicine, Philadelphia, PA, USA
Fangyu Chen	Department of Anesthesiology and Critical Care, Hospital of the University of Pennsylvania, Perelman School of Medicine, Philadelphia, PA19104, USA
Fatimah Habib	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Felipe Guzman	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
George Hsu	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA

Gregory Felock	Department of Medicine, Division of Critical Care, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Ian Brotman	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Irwin Gratz	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Jennifer Ocbo	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Kathleen Kwiatt	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Keyur Trivedi	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Kinjal Patel	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Mary Katherine Carney	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Michael R. Schwartz	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Magdy Takla	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Michele Mele	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Michael Mahrous	Robert Wood Johnson Medical School, New Brunswick, NJ, USA
Nikhil Bhana	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Osama M. Sayed	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Parker Woolley	Department of Anesthesia, Critical Care and Pain Medicine, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA02215, USA
Robin Szewczak	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Rachel Madison	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Reuben D'Souza	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Stuart Pasch	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Talia K. Ben-Jacob	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA
Tina Takla	Nova Southeastern University, Davie, Fl, USA
William Marion	Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA

CHAPTER 1

General Information

Andrea Villa[1] and **Bharathi Gourkanti**[1,*]

[1] *Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

Abstract: The population is aging rapidly worldwide and as this occurs, the rate of surgical procedures in older people is increasing in conjunction with the required anesthesia services. Along with increased life expectancy, the disease burden is also expanding with advanced medical care. This chapter will explore the extent of worldwide aging demographics, the mechanics of aging, health care costs specific to geriatrics, and the significance of anesthetic considerations in a rapidly aging world.

Keywords: Geriatric population, Life expectancy, Demographics, Mechanics of Aging, Healthcare costs.

INTRODUCTION

Worldwide, the population is aging rapidly. In 2004, there were 461 million people over the age of 65 and by 2050, it is estimated to be about 2 billion [1]. Given the increasing age of the population, it is no surprise that the percentage of people presenting for surgical procedures over the age of 65 is also increasing. People now have a longer life expectancy and therefore patients are presenting with increasingly complex medical histories and underlying comorbidities. Aging affects all systems and leads to diminished physiological reserves; therefore, it is imperative to consider all of these effects to minimize morbidity and mortality.

Presently, about 1/3 of surgical patients are over the age of 65 and the number only continues to rise [2]. In England for example, 2.5 million people over the age of 75 had surgery between 2014 and 2015, meanwhile only 1.5 million did between 2006 and 2007 [3]. Adults over the age of 65 account for over 40% of the surgical volume in the United States [4].

* **Corresponding author Bharathi Gourkanti:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, United States; E-mail: gourkanti-bharathi@cooperhealth.edu

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For elderly patients undergoing elective surgery, the operative mortality and prevalence of postoperative complications have increased [5]. Additionally, it is impossible to answer these patients' questions sometimes such as "What will my life look like if I have this procedure?", "Will I develop any disabilities?", "Will I be able to continue living independently?", and "What quality of life can this surgery offer me?". Hence, it is of the utmost importance to carefully assess all the different aspects of this population when planning a surgical procedure.

DEMOGRAPHIC TRANSITION

For centuries, the debate on how population growth affects development has been ongoing with varied viewpoints. Overall, however, it is undeniable that improvements in health have largely altered mortality rates in the aging population worldwide. The demographic transition theory is basically one where societies have transitioned from pre-modern regimes of high fertility and high mortality to post-modern ones that have low fertility and low mortality [6]. More often than not, this theory is associated with the demographic transition model which was created by observing changes that were largely expected in the global north, especially northwest Europe. This model consists of four stages [7]:

Stage1: High-level Equilibrium

This stage consists of fertility and mortality being high which results in low population growth and low life expectancy.

Stage 2: Early Expansion

Fertility continues to be high such as in stage 1, but mortality declines. This leads to an increase in population growth as well as life expectancy.

Stage 3: Late Expansion

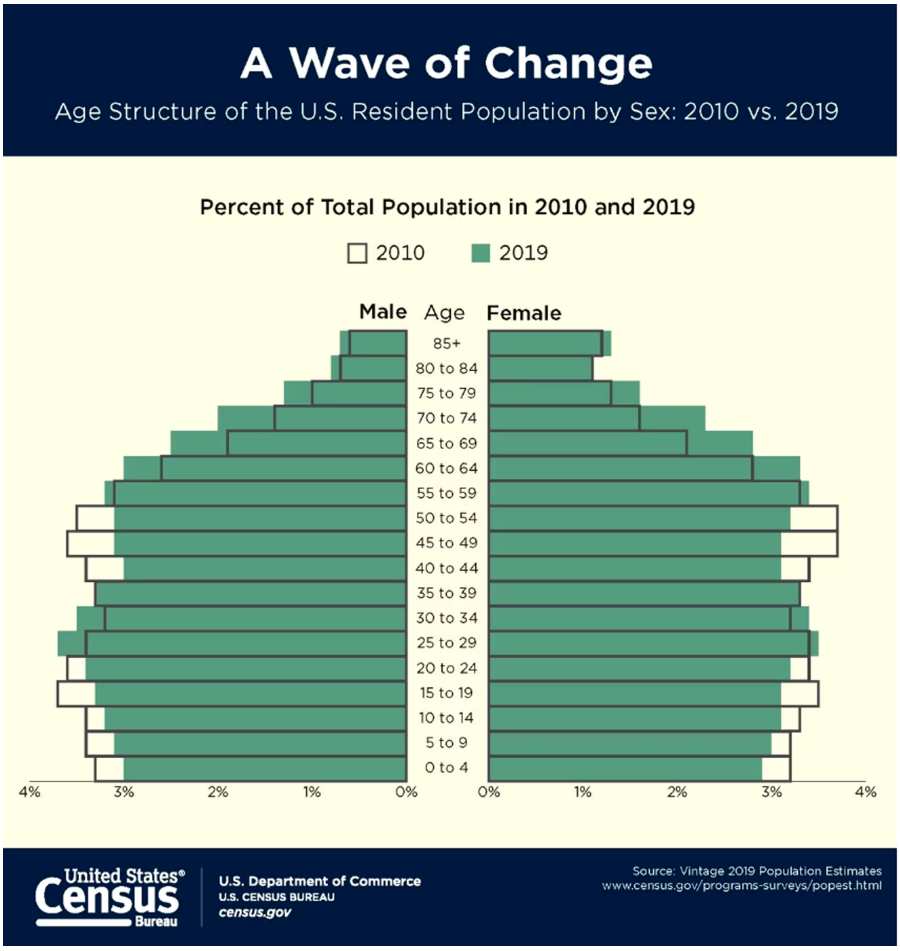
Fertility is not just no longer high, but begins to drastically decline, and mortality continues declining but at a slower rate than in stage 2. Because fertility has declined, population growth slows down from stage 2, and life expectancy continues to increase.

Stage 4: Low-level Equilibrium

There is a new balance between fertility and mortality to the point where mortality may fluctuate above the rate of fertility. Hence, population growth is slower and may eventually stagnate or decline because the birth rate supersedes the death rate.

This model was initially created with the expectation that it would become a universal model. However, multiple variations in demographic trajectories globally have not been able to fit well [7]. In the United States, nevertheless, a rising life expectancy leading to an aging population has prevailed and fertility rates have been lower [8].

Data shows that between 2000 and 2019, life expectancy has increased by more than 6 years [9]. Moreover, it is the fastest-growing population in healthcare and since 1975, the number of Americans over the age of 70 has more than doubled [10] and the projected global life expectancy only continues to rise. In the United States alone, the population that was 65 and older grew by over a third (34.2% or 13,787,044) during the past decade, and by 3.2% (1,688,924) from 2018 to 2019 (see table from United States Census Bureau below) [11]. In the next 10 years, it is estimated that 18 million people will turn 65 [4].



CHAPTER 2

Anatomical and Physiological Changes in Aging

Magdy Takla[1,*], **Michele Mele**[1] and **Tina Takla**[2]

[1] *Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

[2] *Nova Southeastern University, Davie, Fl, USA*

Abstract: The human body is a complex connection of various systems, each affected by the internal and external environment. Each system relies on the other and changes in one can result in variations in all other organ systems. As humans age, their physical appearance changes, but the aging process also occurs below the skin. Each organ system is impacted by time, and an individual's lifestyle can greatly impact his/her organ system. Various anatomical and physiological alterations that occur to the major organ systems due to aging and are relevant to an anesthesiologist are discussed below.

Keywords: Aging, Elderly, Central Nervous System, Cardiovascular system, Respiratory system, Renal system, Gastrointestinal and Endocrine, Musculoskeletal, Anesthetic management & techniques.

INTRODUCTION

The geriatric population is a demographic that is rapidly growing and living longer. According to the statistics, there has been a notable rise in both elective and emergent surgical procedures. Indeed, as people age, their respiratory and organ functions tend to decline.

Perioperative care and management of geriatric patients are different from young patients due to various complications. The care geriatric patients receive during the perioperative period greatly impacts the side effects and complications of the surgery. Furthermore, instances of negative occurrences and extended stays in medical facilities are frequent in these patients [1, 2].

The likelihood of appropriate preoperative assessment, meticulous anesthetic technique, and careful postoperative management may decrease adverse events.

[*] **Corresponding author Magdy Takla:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, United States; E-mail: takla-magdy@cooperhealth.edu

Central Nervous System

Anatomy

The nervous system is divided into two branches: central and peripheral nervous systems. The central nervous system (CNS) includes the brain and spinal cord, while the peripheral nervous system (PNS) consists of nerves that branch from the brain and spinal cord. There are excitatory and inhibitory synaptic inputs and the ratio of these two types determines whether there will be a neuronal event or not. These inputs can come from a voluntary pathway (controlled by the brain) or a reflex arc (controlled by the spine). Each motor pathway uses sensory, motor, and interneurons – starting with sensory neurons and ending with motor neurons [3].

The spinal cord is essential to the CNS, beginning at the medulla oblongata and running through the middle of the spine to the lower back. The spinal cord is segmentally organized. There are 31 segments, defined by 31 pairs of nerves exiting the cord. These nerves are divided into 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal nerve [4]. In a cross-section, the gray matter appears H-shape surrounded by the white matter. The unmyelinated axons and neuroglia cells are sensory neurons, interneurons, motor neurons, and neuropils that compose the gray matter in the spinal cord, whereas myelinated sensory and motor axons make up the white matter [5]. Although more research is required, studies have thus far shown that older patients had worse neurological outcomes following spinal cord injuries, and younger patients had better outcomes after decompression surgery for cervical myelopathy than older patients [6].

The brain contains billions of neurons that allow for proper function. Much like the spinal cord, there is gray and white matter and three layers of protection (the meninges) – dura, arachnoid, and pia maters. Unlike the spinal cord, the white matter is located on the inside with gray matter lines on the outside of the brain. Shrinkage of the brain due to neuronal atrophy occurs as early as middle age. Older individuals lose about forty-five percent of their myelinated fiber length (white matter proportions), and smaller nerve fibers are most affected by age. Aging causes a decrease in the transport rate of materials needed for axon regeneration, resulting in an inability to regenerate axons following degeneration. There is also a significant decrease in brain plasticity as an individual grows older, which allows younger populations to have better outcomes after cerebral procedures/injuries [7].

Peripheral Nervous System

All the nerves that branch out from the brain and spinal cord form the peripheral nervous system. These nerves other than the brain and spinal cord are also

negatively impacted by aging. Slower axonal regeneration, nerve conduction, and myelin expression are slower in older populations.

Degeneration of axons, less electrophysiological interactions, and decreased myelination or myelin abnormalities cause physiological alterations and a slower recovery response when the peripheral system suffers an injury.

PHYSIOLOGY

Brain

Physiological Changes

There is a decline in the weight and the volume of the brain. As we age, the weight and volume of our brain decline by around 5% per decade after the age of 40 [6].

Brain atrophy begins at an earlier age in men but occurs more rapidly in women once it has started [5].

Upon analysis of post-mortem brains, studies have indicated that as we age, we experience greater loss of white matter than grey matter. Additionally, granular degeneration of myelinated axons is commonly observed by the age of 40 (Fig. **1**) [7].

Besides the decrease in brain weight and mass, there are cognitive changes associated with aging, in addition to a decrease in brain weight and mass.

Changes with age of the neurological system			
Brain volume	∇	Blood brain barrier permeability	Δ
Dopamine levels	∇	Arterial wall thickness	Δ
Cerebral metabolic rate	∇	Monoamine oxidase activity	Δ
Δ augmented; ∇ diminished			

Fig. (1). Changes with the age of the neurological system [25].

Cardiovascular System

Arterial wall stiffness, wall thickness, and atherosclerosis are physiological changes in the older population. The cardiac output is reduced but the systolic function could remain intact. **Aging causes a reduction in autonomic control over the cardiovascular system**, this decrease makes the response to adrenergic stimulation decrease. The maximum heart rate and cardiac output also decrease due to aging (Fig. **2**) [8].

CHAPTER 3

Pharmacology in Geriatric Anesthesia

Reuben D'Souza[1] and **George Hsu**[1,*]

[1] *Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

Abstract: In terms of different pharmacokinetic and pharmacodynamic interactions, geriatric patients exhibit greater sensitivity to anesthetics. Therefore, understanding the differences in body composition, hepatic and renal function, changes in protein binding, and minimal alveolar concentration are the key to titration of anesthetics in geriatric patients. In addition, polypharmacy, use of non-prescription medications and adverse medications related events warrant special considerations for the geriatric population, more so than in their younger counterparts. Lastly, careful titration of anesthetics may minimize the development of postoperative delirium and postoperative cognitive dysfunction, which are associated with higher morbidity, mortality, length of hospitalization, and overall cost.

Keywords: Geriatric anesthesia, Geriatric pharmacology, Geriatric pharmacokinetics, Geriatric pharmacodynamics, Geriatric body composition, Geriatric hepatic function, Geriatric renal function, Protein binding, Minimum alveolar concentration, Geriatric anesthetic dosing, Geriatric polypharmacy, Beers criteria.

INTRODUCTION

The process of aging involves the natural physiologic decline of cellular function, resulting in approximately 1% decrease per year after the age of 40 [1]. To best understand geriatric pharmacology, it is helpful to divide it into two basic key concepts: pharmacokinetics and pharmacodynamics. Gradual changes over time in body composition, hepatic function, and renal clearance will explain the pharmacokinetic changes in the geriatric population, while decreased protein binding and sensitivity to anesthesia with aging illustrate the pharmacodynamic interactions between the drugs and the body. In addition, geriatric patients are

* **Corresponding author George Hsu:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA; E-mail: hsu-george@cooperhealth.edu

more sensitive to many types of anesthetics (benzodiazepines, hypnotics, opioids, non-opioid analgesics, local anesthetics, and paralytics) as well as more vulnerable to the ill side effects of medications, polypharmacy, and they are also more prone to postoperative delirium secondary to medications.

Pharmacologic Changes with Aging

In order to understand the pharmacokinetic effects of aging, one must first look at the physiologic changes that have major influences on the way the body metabolizes drugs. While the process of aging is highly variable with regard to calendar age versus physiologic age, the three general physiologic changes that are most relevant include body composition, hepatic function, and renal function [1].

Body Composition

Circulating volume along with total body fat determines the drug distribution based on the hydrophilicity of anesthetic agents. The total body water content decreases by approximately ten to fifteen percent while body fat increases between twenty to forty percent in the geriatric population. This proportional change decreases the volume of distribution for water-soluble medication, leading to an increase in initial plasma concentrations following a bolus administration. Therefore, parental loading dose should be decreased by ten to 20 percent [1, 2]. In contrast, the volume of distribution of lipophilic medications increases with aging, further aided by a decrease in muscle mass and its replacement with adipose tissue. This warrants a need to increase loading doses of lipophilic agents that is further complicated by an increase in volume of distribution and therefore increased elimination half-life due to accumulation in adipose tissue [3].

The processes of drug absorption via the alimentary and transdermal routes are also affected by aging, although by varying extents. The GI tract of the elderly can be affected by decreases in gastric pH and slower transit times in general. Medications that have a greater reliance on ionic conversion for their absorption can be affected by reduced acidity in the stomach, which can be further exacerbated by the use of PPI's. The deceleration of peristalsis and gastric emptying can be attributed to the decline of neuron function in the gut. The absorption of drugs due to a slowed gastrointestinal transit time is more variable, however, depending on the site at which they are absorbed.

Hepatic Function

In addition to changes in the volume of distribution, metabolism, and clearance of drugs must also be factored in, when considering dosing in older patients. The

decline of metabolic activity during the aging process can be difficult to characterize as there is a tenuous relationship between the elimination half-lives of hepatically cleared drugs and liver function tests. However, there is a direct correlation between the extraction of hepatically metabolized anesthetics to the rate of hepatic blood flow, which can decrease from about thirty to forty percent in the elderly population [1, 2]. In addition, there is an age-related decrease in liver mass, thus reducing hepatic microsomal enzymes and extending the half-life of many drugs, including anesthetics. Since many older adults have multiple chronic comorbidities that require the use of medicines, anesthetic drug metabolism is further decreased due to saturation of the reduced number of hepatic microsomal enzymes. However, the exact influence a reduction of hepatic microsomal enzymes has on anesthetic dosing in the aging population is less clear, because other studies evaluating the effect of age on anesthetic drug clearance have been inconclusive. It is currently unknown whether the extrahepatic metabolism of drugs is impacted by aging. Pulmonary metabolism of drugs is well described but the implications of lung metabolism in older adults, particularly for anesthetic drugs, have not been well studied. The extent to which ester metabolism changes in the elderly is also unclear, with conflicting studies.

Renal Function

Many changes occur to the aging kidney that can contribute to a reduction of renal clearance. When compared to 20-year-olds, it was found that 90-year-olds had a reduction in glomerular filtration rate anywhere from 25 to 50% [4]. In fact, renal blood flow begins to decrease by approximately ten percent with every decade after the age of forty [2]. Additionally, the renal vasculature's protective response to variations in blood pressure decreases which is further exacerbated by a medullary hypotonicity. The tubular system is also less effective due to a decreased capacity to exchange solutes and is more prone to toxic or hypoxic damage [3]. Besides impaired tubular function and vasodilatory responses, renin-angiotensin-aldosterone function is also reduced. These changes lead to a prolonged duration of action for medications that are dependent on renal clearance and thus merit a dose reduction [2].

Pharmacodynamics

Protein Binding

The relationship between drugs and protein is important when considering the pharmacodynamic profile of elderly patients. Studies have shown that plasma albumin concentration declines with age. Therefore, for drugs that bind to proteins, a small decline in albumin concentrations can have a major influence on a medication's effects due to a clinically relevant increase in free drug

CHAPTER 4

Pre-Operative Evaluation and Optimization of Geriatric Patient

Kathleen Kwiatt[1,*] and **Robin Szewczak**[1]

[1] *Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

Abstract: Worldwide, life expectancy is increasing and people are living longer. Between 2015 and 2050, the proportion of the world's population over the age of 60 years is expected to double from 12% to 22% [1]. As our elderly population grows, more elderly patients now require elective, urgent, and emergent surgery. Elderly patients are complex due to age-related changes and comorbidities. Anesthesia provides a critical line of defense for these patients, and this begins with a comprehensive pre-operative evaluation. Assessment begins with a history and physical exam and is supplemented with laboratory and clinical data. Special attention must be given to nutritional status, functional capacity, cardiovascular and pulmonary function, cognitive function, and emotional well-being. Understanding the physiologic changes of aging and common pathologies in the elderly helps predict the pharmacokinetics and pharmacodynamics of anesthetic agents. This understanding also helps plan for the hemodynamic, ventilatory, and cognitive impacts of anesthesia on the elderly. Perhaps equally important to determine a patient's physical condition is establishing the individual's goals of care, decision-making capacity, and surrogate decision-making for anesthesia and surgery.

Keywords: Anesthetic planning, Baseline functional status, BEERS criteria, Cardiac preoperative assessment, Cognitive function, Discharge planning, End-of-life care, ETOH.

INTRODUCTION

As life expectancy increases, the number of elderly patients who present for emergent, urgent, and elective procedures requiring anesthesia also increases. These patients require a judicious perioperative plan to optimize their care. A comprehensive pre-operative history and physical exam, with evaluation of laboratory and clinical data, provides the foundation for optimizing the perioperative care of the elderly.

* **Corresponding author Kathleen Kwiatt:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA; E-mail: kwiatt-kathleen@cooperhealth.edu

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DEFINITION AND EPIDEMIOLOGY

Geriatrics is the medical care of older adults. While there is no set age that defines this population, age > 65 is the age of eligibility for Medicare insurance in the United States and is commonly accepted as the defining age [2]. Less than 4% of the population was older than 65 years in the early 1900s; now older adults make up 16% of the population. By 2050, nearly 1.6 billion people are projected to be older than 65, making up 30% of the population [1]. As our population ages, more geriatric patients present for elective, urgent, and emergent operations. Anesthesia care providers must appreciate the cognitive and physiologic changes that occur with aging to develop robust anesthetic plans that maximize desirable patient outcomes, minimize exacerbations of age-related comorbidities, and consider the patients' overall goals.

COGNITIVE FUNCTION AND CAPACITY

Cognitive Function

Dementia is a chronic, progressive, syndrome that results from brain disease or injury and leads to a loss of cognition beyond what is expected from normal aging. Memory, comprehension, calculation, language, and judgment decline in patients with dementia, often with mood disturbances and loss of behavioral control. The incidence of cognitive impairment increases with age; however, it is not a normal part of aging. In 2019, approximately 10% of adults above the age of 69 in the United States had dementia [3].

The most common cause of dementia is Alzheimer's disease, but it also results from stroke, traumatic brain injury, vascular dementia, Lewy body dementia, frontotemporal dementia, and mixed pathology, among other causes [4]. It must be differentiated from dementia-like conditions that are potentially reversible, including infection, medication side effects, nutritional deficiencies, and brain tumors.

Preoperative cognitive function must be assessed for two reasons. First, preexisting cognitive dysfunction is the strongest predictor for postoperative delirium [5]. Second, intact cognition is critical to decision-making capacity and informed consent.

Preoperative screening of patients over the age of 65 without diagnosed cognitive disorders can be performed with the Mini-Cog© test, a simple, short screening evaluation that involves recall of 3 words and drawing a clock (Figs. **1** and **2**). This test can be administered in approximately 3 minutes, and one point is assigned for each correct word, with 2 possible points for a correctly drawn clock,

for a total of 5 points (Fig. **3**). A score of ≥3 suggests a low likelihood of dementia [6]. If the patient is screened positive (score 0-2) on the Mini-Cog© test, a further workup for cognitive impairment is recommended.

Mini-Cog©: 3 Item Recall + Clock Draw	
1. REPEAT: Give the patient 3 words: BANANA, SUNRISE, CHAIR. Ask them to repeat now and remember for later.	Give the patient 3 attempts to repeat the words. If unable, move on to the next item.
2. CLOCK: ask the patient to draw a circle, number 1-12, and set the hands to 11:10.	Allow 3 minutes, if not finished stop and move on to the next item.
3. RECALL: ask the patient to say the 3 words they were asked to remember.	

Fig. (1). The Mini-Cog© test, a screening tool for cognitive impairment [6].

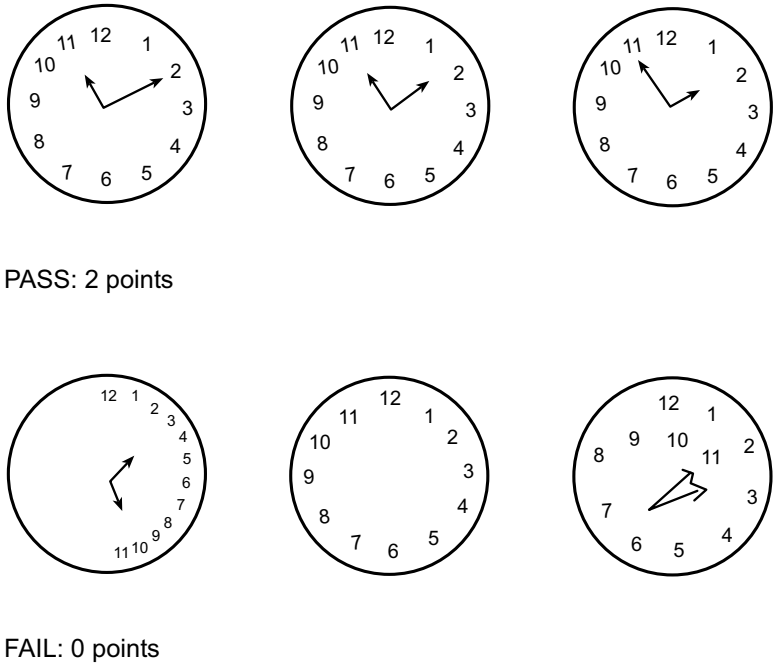

Fig. (2). Clock drawing interpretation for the Mini-Cog© test. Pass = 2 points, Fail = 0 points.

CHAPTER 5

Post-Operative Care of Elderly Patients

Rachel Madison[1] and **Ian Brotman**[1,*]

[1] *Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

Abstract: Geriatric patients have unique postoperative concerns that must be considered to safely guide their care. In this chapter, we discuss the commonly encountered complications in the post-anesthesia care unit with a focus on postoperative delirium, postoperative nausea, and vomiting, as well as issues relating to renal, respiratory, and cardiovascular systems with advancing age. Finally, we discuss opioid and nonopioid analgesic considerations unique to this vulnerable patient population.

Keywords: Geriatrics, Geriatric anesthesia, Geriatric Analgesia, Post-operative care, Post Anesthesia Care Unit, PACU, Emergence Delirium, Intraoperative Myocardial Infarction.

INTRODUCTION

Geriatric patients have unique post-operative concerns that must be addressed to ensure good outcomes in this at-risk population. In studies across the world, with a multitude of various procedures, age appears to be an important predictor of postoperative outcomes [1 - 4]. As in the perioperative period, neurologic, cerebrovascular, cardiovascular, and renal complications are prevalent in the elderly in the postoperative recovery phase [2, 5]. Altered pharmacokinetics also affect the dosing of commonly prescribed postoperative medications, the most ubiquitous being opioids [6]. The following chapter is a discussion of commonly encountered complications in geriatric patients once they are in the recovery unit.

NEUROLOGIC COMPLICATIONS

Postoperative Delirium

In older adults, cognitive and behavioral changes after surgery are common with challenging adverse effects. Delirium is defined by the DSM-5 as a disturbance in

* **Corresponding author Ian Brotman:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA; E-mail: brotman-ian@cooperhealth.edu

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attention and awareness that develops over a short period of time and represents a change from baseline that is not the result of a preexisting neurocognitive disorder [7]. Postoperative delirium, appropriately named, is a change in the attention and awareness that occurs in the postoperative period. Older adults are at increased risk for developing short-term delirium due to a multitude of physical and cognitive changes that coincide with advancing age. The brain of the older adult has less resilience to neurological challenges [8]. There are increased rates of cerebral atrophy after surgery [9]. Older adults with baseline cognitive impairment are at a greater risk of having negative cognitive effects after anesthesia [8]. Delirium is also more common in patients with preexisting neurocognitive diseases and those who have emergent procedures [10]. It increases hospital stay by 2-3 days and is associated with a 30-day mortality of 7-10% [10)]. The anesthesia provider must consider several factors intraoperatively but also postoperatively in order to minimize the risk of developing delirium as there are many factors that can contribute to this challenge.

A thorough assessment of baseline cognitive status prior to surgery is extremely helpful in identifying delirium in the immediate postoperative period. Quick diagnosis of delirium will assist providers in implementing therapies and techniques to treat delirium. Frailty has been associated with a higher incidence of post-operative delirium [11]. The Edmonton Frailty Scale (EFS) assesses cognition, hospital admissions, general health, ADLs, polypharmacy, functional status, weight loss, depression, and forgetfulness [11]. Frailty is suspected to be a better predictor of physiologic age compared to chronologic age alone [12]. Higher scores on EFS indicated an increased risk of developing delirium in the postoperative period [11]. Using this tool preoperatively can assist providers in the postoperative period to quickly identify changes in cognitive status and implement interventions.

Newer technologies such as the BIS or EEG used intraoperatively to identify the depth of anesthesia led some researchers to suggest that deeper anesthetics contribute to cognitive dysfunction [8]. Recommendations for the prevention of cognitive dysfunction include regional anesthesia with light sedation, limiting the duration of the anesthetic, and utilizing an EEG to assess the depth of anesthesia [8]. In a recent study, elderly patients with epidural anesthesia combined with general anesthesia had better-preserved memory, language, and visuospatial functions compared to the older adults under general anesthesia alone [13]. Regional or epidural anesthesia techniques used in the perioperative period can reduce the opioid requirement postoperatively and lead to a reduction in compounding issues that may lead to delirium.

While these previously mentioned strategies help in the intraoperative period, some medications continued in the postoperative period assist with decreasing the incidence of delirium. Recent studies have suggested dexmedetomidine may have neuroprotective effects [10]. Dexmedetomidine in elderly patients postoperatively has been shown to result in a significant decrease in delirium [14]. The dose that was used was 0.1mcg/kg/hr administered for less than 24 hours postoperatively [14]. In 2020 Zhao and colleagues published research that suggested that a bolus of Dexmedetomidine 200mcg or 400mcg as a PCA (combined with a small amount of Sufentanil) for postoperative analgesia significantly decreased incidences of delirium and early cognitive dysfunction [15]. The Mini-Mental State Exam was used to assess the cognitive status of the patients receiving dexmedetomidine [15]. Dexmedetomidine and reorientation have been an effective approach to manage postoperative delirium [10].

Reorientation measures in the postoperative period can decrease and prevent delirium [16]. These measures included clocks and calendars in the room, early mobilization, and sleeping aids such as eye masks [16]. Minimizing staff change, timekeeping devices, and sleep optimization also help to decrease the severity of delirium [10]. With the-multitude of factors that can lead to delirium, it is important to ensure that baseline endocrine and metabolic functions such as blood sugar, temperature, pain, and electrolytes are within normal limits. Comparing preoperative mini-mental state exam results will help the provider conclude delirium and begin the recovery process.

Postoperative cognitive dysfunction (POCD) differs from delirium, it presents later in the days and weeks following surgery and may persist for several months. POCD will be discussed in more detail in another chapter later. Factors contributing to POCD are increased age, history of stroke, and respiratory complications- common comorbidities in older adults [8].

Postoperative Nausea and Vomiting (PONV)

While nausea and vomiting in the postoperative period are not often large risk factors for older adults, some medications routinely given may increase the risk of developing prolonged QT on the EKG which could lead to arrhythmias. Common medications that prolong QT are ondansetron, metoclopramide, droperidol, promethazine, haloperidol, and ephedrine [17]. Older age, ischemic heart disease, ventricular hypertrophy, and electrolyte imbalances are physiologic risk factors for developing prolonged QT [17]. Older adults are often subjected to polypharmacy due to their comorbidities resulting in an increased risk of drug interactions. Certain medications also prolong QT and when given with antiemetics, potentiate the risk of developing arrhythmia. Common drugs are

CHAPTER 6

Postoperative Cognitive Dysfunction (POCD) in Geriatric Patients

Michele Mele[1,*], **Magdy Takla**[1] and **Nikhil Bhana**[1]

[1] *Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

Abstract: As the world population ages, the number of older patients undergoing surgery will increase significantly. Postoperative cognitive dysfunction (POCD) and other perioperative neurocognitive disorders (PND) affecting patients after surgery have long been recognized in older patients and are considered some of the most common postoperative complications. POCD has been correlated with significant morbidity and mortality, and greater healthcare costs. Historically, the lack of standardized nomenclature used to describe cognitive change after surgery and anesthesia has made it challenging to conduct systematic reviews or analyze the results of similar studies to further understand the clinical implications of this disorder. This has led to minimal recognition of this disorder outside of the specialty of anesthesiology. Patient and surgery-related risk factors include old age, preexisting cognitive changes, and emergency surgery amongst others. Proposed etiologies include postsurgical neuroinflammation, impairment of neurotransmitter systems, and cerebral vascular events in the perioperative period. The medical literature offers little guidance to recommend a particular anesthetic to decrease the risk of POCD in the postoperative patient. Most studies found similar risks of POCD after general and regional anesthesia techniques. While there is no standardized test for diagnosing preoperative cognitive impairment, it is critical to identify high-risk patients so that timely interventions can be made to minimize POCD.

Keywords: Delayed neurocognitive recovery, Intraoperative risk reduction, Perioperative neurocognitive disorder, Postoperative cognitive dysfunction, Risk factors.

BACKGROUND AND INCIDENCE

In the United States (U.S.) and worldwide, it is anticipated that the older population will grow considerably. The U.S. Census Bureau projects the U.S.

[*] **Corresponding author Michele Mele:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, United States; E-mail: mele-michele@cooperhealth.edu

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population aged 65 years and over will be 83.7 million in the year 2050, nearly double the 2012 estimated population of 43.1 million (Fig. **1**).

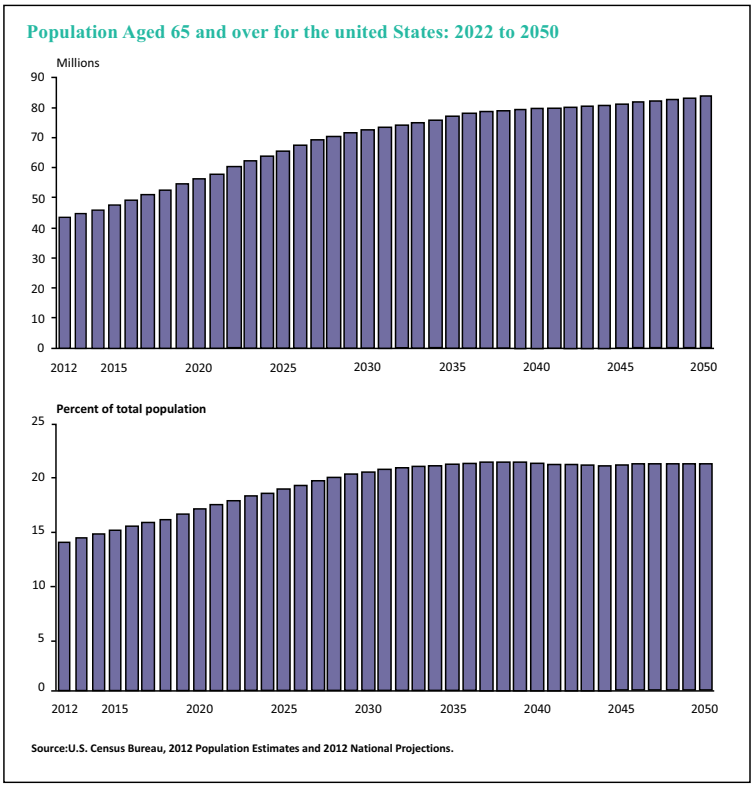

Fig. (1). United States, Census Bureau 2012.

As the world population ages, patients greater than 60 years old requiring anesthesia and surgery have increased significantly. In Australia, individuals > 60 years old receive nearly one-third of all anesthetics, while they only account for <14% of the population. By 2050, they will comprise 25% of the population and are projected to receive 50% of all anesthetics [1]. In the U.S., more than 19 million anesthetics are administered to those aged >65 years every year, and a similar increase in anesthesia administration is expected [2].

Postoperative cognitive dysfunction (PCOD) has long been recognized in older patients and is considered a complication frequently experienced after surgical procedures [3]. It is characterized by a wide spectrum of clinical conditions featuring a decline in neuropsychological areas including memory, executive functioning, and processing speed after anesthesia and surgery. It is an illness of considerable importance as it is recognized as the most common surgical

complication in older patients [4] and is linked to increased hospital length of stay [5] and increased postoperative death [6]. The exact prevalence of POCD is uncertain and varies within a broad range as it depends on perioperative and intraoperative risk factors and type of surgery. Non-standardized terminology around this diagnosis also adds to the uncertain incidence.

Interest in research into POCD increased after early studies identified cognitive change after cardiac surgery. These early studies revealed cognitive changes can persist up to 7.5 years after surgery. While initially reported in the literature after heart surgery, it is also a well-known postoperative complication of non-cardiac surgery. Several studies have indicated that there is a similar incidence of cognitive change after non-cardiac surgery ranging from 10% to 65% and are known to be influenced by numerous factors including age, gender, level of education, pre-existing medical conditions, and type of surgery [7, 8]. In one meta-analysis, Bruce *et al*. reported an incidence between 4.0% to 53.3% in patients undergoing urgent hip surgery and 3.6 to 28.3% in patients having elective orthopedic procedures [9]. Other investigators revealed the occurrence of POCD to be 26% of patients who have had urologic procedures, 25-32% in patients following coronary artery bypass grafting (CABG), and 50-67% among patients after cardio-pulmonary bypass [10, 11].

NOMENCLATURE

Historically, there has been a lack of standardized terminology used to describe cognitive change after surgery. The terms most used to describe this condition are postoperative delirium (POD) and postoperative cognitive dysfunction or decline. The term delirium has been used to describe the clinical condition of change in mental status which can appear after anesthesia and surgery commonly occurs in the first week post-procedure. In addition to delirium, much research has focused on postoperative cognitive dysfunction (POCD). The definition of POCD is poorly defined; however, it is considered a deterioration in cognitive function compared to baseline that continues passed the usual pharmacologic and physiologic effects of the anesthetic drugs. It impacts numerous cognitive areas including memory, behavior, attentiveness, dexterity, and executive function. The lack of standardized nomenclature has led to inconsistent definitions and little recognition of this condition by non-anesthesiology clinicians. Consequently, the absence of agreement on terminology has created challenges in evaluating published intervention outcomes and understanding the clinical implications of this condition.

In recognition of these limitations, in 2018 the Nomenclature Consensus Working Group, a multidisciplinary, international group of physicians and scientists

CHAPTER 7

Geriatric Patients with Congestive Heart Failure and Low Ejection Fraction; Non-Cardiac Surgery after CABG

William Marion[1,*], **Anthony Hikes**[1] and **Michael Mahrous**[2]

[1] *Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

[2] *Robert Wood Johnson Medical School, New Brunswick, NJ, USA*

Abstract: In the perioperative care of geriatric patient, it is common to have patients with heart failure and who have had previous cardiac surgery. In order to safely and successfully care for these patients it is imperative to understand the pathology and progression of the disease. Additionally, it is necessary to be able to recognize the signs and symptoms of heart failure so that it may be recognized in patients who have yet to be diagnosed in order to determine if further testing or optimization is required. Furthermore, it is necessary to know the special considerations necessary for the management of patients with heart failure or previous CABG.

Keywords: AHA, Diastolic dysfunction, Epidemiology of heart failure, Geriatric, Heart failure preserved ejection fraction (HFpEF), Heart failure classification, Intraoperative management, NYHA, Postoperative care, Preoperative evaluation, Reduced ejection fraction, Systolic dysfunction.

INTRODUCTION

As people age, the accumulated insults and injuries of time take a physical toll. As the constantly running engine of our bodies, the heart often takes the largest portion of this burden. However, advances in modern medicine and technology have led to unprecedented extensions of human life expectancy. Considering this, we as clinicians need to be familiar with and adept at treating the geriatric population with an understanding of how their cardiac status necessitates changes in our anesthesia plan.

[*] **Corresponding author William Marion:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA; E-mail: marion-william@cooperheallh.edu

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EPIDEMIOLOGY

Heart Failure (HF) is a serious burden to healthcare systems and occupies a large portion of healthcare spending. It is estimated to affect 64 million people worldwide [1]. In the United States of America (US), the estimated 2020 prevalence of HF is 6.9 million and it is expected to increase by 24% to nearly 8.5 million in 2030 owing to the growth of the US population [2, 3]. In parallel with the rising prevalence of HF is a significant increase in healthcare dollars allocated towards caring for these patients. In the US, the total cost of care for HF in 2020 was estimated at $43.6 billion, and the annual total cost of care is projected to increase to $69.7 billion by 2030 [3]. Outside of the direct costs incurred for treating HF, patients presenting with comorbid conditions (diabetes mellitus, hypertension, peripheral vascular disease, coronary artery disease) present a double burden to already strained and valuable healthcare resources [4]. Given these population trends, the practicing anesthesiologist must understand that geriatric HF patients will continue to present in the perioperative setting with increasing frequency.

DEFINITION AND STAGES OF HEART FAILURE

HF is discussed and categorized in various ways depending on patients' risk factors or symptomatology. Various organizations, including the American College of Cardiology (ACC), American Heart Association (AHA), New York Heart Association (NYHA), Heart Failure Society of America (HFSA), Heart Failure Association of the European Society of Cardiology (HFA/ESC), and Japanese Heart Failure Society (JHFS) have provided different ways to classify patients with HF. The practicing anesthesiologist must understand these definitions to correctly risk stratify patients presenting to the operating room and appropriately converse with perioperative consultants.

In 2020, the ACC/AHA, HFSA, HFA/ESC, and JHFS assembled to release a consensus definition of HF defined as a clinical syndrome with symptoms and/or signs caused by a structural and/or functional cardiac abnormality and corroborated by elevated natriuretic peptide levels and/or objective evidence of pulmonary or systemic congestion [5]. Further, they defined the stages of HF as follows:

At Risk (Stage A)

Patients at risk for HF, but without current or prior symptoms or signs of HF and without structural cardiac changes or elevated biomarkers of heart disease [5].

Pre-HF (Stage B)

Patients without current or prior symptoms or signs of HF with evidence of one of the following: structural heart disease, abnormal cardiac function, or elevated natriuretic peptide or cardiac troponin levels [5].

HF (Stage C)

Patients with current or prior symptoms and/or signs of HF caused by a structural and/or functional cardiac abnormality [5].

Advanced HF (Stage D)

Severe symptoms and/or signs of HF at rest, recurrent hospitalizations despite goal-directed medical therapy (GDMT), refractory or intolerant to GDMT, requiring advanced therapies, transplantation, mechanical circulatory support, or palliative care [5].

The NHYA classification system focuses on patient symptomology. Patients with HF are classified into 4 categories [6]:

I. No limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitation, or dyspnea.
II. Slight limitation of physical activity. Comfortable at rest. Ordinary physical activity results in fatigue, palpitation, or dyspnea.
III. Marked limitation of physical activity. Comfortable at rest. Less than ordinary activity causes fatigue, palpitation, or dyspnea.
IV. Unable to carry on any physical activity without discomfort. Symptoms of heart failure at rest. If any physical activity is undertaken, discomfort increases.

Importantly, the anesthesiologist must understand the differences between these classification systems. One can see that the NYHA classification system focuses on subjective patient symptoms. Likewise, the ACC/AHA classification system focuses on objective clinical findings. Thus, a patient's NYHA stage may not necessarily correlate with their ACC/AHA classification (Fig. **1**).

SIGNS AND SYMPTOMS

Heart failure is a complex disease process with a wide spectrum of presenting signs/symptoms depending on the etiology. Geriatric patients presenting with symptomatic heart failure can generally be attributed to coronary artery disease, arrhythmias, myopathies, or valvular disease. Congenital heart disease typically presents early in life and will not be discussed in this section.

CHAPTER 8

Anesthetic Considerations in Patients After Valve Replacements and Cardiac Stents, with Associated Anticoagulation Concerns

Abhishek Patel[1], Christopher Mahrous[1] and **Dejan Vuckovic[1,*]**

[1] *Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

Abstract: Geriatric patients are a significant proportion of the patients seen in the perioperative setting. Oftentimes, these patients are presenting for non-cardiac surgery after undergoing a cardiac procedure previously. Management of these patients starts with understanding the pathophysiology, surgical intervention, and anesthetic considerations. This management starts from risk assessment and perioperative management. In this chapter, risk assessment stemming from a patient's co-morbid conditions is taken into account to form an overall risk profile. These conditions help the anesthesiologist establish a framework to model an anesthetic plan. Notably, a prior cardiac history, including a history of coronary artery disease (CAD), hypertension (HTN), and a history of valve disease and possible repair, is prudent. Also discussed is the need for appropriate intra-operative monitoring in specific situations as well as anticoagulation guidelines in the pre and post-operative settings.

Keywords: Anticoagulation, Cardiac stents, Geriatric anesthesia, Preoperative cardiac testing, Intra-operative monitoring, Valve replacement, Post-operative considerations.

INTRODUCTION

Geriatric patients are often the most challenging patients an anesthesiologist can take care of. They are often with many co-morbid conditions presenting for minimally invasive surgeries or surgeries that can cause an affront to their cardiopulmonary status. Therefore, an adept anesthesiologist should be comfortable with managing their prior cardiovascular medical issues. This next chapter offers an overview of the major concerns an anesthesia provider may face

* **Corresponding author Dejan Vuckovic:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, United States; E-mail: vuckovic-dejan@cooperhealth.edu

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during the preoperative and intraoperative settings. Through recognizing these issues, it is the hope of the writers that the anesthesiology provider can safely navigate the complex cardiovascular physiology many geriatric patients have.

RISK ASSESSMENT AND MANAGEMENT FOR NONCARDIAC SURGERY

Surgery causes cardiac stress in patients due to multiple factors including, but certainly not limited to hemodynamic alterations, fluid shifts, stress responses, and tissue injury, thereby increasing the risk of cardiovascular adverse events. In geriatric patients, this risk is increased and is particularly elevated in patients who have undergone cardiac interventions and valve therapy. To attenuate this risk, consideration of patient risk factors, the type of non-cardiac surgery, and optimization of the patient's status prior to their procedure is advised. As minimally invasive cardiac techniques become increasingly prevalent and safer in patients with increasing ages and frailty, so has the prevalence of non-cardiac surgical procedures in patients with percutaneous coronary interventions and valvular replacements.

As with all patients, a thorough preoperative history and physical exam are paramount in initiating a safe anesthetic plan. Discussion regarding the timeline of the patient’s intervention, the post-intervention functional status, the type of intervention and prosthetic utilized and the patient’s medication regimen (with particular consideration given to anticoagulants, diuretics, and beta-blockers) are all highlights when eliciting a history. Physical examination should include a comprehensive cardiopulmonary exam with auscultation in all lung fields and cardiac auscultation points as well as an assessment of the patient’s strength and functional status with particular attention to examining for levels of peripheral edema. A preoperative neurologic examination should also be considered, especially for patients undergoing vascular procedures, who have a history of strokes, TIAs, or DVTs, or have undergone left heart or arterial interventions. The astute anesthesiologist can utilize this neurological exam as a baseline allowing postoperative deviations from such a baseline to indicate unintended vascular events. Finally, an understanding of the patient’s overall frailty, as alluded to earlier in this book, is helpful in providing overall balanced and safe anesthetic care.

As with adult patients of all age groups, a Revised Cardiac Risk Index (RCRI) after the aforementioned history and physical examination, is generally a good starting point when determining anesthetic management of patients after cardiac intervention. The scoring system is relatively simple, with 1 point given for each of the following: ischemic heart disease, cerebrovascular disease, heart failure,

insulin-dependent diabetes, chronic kidney disease (Cr >2), and high-risk surgery (intraperitoneal, intrathoracic or vascular) [1]. A score of 0 indicates a 3.9% risk of myocardial infarction, death, or cardiac arrest 30 days after undergoing noncardiac surgery, while a score of 3 or more increases the risk to 15%. These values should certainly be communicated to the patient and their decision-making family and friends when discussing the need for surgery as the interpretation of these percentages is relative. For example, a 15% risk of these incidents occurring may seem small to one patient while unacceptably high for another [1].

THE ROLE OF PREOPERATIVE CARDIAC TESTING

Preoperative cardiac testing can be effective in assisting in the management and risk assessment of post-intervention patients prior to surgery and is especially important when caring for the elderly who tend to have elevated fragility scoring. In 2014, a proposed algorithm (see Fig. **1**) targeting the decision-making for the need of preoperative cardiac testing prior to non-cardiac surgery was generally adopted, but such an algorithm, while useful, is not backed by random clinical trials and more importantly, is not specifically geared to the geriatric patient [1]. Therefore, this algorithm in conjunction with the clinical intuition of the anesthesiologist as well as the level of urgency of the procedure is best considered in its entirety in order to provide safe anesthetic care. Finally, preoperative clinical testing should be used only when appropriate. Over testing, when not appropriately indicated, places a strain on the healthcare system, creates unnecessary costs, and can even delay the availability of testing for other patients who may require testing.

In more complex cases, the opinion of a cardiology team, time permitting, may be warranted when planning anesthetic care for these patients. However, as with testing, over utilization of medical resources is not ideal, therefore knowing the appropriate time to consult a cardiology team is important. Frankly, cardiology consultation is best when the input that they would provide has direct effects on the anesthetic care the patient is about to receive rather than simply understanding their cardiac state. Patients with a history of stenting, or those with very high risk or indeterminate findings on cardiac testing are candidates for a preoperative cardiology consultation. The insight of the cardiology team may directly influence the anesthetic care plan, provide a more comprehensive look at the risks of the procedure and the associated anesthesia, and may allow for preoperative medical optimization to attenuate those risks. A summary of the 2014 guidelines published by the ACC/AHA is described below [1].

Patients who require surgery within 1 year after percutaneous coronary intervention are at increased risk of perioperative events compared with those

CHAPTER 9

Pulmonary Hypertension and Geriatric Patients

Stuart Pasch[1] and **Irwin Gratz**[1,*]

[1] *Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

Abstract: Pulmonary hypertension is a common and life-threatening condition, characterized by elevated blood pressure in the pulmonary artery, which supplies blood to the lungs. This condition is typically classified into five groups based on etiology. The etiology of pulmonary hypertension in the elderly is complex and multifactorial. Some of the common causes of pulmonary hypertension in this population include left-sided heart disease, chronic obstructive pulmonary disease (COPD), interstitial lung disease (ILD), and pulmonary embolism. The initial evaluation determines the cause, which guides the appropriate treatment. The most common causes in the elderly arise from left heart disease and the sequela of COPD. Long-standing disease can result in pulmonary hypertension leading to right heart failure and potentially catastrophic consequences in a patient population with decreased physiologic reserve. Anesthesia and surgery in patients with pulmonary hypertension pose a significant risk of complications including death. Acute right ventricular decompensation can result from various physiological changes induced by anesthesia and sedation. Adequate risk assessment and individualized care are essential components of care. Efforts to avoid increases in pulmonary vascular resistance are keys to anesthetic management. However, despite the increase of pulmonary hypertension in the geriatric population, limited studies are dedicated to this group.

Keywords: Chronic obstructive pulmonary disease, Left heart failure, Pulmonary vascular physiology, Pulmonary hypertension, Pulmonary Hypoxic pulmonary vasoconstriction, Right heart failure.

INTRODUCTION

Pulmonary hypertension (PH) is a complex and progressive cardiovascular disorder characterized by elevated pressure in the pulmonary arteries, imposing a significant burden on the right side of the heart. While PH is recognized across various age groups, its manifestation in the geriatric patient population introduces

* **Corresponding author Irwin Gratz:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA; E-mail: gratz-irwin@cooperhealth.edu

Bharathi Gourkanti, Dinesh Chaudhry, Irwin Gratz, Keyur Trivedi & Erin Pukenas (Eds.)

unique challenges and considerations. As the global demographic landscape undergoes a transformative shift towards an aging society, understanding and addressing pulmonary hypertension in older individuals become increasingly imperative.

This chapter delves into the intricate interplay of aging, comorbidities, and physiological changes that contribute to the development and progression of pulmonary hypertension among the elderly. By exploring the distinctive features of pulmonary hypertension in geriatric patients, we aim to enhance the comprehension of this condition within the context of an aging cardiovascular system. From the molecular mechanisms underlying vascular remodeling to the clinical implications for diagnosis and management, this chapter seeks to provide a comprehensive overview of pulmonary hypertension in the geriatric population.

DEMOGRAPHICS

The incidence and prevalence of pulmonary hypertension (PH) increase with age, and the elderly population is at higher risk for developing this condition. The early registries (1981-1985) of patients with pulmonary arterial hypertension (PAH) demonstrated only 9% of patients who were greater than 60 years of age [1]. However, most current studies have reported an increase in the mean age and proportion of geriatric patients having PAH. The most current data suggest that the age of PAH patients is increasing and some have reported the number as high as 63% [2, 3].

PHYSIOLOGY OF THE PULMONARY CIRCULATION

Unlike the rest of the circulatory system, the pulmonary vasculature is unique in that it is a high-volume low-pressure system that carries almost the entirety of the cardiac output. Flow through any tube can be approximated by a simplified version of Poiseuille's law (equation 1) which states that flow (Q) is related to the difference in pressure and inversely proportional to the resistance (R) in that system. Again, this is only an approximation because this equation assumes a Newtonian fluid in a laminar flow pattern in a non-distensible system (all 3 of which are not true of the pulmonary vascular system).

$$P_1 - P_2 = Q * R$$

Equation 1. Simplified Poiseuille's Law.

In the pulmonary circulation, flow (Q) is equal to the total cardiac output, and resistance (R) is equal to the pulmonary vascular resistance (PVR). The pressure

terms can be replaced with mean pulmonary artery pressure (MPAP) and mean left atrial pressure (MLAP). Replacing the terms and rearranging the equation to solve for resistance, we get equation 2.

$$PVR = \frac{MPAP - MLAP}{Q}$$

Equation 2. Pulmonary Vascular Resistance.

This equation is useful because PVR cannot be directly measured but rather calculated from the other variables. The total cardiac output is the same for both the left and the right hearts and can be calculated in a number of different ways. The MPAP can be directly measured using a Swann Ganz catheter or by ultrasound techniques. Again, the MLAP can be measured using ultrasound or Swan Ganz techniques.

The resistance in the pulmonary vasculature differs from the systemic circulation for several reasons. In systemic circulation, the largest pressure drop occurs in the arterioles and most of the resistance is in the thick-walled and muscular arteries [4]. The pulmonary system lacks these thick muscular vessels and rapidly divides. As a result, most of the resistance in the system resides in the capillary beds [5]. Effectively, the system can be modeled in parallel for purposes of a resistance diagram. A circuit in parallel provides a large cross-sectional area for blood flow which lowers pressure in the system and allows for more equal distribution of pressures throughout the lung parenchyma thus improving gas exchange [6].

A number of different factors can affect PVR but broad categories include lung volume, gravity, smooth muscle tonicity, and alveolar hypoxia [7].

Lung Volumes

The lung is a dynamic tissue with volumes primarily made up of alveolar volumes. When a tissue is dynamic, the diameter of blood vessels can be affected by changing volumes of the parenchyma and with a change in the diameter comes a change in the pressure in the vascular system. The pressure in this vascular system can be directly related to the volume of the lung at any given time. The lungs inflate when the chest wall generates more negative pressure in the thoracic cavity. This negative pressure affects all intrathoracic tissues including blood vessels. The large blood vessels are gently pulled and a negative transmural pressure is created which actually lowers the PVR in large vessels (Fig. **1**) [8, 9]. Meanwhile in the capillaries with expanding alveolar volume, there is local compression and increasing PVR (Fig. **2**). Resistance is lower during normal

CHAPTER 10

Anesthetic Considerations for a Patient with a Cardiovascular Implantable Electronic Device (CIED)

Dave Shah[1], Keyur Trivedi[1,*] and **Kinjal Patel[1]**

[1] *Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

Abstract: As the number of patients and use of cardiovascular implantable electronic devices have increased, anesthesiologists must understand the different types of implanted devices and their management during the perioperative period. Caring for these patients requires knowledge of the standard nomenclature used to describe device function, the role of a magnet, and the differential responses a magnet can cause based on the device type.

Keywords: Cardiovascular implantable electronic device, Cardiac resynchronization therapy, Defibrillator, Electromagnetic interference, Pacemaker, Perioperative care, Pacemaker codes.

INTRODUCTION

A cardiovascular implantable electronic device (CIED) refers to any permanently implanted pacemaker (PM) for bradyarrhythmia therapy, automatic implantable cardioverter defibrillator (AICD) for tachyarrhythmia management, cardiac resynchronization therapy device (CRT) for systolic dysfunction with conduction delays, and implantable loop recorders (ILR). It is estimated that over 300,000 people in the USA currently have an AICD and more than three million have a pacemaker [1]. Worldwide, over one million CIEDs are placed yearly with an annual increase in CIED placement [2]. The use of CIEDs is increasing as the indications for device placement increase, advancements in technology continue, and the population ages. In order to safely care for their patients, anesthesiologists

* **Corresponding author Keyur Trivedi:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA; E-mail: trivedi-keyur@cooperhealth.edu

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are expected to be knowledgeable about a variety of CIEDs and their functions, standard CIED terminology, perioperative management of these devices and the approach to using an unknown device.

DEVICES AND NOMENCLATURES

Nomenclatures

The North American Society of Pacing and Electrophysiology (NASPE) created a task force in 2001 that brought the NASPE/British Pacing and Electrophysiology Group (BPEG) Generic Pacemaker Code (NBG Code) up to date. The revised NBG code published in 2002 has five positions (Table **1**) and all five are exclusively used to describe anti-bradycardia pacing. Positions I, II, and III refer to the chamber(s) paced, chamber(s) sensed, and the triggering or inhibiting response to sensing, respectively. Position IV is used to refer to the presence (R) or absence (O) of an adaptive rate mechanism (rate modulation). Rate modulation produces a compensatory heart rate increase during emotional or physical activity by motion sensing through an accelerometer, minute ventilation through measurement of impendence between pacemaker case and intracardiac electrode, or cardiac contractility sensing through the measurement of the right ventricular (RV) impedance by unipolar intracardiac electrode [3]. Position V refers to the presence of multisite pacing. While all five positions may be necessary in certain situations, the first three positions are always required.

Table 1. Revised NASPE/BPEG Generic Code for anti-bradycardia pacing (2002) [4].

Position	I	II	III	IV	V
Category	Chamber(s) Paced	Chamber(s) Sensed	Response to Sensing	Rate Modulation	Multisite Pacing
-	O = None A = Atrium V = Ventricle D = Dual (A and V)	O = None A = Atrium V = Ventricle D = Dual (A and V)	O = None T = Triggered I = Inhibited D = Dual (T and I)	O = None R = Rate Modulation	O = None A = Atrium V = Ventricle D = Dual (A and V)

A device programmed in the O mode in position II will pace at the specified rate, regardless of intrinsic rhythm. With regard to position III, if programmed to T, an output pulse is triggered in response to a sensed event. If programmed to I, a sensed event results in the inhibition of the output pulse until the next cycle. D indicates dual modes of response and is reserved for dual chamber systems (See Table **2**).

Table 2. Pacing modes examples.

Mode	Functionality of Pacemaker
VOO/DOO	Single ventricle or dual chamber paced at a fixed rate. Also called asynchronous pacing.
VVI	Single ventricle chamber paced and sensed, inhibited by sensed activity. Example: Patients with chronic atrial arrhythmia (Atrial fibrillation or Atrial flutter)
AAI	Single atrial chamber paced and sensed, inhibited by sensed activity. Example: Patients with AV node preserved conduction but symptomatic sinus bradycardia.
DDD	Dual chamber paced and sensed, inhibited by sensed activity. Example: Paroxysmal Atrial Arrhythmias or AV node conduction not preserved.

Pacemakers

Permanent pacemakers are most commonly placed for sinus node dysfunction, acquired AV block, and post-myocardial infarction. Several less common indications include congenital complete heart block, long QT syndrome, hypertrophic cardiomyopathy, and heart failure. There is currently no consensus definition of pacemaker dependency. The traditional definition of pacemaker dependency is the absence of an underlying escape rhythm when ventricular pacing is stopped [5]. Clinically, patients are considered pacemaker dependent where there is an absence of an escape rhythm with the pacemaker set at 30-50 beats-per-minute in the VVI mode, or the presence of symptoms despite an escape rhythm greater than 30-50 bpm in VVI mode [5]. Pacemakers, including leadless systems, are typically placed transvenously, while epicardial pacemakers are usually placed during an open procedure. Transvenous pacemakers include a pulse generator and one or more electrodes (referred to as leads). The pulse generator generates the electrical current required for stimulation of the myocardium while the leads transmit the electrical activity from the pulse generator to the myocardium. The pulse generator is usually placed in either the left or right infraclavicular region of the anterior chest wall. The leads of epicardial pacemakers are directly attached to the epicardial surface of the heart and are usually placed during cardiac surgery for temporary pacing. Other indications for epicardial pacemakers include patients with congenital anomalies, absence of venous access to the heart or an open shunt between the left and right sides of circulation, recurrent device infections, and occluded veins [3]. Leadless pacemakers contain the pulse generator and lead within a single unit and are implanted *via* the femoral vein into the RV. Currently, leadless pacemakers can only be used for single chamber ventricular pacing and are largely limited to patients with permanent atrial fibrillation with slow ventricular response or patients with paroxysmal infrequent atrioventricular (AV) block [6].

CHAPTER 11

Geriatric Pain Patient

Afrin Sagir[1,2,*], **Parker Woolley**[3] and **Fangyu Chen**[1]

[1] *Department of Anesthesiology and Critical Care, Hospital of the University of Pennsylvania, Perelman School of Medicine, Philadelphia, PA19104, USA*

[2] *Penn Center for Perioperative Outcomes Research and Transformation, University of Pennsylvania, Perelman School of Medicine, Philadelphia, PA19104, USA*

[3] *Department of Anesthesia, Critical Care and Pain Medicine, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA02215, USA*

Abstract: Chronic pain is a major cause of physical disability, poor mental health, and decreased quality of life [1,2]. The burden of chronic pain is reflected in increased medical care utilization and consequently increased healthcare costs, which are estimated at an astounding $560 billion per year [3]. CDC estimates from 2019 reveal that while 20.4% of adults in the USA live with chronic pain, the prevalence increases with advancing age [4]. 30.8% of people aged 65 years and above had chronic pain while 11.8% of them had high-impact chronic pain, which is defined as pain that causes significant restriction of self-care, social and work-related activities [5]. The impact of chronic pain is more severe in the elderly; older adults report poorer physical health and disability in comparison to younger adults [6-8]. Chronic pain in the elderly is also associated with poorer sleep, cognitive decline, dementia, and death [9-13]. With the projected increase in the elderly population in the US every year, the burden of chronic pain is only expected to increase. This chapter outlines the physiologic and pharmacologic changes that happen with ageing, the major causes of chronic pain in the elderly, as well as the myriad of treatment options available with a focus on pharmacotherapy, behavioral and alternative therapies, and interventional pain therapies. The focus of treatment is not only targeted towards reducing pain but special considerations should be made to minimize the cognitive effects of polypharmacy in light of multiple comorbidities and promote mental well-being and functional independence [14].

Keywords: Geriatric pain, Geriatric pain assessment, Interventional pain management, Neuromodulation, Radiofrequency ablation, Spinal cord stimulation.

[*] **Corresponding author Afrin Sagir:** Department of Anesthesiology and Critical Care, Hospital of the University of Pennsylvania, Perelman School of Medicine, Philadelphia, PA 19104, USA; and Penn Center for Perioperative Outcomes Research and Transformation, University of Pennsylvania, Perelman School of Medicine, Philadelphia, PA 19104, USA; E-mail: afrin.sagir@pennmedicine.upenn.edu

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INTRODUCTION

Chronic pain significantly contributes to physical disability, diminished mental health, and a lower quality of life [1, 2]. Among individuals aged 65 and above, the prevalence of chronic pain is staggering, reaching up to 30.8%, with 11.8% experiencing high-impact chronic pain [5]. This demographic's chronic pain is linked to poorer physical health, increased disability, disrupted sleep, cognitive decline, dementia, and even mortality [6 - 13]. This chapter delves into the physiological and pharmacological changes associated with aging, the primary causes of chronic pain in the elderly, and the diverse array of available treatment options, emphasizing pharmacotherapy, behavioral and alternative therapies, and interventional pain therapies. While the primary goal of treatment is pain reduction, an inclusive approach is essential to enhance mental well-being, foster functional independence, and mitigate the cognitive effects of polypharmacy, particularly considering multiple comorbidities [14].

Physiological Considerations in the Ageing

Treatment of the elderly pain patient requires a good understanding of the physiological changes that occur with aging as well as knowledge of the common comorbidities encountered in this patient population, which would impact clinical evaluation and decision-making for treatment. Table **1** highlights some of the major physiological changes that occur with ageing in the various organ systems.

Table 1. Physiological changes that occur with ageing and their clinical implications for pain management.

Physiological Changes	Clinical Implications
Cardiovascular system	-
Decreased heart rate	Slower distribution of drugs
Decreased arterial elasticity and increased afterload	Increased risk of vascular events secondary to pain.
Increased systolic and diastolic BP	-
Decreased cardiac output	-
Decreased baroreceptor sensitivity	-
Decreased adrenergic activity	-
Decreased sinoatrial node cells and fibrosis of the conduction system	-
Respiratory system	-

(Table 1) cont.....

Physiological Changes	Clinical Implications
Increased chest wall rigidity	Decreased respiratory reserve with increased risk of respiratory failure.
Decreased respiratory muscle strength	
Diminished cough	
Decreased sensitivity to hypoxia and hypercapnia	
Decreased arterial oxygen tension	
Ventilation perfusion mismatch	
Gastrointestinal system	-
Decreased hepatic and intestinal blood flow	Reduced drug metabolism and excretion
Decreased hepatocyte number and function	Reduced absorption of drugs
Decreased intestinal transit time	Increased susceptibility to constipation
Hypoalbuminemia	Increased free drug fraction leads to increased drug activity and side effects.
Renal system	-
Decreased renal blood flow	Decreased renal excretion of drugs
Decreased glomerular filtration rate	Increased vulnerability to nephrotoxicity of drugs.
Decreased number of nephrons and reduced renal tubular function	-
Decreased RAAS* sensitivity	-
Neurological system	-
Cognitive decline	Altered pain processing
Decreased blood supply to the brain and cortical atrophy	Underreporting of pain
Decreased proprioception	Increased risk of falls
Autonomic neuropathy	Increased risk of dementia and delirium
Musculoskeletal system	-
Reduced plasma volume and muscle atrophy Increased body fat and reduced lean body mass.	Reduced volume of distribution of water-soluble drugs, higher risk of toxicity.
	Increased duration of action of fat-soluble drugs

***** Renin Angiotensin Aldosterone System.

Changes in the cardiovascular system include a reduction in heart rate, stroke volume, and cardiac output, which alters the pharmacodynamics of analgesic medications. Comorbidities including cardiac arrhythmias, hypertension, heart failure, and stroke lead to an elevated risk of morbidity and mortality [15].

CHAPTER 12

Geriatric Trauma Patient

Akhil Patel[1,*]

[1] *George Washington University School of Medicine and Health Sciences, Washington, D.C., USA*

Abstract: Trauma is a leading cause of death for the geriatric population. Because of the acuity of the patient presenting in such circumstances, it is imperative to have a grasp of physiological changes that occur with time. As an anesthesia provider, understanding physiological changes can adjust the anesthetic plan, dosages, and uses of certain medications. It is also important to convey the risks and benefits of proceeding with major invasive surgery and recovery. Many patients now have living wills or advanced directives that may assist in decision-making.

Keywords: ADLs, Anticoagulation reversal, Blunt trauma, Clinical frailty scale, Code status, Coagulopathy, Delirium, FAST, Frail Scale, GCS, Hemorrhage shock, Hypothermia, NORA, Orthopedic injury, Physiological changes, Pain control, Resuscitation.

INTRODUCTION

As illustrated earlier in this textbook, geriatric medicine is an evolving field. The management of a geriatric patient, although similar to adult patients, has nuances that must be understood in order to adequately and safely manage the patient. In particular, there are many important principles that must be taken into consideration when addressing geriatric trauma.

As of 2020, geriatric trauma, defined as injury above the age of 65, has been the 7th leading cause of death, ranking above hypertension, renal failure, sepsis, and aspiration and just below diabetes and chronic lower respiratory diseases [1].

Blunt and penetrating trauma are very different pathologies. For the geriatric population, blunt trauma is more prevalent than penetrating. According to the Centers for Disease Control and Prevention, one out of every four geriatric adults in the USA will have a fall [2]. Falls are the primary reason for injury and death in this population. Three million adults are seen in the emergency department with

* **Corresponding author Akhil Patel:** George Washington University School of Medicine and Health Sciences, Washington, D.C., USA; E-mail: ap1189@gmail.com

falls, of which, about 20 percent have sustained fractures. Other blunt trauma injuries include cerebrovascular bleeding with a history of anticoagulation use, pulmonary contusions and rib fractures, splenic and liver lacerations, and orthopedic injuries [2].

In this chapter, we will discuss the management of this population in three settings: pre-operative, intra-operative, and post-operative. Pre-operatively, we will discuss initial evaluation including trauma surveys, common physiological changes, and resuscitation targets. For intra-operative management, we will discuss the various modes of anesthesia. Finally for post-operative management, pain control and delirium will be covered.

PRE-OPERATIVE EVALUATION

Trauma Evaluation

Trauma patients appearing in the emergency room or trauma bay have a very specific evaluation to immediately address any life-threatening injuries. Typically, an anesthesia team, along with trauma surgery and emergency medicine teams, will evaluate the patient. The evaluation consists of primary, secondary, and tertiary surveys [3, 4].

The primary survey is a quick evaluation to rule out all imminent causes of death including airway obstruction, pneumothorax, cardiac tamponade, and intracranial bleed amongst other diagnoses. A primary survey must be completed on all trauma patients. “ABCDE” is the acronym used when performing the primary survey which is illustrated in Table **1** below. Many of the steps are performed simultaneously in order to complete the evaluation as quickly as possible [3, 4].

Table 1. Primary survey acronym ABCDE and it’s corresponding meanings [3].

Primary Survey	
A	**Airway with cervical spine precaution/protection**
B	**Breathing and ventilation**
C	**Circulation with hemorrhage control**
D	**Disability**
E	**Exposure and environmental control**

The airway evaluation can be completed by asking the patient a question, such as their name. The goal is to assess the patency of the airway. The anesthesia team should be at the head of the bed assisting the patients who are unable to protect their airways or have concerns about impending airway compromise. If the patient

must be intubated, it occurs at this time. If the patient is able to communicate, it is imperative to evaluate for any trauma to the head or cervical spine. If the patient is unable to communicate, cervical neck precautions must be taken until ruled out with either imaging or examination with a neurologically intact patient. Combative or intoxicated patients impeding the primary survey may require intubation for the completion of the evaluation. Patients who require intubation must always be considered to have a full stomach and at risk for gastric content aspiration. Precautions must also be taken for airborne illnesses. Members of all teams must don protective gear prior to evaluating the patient [3, 4].

Evaluation of breathing and ventilation is completed with the above evaluation. Tracheal deviation, signs of flail chest, and positive bilateral chest sounds are documented. If the patient needs airway assistance, the anesthesia team must be prepared at the head of the bed. Chest tube placement and needle decompression may occur if there is a high risk of pneumothorax or hemothorax. A pulse oximeter is connected as soon as possible [3, 4].

Circulation and hemorrhage control begins as soon as the patient enters the trauma bay. Electrocardiograms (EKG), pulse oximetry and blood pressure cuff readings help in this assessment. Manual blood pressures are typically used prior to evaluating with a pneumatic cuff. Level of responsiveness, skin color, capillary refill, hemodynamic measurements, and obvious sources of hemorrhage are evaluated. Control of obvious hemorrhage must take place with manual pressure or tourniquet application. Resuscitation occurs at the first signs of circulatory shock. Table **2** below describes the stages of hemorrhagic shock. If the patient is likely in a state of hemorrhagic shock, a blood transfusion is recommended for resuscitation. If unavailable, isotonic fluid such as lactated ringers can be administered; however, isotonic fluids should be minimized and blood transfusions should be initiated as soon as possible. We will discuss resuscitation goals and concerns in the geriatric population later in this chapter [3, 4].

Table 2. Hemorrhagic shock classification in adults [3, 4].

Hemorrhagic Shock Classification				
Class	1	2	3	4
Blood Loss (mL)	< 750	750-1500	1500-2000	>2000
Blood Loss (% Blood Volume)	<15%	15-30%	30-40%	>40%
Pulse	<100	>100	100-120	>120
Blood Pressure	normal	normal	depressed	Depressed
Respiratory Rate	14-20	20-30	5-15	Negligible

CHAPTER 13

Geriatric Ambulatory Patients

Fatimah Habib[1,*] and **Ershad Khan**[2]

[1] *Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

[2] *Philadelphia College of Osteopathic Medicine, Philadelphia, PA, USA*

Abstract: With the advent of enhanced recovery programs, postoperative recovery has become more and more efficient with improved postoperative times to discharge, decreased hospitalizations, and improved patient satisfaction. Employing these same principles to a more vulnerable population in an ambulatory setting has proven effective in making outpatient day surgery possible and successful for the elderly population. This chapter will discuss the advancing age of the surgical population, the advancing numbers of surgeries being performed in an ambulatory setting, and the implications on the elderly population as they undergo ambulatory procedures. Further, the chapter will discuss how to optimize the elderly population to have a successful perioperative course by utilizing a team of professionals preoperatively and enhanced recovery programs peri-operatively. Finally, the chapter will conclude with certain potential complications that may occur with this populous and how to best avoid them.

Keywords: Airway assessment, Common ambulatory surgeries, Clinical frailty scale, Enhanced recovery after surgery (ERAS), Multimodal analgesia, Perioperative nutrition screen (PONS), polypharmacy, Pharmacodynamics, Postoperative cognitive dysfunction (POCD).

INTRODUCTION

Recent advancements in technology and healthcare have led to people living longer and healthier lives, resulting in an increase in life expectancy and growth of the elderly population [1]. Though there is no consensus on the defined age of a patient that is considered "elderly," for the purpose of this chapter, we will define the elderly as a patient over the age of 65 years. In the US, the population of people over the age of 65 years has been increasing at a rate of 2% per year, double the rate of people under the age of 65 years [2]. According to the US Census Bureau, in 2009, the elderly population contributed to 12.9% (39.6 million people) of the US population [3]. The 2020 census revealed the number has since

* **Corresponding author Fatimah Habib:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA; E-mail: Fatimah.habib@gmail.com

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increased to 16.8% or 55.7 million people [4]. The 2030 projections estimate this number to rise to approximately 19% or 72.1 million people [3].

In conjunction with the global rise of the elderly population, the number of ambulatory surgeries has increased over the years. Advancements in surgical techniques have allowed for some common surgeries to be done safely in an ambulatory setting. Table **1** shows common procedures done in an outpatient setting. The geriatric patient will have surgery in an ambulatory setting at some point or another. A retrospective cohort study by Chaturvedi *et al*. showed that over 1.3 million elderly patients underwent outpatient surgery between 2017 and 2019 [5]. Ambulatory surgery, or outpatient surgery, is defined as a planned surgery that does not take place in a hospital and patients are discharged within the same day [6]. Ambulatory surgery comes with numerous advantages but is not free of disadvantages. Table **2** shows a summary of the advantages and disadvantages of outpatient surgeries.

Table 1. 10 Most Common Procedures Done in an Ambulatory Setting [3].

Common Ambulatory Surgeries
1. Laparoscopic cholecystectomy
2. Laparoscopic appendectomy
3. Partial mastectomy
4. Laparoscopic inguinal hernia repair
5. Inguinal hernia repair
6. Umbilical hernia repair
7. Knee arthroscopy
8. Laparoscopic removal of adnexal structure
9. Shoulder arthroscopy
10. Lumbar laminectomy

Table 2. Advantages and Disadvantages of Ambulatory Surgery [2, 7].

Advantages:	**Disadvantages:**
- **Lower costs for the patient** - **Benefits:** o **Reduced incidence in postoperative cognitive dysfunction** o **Decreased infection rates** o **Early mobilization** o **Decreased thromboembolic events** o **Higher patient satisfaction**	- Limitation of resources available at the facility - Not ideal for: o Severe frailty o Non-elective surgery o Major surgery

Not every patient will be eligible to have his or her surgery in the outpatient setting. Whether it is due to the limitations of the facility or the patient's health, every patient planning to undergo ambulatory surgery should be screened to see if

they are candidates for surgery in an outpatient setting. Part of what makes ambulatory surgery successful is if the candidates are optimal for that setting. However, there is no consensus regarding the best way to assess a patient's readiness and to predict the responses to surgical interventions, even with the most sophisticated risk calculators. To decrease same day cancellations, need for admission and overall complications, the patients must meet certain criteria to be considered for ambulatory surgery. Each facility may have slightly different requirements, which are based on the resources each facility has available, but, in general, certain standards should be met. Overall, ambulatory surgery is considered safe if the patient is deemed to be a good candidate [8]. Table **3** identifies the basic criteria for ambulatory patients with special consideration for the geriatric population.

Table 3. Suggested Patient Specific Criteria for Ambulatory Surgery [9].

ASA class 1-3
On the clinical frailty scale, the patient is classified as moderately frail or better.
No evidence of active infection.
In the last 6 months the patient has not had any cardiovascular or cerebrovascular events.
Negative for obstructive sleep apnea (OSA).
Body mass index (BMI) of less than 40kg/m^2.

For those patients who do qualify for ambulatory surgery, it is imperative to formulate a plan of care with the patient's health care team in order to ensure the patient is optimized day of the procedure. As anesthesiologists, we must do a thorough preoperative history and physical examination so that we can consider all factors that would affect the patient's perioperative course.

PREOPERATIVE CONSIDERATIONS

There are many considerations to take into account during the preoperative evaluation. There must be clear communication about the entire operative course. Since the elderly population tends to have more complex histories, often with multiple comorbidities and taking a plethora of medications, there is much to consider when prepping these patients prior to surgery. A vital part of the preoperative evaluation process is to make sure all those patients coming to an ambulatory center for surgery fit appropriate criteria for being in an ambulatory setting [9]. Elderly patients should be regularly seen by their primary care physician (PCP), ideally one that specializes in geriatrics. A team approach is often helpful when attempting to enhance the patient's condition preoperatively. This often involves the need for consultation with other specialists depending on

CHAPTER 14

Anesthetizing the Critically Ill Geriatric Patient

Christopher J. Mahrous[1], Gregory Felock[2] and **Talia K. Ben-Jacob[1,*]**

[1] *Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

[2] *Department of Medicine, Division of Critical Care, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

Abstract: Caring for and anesthetizing critically ill geriatric patients requires multiple special considerations. This chapter will explore the considerations that must be taken when anesthetizing this geriatric critically ill population. In addition, it will also describe in detail common critical care scenarios in the geriatric population such as airway and ventilation management, resuscitation, and sepsis. Finally, some critical care issues specifically related to the geriatric population such as frailty and end-of-life considerations will be discussed.

Keywords: End-of-life, Elder Abuse, Frailty, Functional Decline, Hospice, Intubation, Sepsis, Resuscitation, Palliative care.

INTRODUCTION

Anesthetizing a critically ill patient is a challenge as critical physiology poses an increased risk with anesthesia. Often, the critically ill patients requiring anesthesia are also geriatric patients, therefore compounding the risk of adverse outcomes and the challenges associated with critical illness physiology, age-related physiology, significant comorbidities, and pharmacokinetics. These situations often arise without an ideal solution and thus competing interests require a thorough knowledge of both caring for the critically ill and caring for aging patients in order to make the best, risk-attenuated decision for the patient. These patients may also present without a viable treatment option and the astute physician must understand the nuances for navigating care toward more comfort-based and quality-of-life goals for their patients.

* **Corresponding author Talia K. Ben-Jacob:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA; E-mail: ben-jacob-talia@cooperhealth.edu

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EPIDEMIOLOGY

It is estimated that 80 million people will be 65 years or older by 2050 [1]. In addition, the geriatric population makes up approximately 50% of intensive care unit (ICU) admissions [2]. This percentage is only expected to grow. Much of this care involves end-of-life, which has been shown to account for a significant portion of Medicare dollars spent. For this reason, end-of-life spending is often a focus of policymakers [3]. As this population lives longer, they will be admitted with a wide variety of diagnoses ranging from acute trauma to exacerbations of chronic conditions to catastrophic presentations of end-stage pathology [2]. The average length of stay for a patient older than 65 years of age was about 3.4 days, however, 1.3% of patients were in the ICU for greater than 21 days. There was also an increased odds of death at 1-year for each day beyond seven days in the ICU [4]. It is clear that the geriatric population will be an increasingly important population for critical care physicians and anesthesiologists.

RESUSCITATION OF THE CRITICALLY ILL GERIATRIC PATIENT

As will be discussed in later sections, it is extremely important to attempt to determine the patient's wishes in this population, if possible, prior to beginning aggressive resuscitation. However, once it is established that the patient is to be resuscitated, the clinician should act rapidly. Early treatment has been shown to improve survival in the geriatric population [5]. The resuscitation of any critically ill patient should begin with the assessment of the patient's airway, breathing, and circulation. Geriatric airway and intubation will be discussed in a later section. Due to weakened respiratory muscles and increased dead space, the geriatric population has a significantly decreased respiratory reserve when compared to the younger population. Pulse oximetry monitoring should be maintained, and supplemental oxygen applied to maintain oxygen saturation in the low 90s [6]. The geriatric population has a blunted compensatory response to hypoxia, hypercarbia, and acidosis requiring close monitoring [7]. Once the patient has demonstrated the inability to compensate for the above, the physician should prepare to move towards intubation or other forms of ventilation depending on the patient's wishes. Following the assessment of airway and breathing, the provider should work on the assessment of circulation. This can most quickly be assessed by evaluating peripheral pulses, skin perfusion, and mental status. If the femoral pulses are palpable, the systolic blood pressure is at least 40 mmHg and if peripheral pulses are palpable, the systolic blood pressure is at least 60 mmHg [8]. Heart rate and blood pressure should be continuously monitored, as these can change quickly so the placement of an arterial line early in the resuscitation course is appropriate. The assessment of a geriatric patient's circulation is difficult due to concomitant hypertension and heart disease. Patients are often

taking medications such as beta-blockers or calcium channel blockers and these medications will blunt the normal physiologic response to stressors such as pain or developing shock [6]. In addition, as the geriatric population is often significantly hypertensive at baseline, otherwise normal blood pressure in this population may actually represent a state of mal-perfusion [9]. As discussed already, geriatric patients often have blunted physiologic responses to stressors that make detection of the shock challenging. When a patient appears toxic, the provider must often look to secondary signs of malperfusion to determine that a shock state exists. This includes evaluation of the patient's serum lactate, liver profile, renal function, and mental status [10, 11]. Once it is determined that a shock state exists, attention must be rapidly turned towards addressing the cause. There are four main classes of shock. These are hypovolemic, distributive, obstructive, and cardiogenic. Determining the cause of the shock is helpful as this can guide therapy and resuscitation.

Early determination of the cause of shock can be done with a good history and physical exam, however, this method is wrong in up to 30% of cases [12]. This is important because based on the etiology of the shock, both over or under resuscitation can be detrimental. Point of care ultrasound (POCUS) has become a mainstay of shock assessment to further elucidate etiology and monitor resuscitation. The Rapid Ultrasound for Shock and Hypotension (RUSH) exam is one example protocol that evaluates the inferior vena cava, heart, lungs, abdomen and aorta. It has been shown to correctly determine the etiology of shock in 80% of cases in the first 15 minutes [12]. With ongoing reassessments, it can also be used to guide therapy and assess response. In the trauma population, ultrasound has also proven beneficial and has been shown to decrease both the volume of resuscitation and ventilator days [13].

CRITICAL CARE INTUBATION OF THE GERIATRIC PATIENT

Unlike intubations in the operating room, intubations occurring in the intensive care unit are often unexpected and unoptimized. Intubation in this setting already requires special consideration, which is only further necessary when the patient is geriatric. Geriatric patients, especially those who are critically ill, are at higher risk for airway complications such as desaturation, hypercarbia, aspiration, and hemodynamic instability because of decreased functional reserve [14]. In addition, this population has additional characteristics that make their airways inherently difficult including but not limited to: poor dentition, atrophy of bone and muscles, osteoarthritis, and rigidity of head and neck joints [15, 16]. Anatomical considerations in the geriatric population were discussed previously in this book. With the above in mind, the first step will be to prepare for the intubation. This includes organizing the room, obtaining the equipment, preparing

CHAPTER 15

Anesthetic Considerations for Patients with Chronic Neurologic Disorders

Dhaval Rana[1] and **Felipe Guzman**[1,*]

[1] *Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

Abstract: Chronic neurological disorders encompass a broad range of challenges for the surgical and anesthesiology team in the perioperative setting. According to the World Population Prospects 2019, by 2050, 1 in 6 people will be over 65, from 1 in 11 in 2019 [1]. As our population continues to age, our understanding and ability to provide medical and surgical services must improve as well. Perioperative strokes are rare, but they can greatly impact a patient's recovery and function when they occur. Dementia strongly predicts postoperative complications, higher hospital costs, and 30-day mortality [2]. Patients with Parkinson's disease are at a higher risk of perioperative medical and surgical complications not to mention specific medication regimens that need to be adjusted to avoid worsening symptomatology. Although rare, a patient presenting with Amyotrophic lateral sclerosis (ALS), can present with a broad range of neurologic symptoms, and cardiovascular and pulmonary dysfunction that can be daunting for any anesthesia provider. In this chapter, we will explore the comprehensive approach to managing chronic neurologic disorders, including multidisciplinary care, early identification of potential complications, specialized medication management, and intraoperative considerations.

Keywords: Alzheimer's Dementia, Bradykinesia, Beer's criteria, Frontotemporal dementia, Ischemic stroke, Lewy body dementia, Perioperative stroke, Pick's disease, Postoperative delirium (POD), Parkinson's disease, TPA exclusion criteria.

INTRODUCTION

Patients with diseases affecting the central nervous system (CNS) or peripheral nervous system (PNS) will undergo surgery to treat their neurological condition or other surgeries unrelated to their disease. Regardless of the reason they present to the operating room, these diseases can have important impacts on preoperative, intraoperative, and postoperative anesthetic care. This chapter will delve into dif-

* **Corresponding author Felipe Guzman:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA; E-mail: guzman-felipe@cooperhealth.edu

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ferent neurological diseases that are commonly encountered in the geriatric population.

Stroke

Ischemic

Introduction

Ischemic stroke (IS) represents about 87% of strokes and is the 5th leading cause of death in the USA [3]. IS is caused by focal (or global) cerebral, spinal, and retinal infarction leading to neurological dysfunction. IS occurs when the blood flow region within the CNS is compromised leading to severe oxygen and nutrient delivery, eventually leading to neuronal cell death.

Anesthesia care providers provide care to patients with acute or subacute IS as well as prior strokes in different hospital settings such as Interventional radiology suites, Critical Care areas, or Operating Rooms. As such, anesthesia care providers should be familiar with all aspects of caring for a neurologically injured patient, including initial assessment, treatment, anesthetic management, and postoperative care.

Pathophysiology

The brain typically uses 20% of the body's oxygen, with 60% of that consumption going towards producing ATP to support neuronal electrical activity. Therefore, the brain exhibits exceptional sensitivity to any decrease in the supply of metabolic substrates, owing to its substantial metabolic requirements and constrained reserves. Therefore, it heavily relies on the continuous blood flow. Like the kidney and the heart, the brain can typically handle a broad range of blood pressure with a minimal impact on blood flow. The blood vessels in the brain can quickly adjust to alterations in mean arterial blood pressure to keep the cerebral perfusion pressure within the standard range of 60 to 80 mmHg. A decrease in CPP results from vasodilation while an increase in CPP results from vasoconstriction. CBF remains nearly constant between MAPs of about 60 to 160 mmHg.

IS occurs when there is an interruption in blood flow to regions with the CNS, leading to a lack of oxygen and nutrient supply. This leads to increased release of glutamate, an excitatory neurotransmitter, resulting in an influx of calcium ions into cells. This influx of calcium leads to the activation of enzymes and a cascade of events ultimately leading to cell death. IS can also disrupt the blood-brain barrier, which is a protective layer that separates the brain from the blood

circulation. This disruption allows toxic metabolites, immune cells, and fluid to enter the brain further contributing to inflammation, edema, and brain damage [4].

Another important concept to discuss when talking about IS is the "*Penumbra*", referring to the peripheral region surrounding the central area of the infarcted tissue. The penumbra region typically exhibits cerebral blood flow ranging from 5 mL/100 g/min to 15 mL/100 g/min. Despite its electrical dysfunction, this area can still be potentially salvaged if blood flow can be successfully restored within a specific timeframe [4]. The penumbra is a target for therapeutic interventions to prevent further damage and promote recovery.

Diagnosis/Treatment

The diagnosis of IS involves both clinical assessments accompanied by some form of imaging. In addition to the clinical assessment, the comprehensive medical management of acute ischemic stroke encompasses the management of the airway, oxygenation, ventilation, systemic blood pressure, blood glucose concentration, and body temperature. The initial phase of evaluation typically involves a comprehensive neurological assessment. The National Institutes of Health Stroke Scale (NIHSS) serves as a valuable tool for quantifying clinical impairment and aiding in the identification of patients suitable for revascularization therapy. This assessment encompasses eleven distinct clinical elements, with scores ranging from 0 to 42. Increased impairment is associated with higher scores. Notably, a score exceeding 16 is indicative of a heightened likelihood of mortality, while a score below 7 suggests a substantial likelihood of a favorable recovery outcome [3].

The clinical assessment is rapidly followed by imaging. Imaging modalities include computed tomography (CT) or magnetic resonance imaging (MRI) which can both be used to confirm the diagnosis of ischemia stroke and to determine the extent and location of the brain injury. Non-contrast CT is usually the first imaging study performed in acute strokes due to its availability/speed and sensitivity for ruling out intracranial hemorrhage (ICH) and helps the decision to start initial treatment with tissue plasminogen activator (tPA). The American Stroke Association recommends that the door-to-imaging time for acute stroke should be less than 25 minutes for CT and less than 45 minutes for MRI [5].

Tissue Plasminogen activator (tPA) is a medication used for the treatment of acute IS. tPA works by converting plasminogen, an inactive enzyme within the bloodstream, to plasmin, an active enzyme that can break down blood clots. tPA is most effective within a specific time window, due to the increased risk of bleeding if given outside of the window period. According to the guidelines set forth by the American Stroke Association, eligible patients with acute ischemic

CHAPTER 16

Controversies in Geriatric Anesthesia

Aakash K. Patel[1], Irwin Gratz[1] and **Bharathi Gourkanti[1,*]**

[1] Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, New Jersey, USA

Abstract: There are several controversies when it comes to geriatric anesthesia including:

1. Determining the appropriate anesthesia technique: Geriatric patients may have decreased organ function and may be more susceptible to the adverse effects of anesthesia. There is ongoing debate about the best anesthesia technique for older adults, with some arguing for the use of regional anesthesia and others advocating for general anesthesia.

2. Perioperative Beta-blockers: The use of perioperative beta-blockers continues to be debatable. On one hand, evidence suggests beta-blockers may reduce perioperative cardiac events in the elderly. On the other hand, there are concerns and potential risks, especially in this population.

3. Cognitive impairment: Older adults may be at increased risk of delirium and cognitive impairment after surgery. The use of certain medications, such as propofol or midazolam, may increase the risk of cognitive impairment. There is ongoing debate about the best way to minimize the risk of cognitive impairment in older adults.

4. Pain management and Frailty: Geriatric patients may have increased sensitivity to pain and may require higher doses of pain medication. However, older adults may also be at increased risk of adverse effects from pain medications, such as respiratory depression.

5. Advance care planning and ethical considerations: Geriatric patients may have a higher risk of complications and death after surgery. Advance care planning, such as discussing the patient's goals of care and treatment preferences, can help ensure that the patient's wishes are respected in the event of an emergency. Geriatric patients may have a decreased ability to make decisions about their care due to cognitive impairment or other factors. There is ongoing debate about the best way to obtain informed consent from older adults and ensure that their wishes are respected.

[*] **Corresponding author Bharathi Gourkanti:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA;
E-mail: gourkanti-bharathi@cooperhealth.edu

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6. Cardiac-related controversies including the use of Aminocaproic Acid in CABG surgeries. There are several studies that have shown reduced bleeding and the need for blood transfusions, while others have raised concerns about an increased risk of adverse events, such as renal failure and thromboembolic events.

Keywords: Advance care planning, Controversies, Cognitive impairment, Cognitive impairment, Geriatric anesthesia, Hip-fracture surgery, Pain management, Perioperative beta-blocker.

INTRODUCTION: SURGERY IN THE ELDERLY AND THE ROLE OF SURGERY

The U.S. Census 2010 data revealed that the number of people older than 65 years of age in the USA had increased to 40.4 million, with 21.7 million 65 to 74 years old, and 13.1 million 75 to 84 years of age, with 5.5 million over the age of 85 years [1]. These numbers are going to continue to rise, and it is estimated that by 2030, 20% of U.S. citizens will be older than 65 years [1]. In addition, these older individuals will more frequently need to access health care. Patients 65 years of age and older have surgery at the rate of 2 to 3 times that of younger patients and tend to have longer hospital stays [1]. According to the American Geriatrics Society, about 40% of adults over the age of 65 will have at least one surgical procedure during their lifetime, and this number is expected to increase as the older adult population continues to grow [2]. A study by the National Center for Biotechnology Information (NCBI) states that surgery rates in older adults increase with age, with the highest rate among those aged 85 and older [3]. It is also worth noting that older adults are more likely to have multiple comorbidities, which may increase the risk of complications and the need for additional surgeries. Also, as older adults tend to have a longer life expectancy, surgeries on this population may have a greater impact on the patient's life. The leading cause of death among today’s geriatric population has changed from acute to chronic illnesses. This change in pattern will continue to be a challenge for all providers of health care. With the increased chance of needing surgery, it is becoming increasingly important to be aware of some of the controversies in the geriatric population.

OVERALL SURGICAL MORTALITY AND MORBIDITY IN GERIATRIC POPULATION

The aging population of the USA results in increasing numbers of surgical operations on elderly patients. Although several risk factors for postoperative morbidity and mortality increase with age, this increasing age itself remains an important risk factor for postoperative morbidity and mortality. A study completed by the University of Virginia examined over 7500 surgical procedures

and the morbidity and mortality rates of those patients. Although the respective morbidity and mortality were 28% and 2.3% for all study participants, for those over the age of 80 years the rate was 51% and 7% respectively. Age was statistically significantly associated with morbidity (wound, $p = 0.021$; renal, $p = 0.001$; cardiovascular, $p = 0.0004$; respiratory, $p < 0.0001$) and mortality ($p = 0.001$) [4]. It is important to note that the increase is almost double when compared to those under the age of 80.

REGIONAL *VS.* GENERAL

One of the first controversies in this population is one of anesthetic techniques and the decision to undergo general anesthesia *vs*. regional anesthesia. The difference in outcome between regional and general anesthesia in the elderly population is not entirely clear, but the actual mode of anesthesia appears to have minimal effect on the outcomes that we routinely measure. Factors other than the choice of anesthesia appear to be more important. Hospitals should focus on a range of standards that they consider appropriate using established age-related dosages.

The debate on the use of regional *versus* general anesthesia in the geriatric population has been largely settled by the recently published RAGA [5] and REGAIN -1 [6] studies which failed to show any significant difference between general *versus* regional anesthesia in geriatric patients undergoing hip fracture surgery. Both types of anesthesia have their advantages and disadvantages, and the decision to use one or the other depends on various factors, including the patient's overall health, the type of surgery or procedure being performed, and the surgeon's preferences.

Regional anesthesia has some potential benefits for older adults. It may reduce the risk of complications associated with general anesthesia, such as confusion, delirium, and cognitive impairment [7]. However, there are also some potential disadvantages to regional anesthesia in that a significant number of older adults are taking anticoagulants which limit the use of regional anesthesia. In addition, there is a fair amount of crossover due to failed regional anesthesia. It can be more difficult to perform in older patients, particularly those with multiple comorbidities or cognitive impairment. Additionally, some older adults may have a reduced ability to tolerate prolonged periods of immobility, which may be necessary with regional anesthesia.

General anesthesia is commonly used in older adults undergoing surgery or other procedures. While general anesthesia carries some potential risks, including cognitive impairment and postoperative delirium, it is generally safe and effective in older adults.

CHAPTER 17

Ethics and Legal Issues in Geriatric Anesthesia

Nikhil Bhana[1] and **Jennifer Ocbo**[1,*]

[1] *Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

Abstract: This chapter discusses the ethical and legal challenges faced by anesthesiologists in geriatric anesthesia due to medical, economic, and social issues. Anesthesiologists must exhibit patience, understanding, and compassion in order to overcome multiple challenges. It is also imperative that they stay up-to-date on the issues facing this particular population in order to adequately address them efficiently through collaborative communication and active involvement in patient care.

Keywords: Anesthesia, Advanced directive, Anesthesiologist, Autonomy, Consent, Competency, Decision-making capacity, Ethics, Geriatrics, Legal, Living will, Medical decisions, Medical futility, POLST, Palliative care, Power of attorney, Surrogate decision-making, Voluntary.

INTRODUCTION

Ethical concepts have become important in guiding the practice of medicine. The use of the four ethical pillars (respect for autonomy, non-maleficence, beneficence, and justice) is necessary when faced with framing medical discussions and making healthcare decisions in the best interest of the patient [1, 2]. The geriatric population is at risk for ethical dilemmas when these concepts conflict with one another. Respect for one's autonomy can be compromised if their disease process results in a loss of consciousness and inability to educate their doctor on their wishes. Also, any level of underlying dementia that causes difficulty expressing their wishes may be prevalent in the geriatric population and affect the communication that healthcare providers need to honor one's wishes. Honoring a geriatric patient's beneficence and overall well-being may be difficult in the setting of a terminal disease which complicates any intervention and fosters concerns for futility. Justice, especially in the geriatric population, is more chall-

* **Corresponding author Jennifer Ocbo:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA; E-mail: ocbo-jennifer@cooperhealth.edu

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enging in offering easier access to healthcare resources when navigating the ever-evolving and technologically advancing landscape of modernized healthcare. Surgery and other interventions may not be a good choice or result in better outcomes for this population which tends to be more frail and has developed complicated comorbidities [3].

For this chapter, we would like to focus on the main issues that seem to arise and affect the geriatric population. By virtue of the pathophysiology of aging or senescence, geriatric patients may experience the loss of specific functions that may result in decreased vision and hearing, decision-making capacity, and cognition, all of which can contribute to the vulnerability of a geriatric patient and the inability for them to voice and protect their interests regarding medical care and decision-making. They also have decreased balance, proprioception, and mobility, which predisposes them to increased risk of complications in addition to exacerbating their preexisting medical conditions which can increase their severity of injury and length of recovery. Due to these issues that are more likely to be present in the geriatric population, we as physicians are tasked to remain up to date with how to best communicate and treat this population (beneficence) and how to fairly provide the best and most applicable methodologies to treat the disease compared to the rest of the population (justice). We should try to preserve the patient's rights to informed consent (autonomy), avoid doing harm or futile interventions (non-maleficence), and understand the alternatives and avenues available when these concepts are in conflict [3].

RESPECT FOR PERSONAL AUTONOMY

Medical ethics is always changing because we evolve, religion changes, and technology continues to challenge our thinking. Respectful conversations are the path to solving problems involving medical ethics. One of the core ethical principles of being a physician is patient autonomy. Autonomy is a physician's obligation to respect patients as individuals, create conditions necessary for autonomous choice, and honor their preference in accepting or refusing medical care. Respect for autonomy is invoked through discussions with the patient supporting the principles of confidentiality, beneficence, and truth [4]. In many cases, autonomy is most strongly related to the idea that patients should be allowed to make autonomous decisions about their healthcare. These decisions are made clearly with full understanding and intention, and without coercion or substantial influence [4]. This is supported by the ethical and legal precedent as stated in The Patient's Bill of Rights (The American Hospital Association 1972) and the Patient Self-Determination Act of 1990 [3]. Autonomy requires the patients to have autonomy of thought, intention, and action regarding their healthcare decisions. Physicians are to tell patients about their healthcare options,

help them understand these options, provide recommendations, and then respect and abide by their choices. This helps to prevent paternalism and provides patients the power to choose and refuse unwanted interventions [3].

For example, autonomy permits individuals to decline surgery or other interventions that they do not perceive to be beneficial [4]. However, it is important to note that this principle may fail to protect competent patients who struggle to choose for fear of making the wrong decision, have conflicting priorities, lack confidence, and blame themselves if the outcome is poor. We as clinicians need to guide and offer discussion instead of just offering the options and expecting the patient to choose. Attention to this issue by clinicians is important in order to better promote patient autonomy. This is also especially important for those patients who speak another language and require translation services. Physicians should be aware of the patient's right to proper translation and provide that service to ensure an accurate understanding of their medical condition in order to give genuine informed consent.

Personal autonomy is highly valued, and ease of consent is preferable from the patient directly, but only if the patient has the appropriate insight to make an informed decision. This follows into the next concept of patient capacity, which is part of determining a patient's ability to provide informed consent. This is part of the medical judgment of all surgeons, physicians, and anesthesiologists when obtaining consent for procedures, surgery or anesthesia. For patients who are unconscious due to a medical condition (perhaps intubated and sedated, or severely obtunded due to critical dependence on medications to maintain hemodynamics), these situations require the physician to speak to a surrogate to provide informed consent. However, for the patient who is not unconscious but cannot necessarily give informed consent (such as one with dementia or delirium), the physician will have to evaluate the patient's decision-making capacity. The need for informed consent came about due to the presence of these situations to protect the personal autonomy of the patient and has been upheld in U.S. courts since 1914 [1].

INFORMED CONSENT

"Informed consent" is a legal term that describes an independent, uncoerced, and informed agreement given by the patient authorizing their approval to proceed with a medical procedure or treatment [5]. In practice, surgical consent was obtained by surgical residents and the risks of anesthesia were usually discussed as part of conversation about surgery [6]. However, since anesthesia has its risks and consequences, which are separate from those associated with surgery, the practice has changed to require anesthesiologists to obtain their informed consent

CHAPTER 18

Female Geriatric Patients

Andrea Villa[1], Anil Bhatnagar[2] and **Bharathi Gourkanti[1,*]**

[1] *Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

[2] *Cooper Medical School of Rowan University, Camden, NJ, USA*

Abstract: Men and women are created equal, but there are some biological differences between the two sexes that should be considered in the perioperative period to provide safe and equitable care. This chapter highlights specific anatomical differences between men and women and discusses conditions by system that are more prevalent among female geriatric patients. Plus, it briefly discusses particular sex differences in the pharmacokinetics of some drugs.

Keywords: Cardiovascular, Common female surgical procedures, Musculoskeletal, Neurological, Psychiatric, Pulmonary.

INTRODUCTION

It is important as a prelude to this chapter to first define the terms sex and gender. Gender is a social construct, while sex refers to the biological determination established at conception and according to the WHO definition, includes "norms, behaviors and roles associated with being a woman, man, girl, or boy, as well as relationships with each other" [1]. Here, we will focus on the biological definition of sex and the resultant implications for clinical practice which are determined by sex chromosomes that result in differing hormonal activities and reproductive organs and functions.

DOES A "ONE SIZE FITS ALL" MODEL WORK DESPITE THE DIFFERENCES?

While it is true that clinical protocols are important tools to help remove variation in practice and encourage patient safety, in the overall perioperative risk assessment of patients and optimization for surgery, there is no clear-cut "one size fits all" model of any individual, and much less so when it comes to differences

* **Corresponding author Bharathi Gourkanti:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA; E-mail: gourkanti-bharathi@cooperhealth.edu

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between the sexes. Many studies over the years have demonstrated that there exists both structural and functional differences between males and females and therefore, it is an important distinction to always bear in mind when partaking in the care of a patient. For example, a commonly known fact in medicine is the classical symptoms of a myocardial infarction, which are chest pain or pressure, shortness of breath, pain or discomfort in the jaw, neck, shoulder, or arm, *etc.* It is also commonly known that women are far less likely to present with these common symptoms and may not even experience the number one sign of chest pain. Some women present with indigestion, back pain, or cold sweats. Despite this common knowledge, a shocking study on mortality of female patients suffering from acute myocardial infarctions found that women treated for this by male doctors, had a higher mortality than those treated by female doctors and that the effect was attenuated if the male doctors had more exposure to female patients and colleagues [2]. This is further discussed in the cardiovascular section in this chapter.

Moreover, much of the data acquired in the past regarding diseases and drug development was based on only male subjects because female subjects showed variable results because of reproductive hormonal changes [3, 4]. It was not until recently that policies were implemented to mandate including female subjects in clinical research [3]. Luckily, nowadays, the fields of science, medicine, and global health are considering these differences and it is up to the anesthesiologist to do so as well in order to optimize the care of each individual patient.

An important distinction between the 2 sexes is the sex steroids that prevail in one *vs* the other – testosterone in males, and estrogen in females. Besides regulating the menstrual cycle, estrogen affects the entire body. For example, it helps to shield bone density, shields nerves from damage, and balances the liver's formation of cholesterol which reduces the incidence of atherosclerosis, and many other effects [5, 6]. which is why after menopause, when its levels decrease sharply, certain disease burdens increase among geriatric female patients.

This could be a contributing factor to why clinical studies have shown that despite living longer, women are more frail than men [7]. This has been shown when using both the "frailty phenotype" and the "frailty index" which are the most widely used assessment tools and are further discussed in Chapter 4. One systematic review which looked at 10 studies that investigated community-dwelling adults over the age of 65, found that the overall prevalence of frailty was 9.6% for women, and 5.2% for men [8]. Nevertheless, the factors responsible are still not well understood.

SYSTEM BASED DIFFERENCES

Cardiovascular

Like in men, cardiovascular disease (CVD) is the leading cause of death in women. Many of the risk factors are the same such as hypertension, diabetes mellitus, hyperlipidemia, smoking, obesity, *etc*., but there are some sex-specific factors which include oral contraceptive use, premenstrual syndrome, polycystic ovarian syndrome, and hysterectomy [9, 10]. Table **1** depicts the various risk factors for CVD common to both men and women and also lists those which are unique to women.

Table 1. Risk factors to both men and women *vs* those unique to women for cardiovascular disease.

Men and Women	Unique to Women
Age	
Family history	
Hypertension	Early menarche ≤10 years old
Diabetes mellitus	Being post-menopausal
Hyperlipidemia	Premenstrual syndrome
Smoking	History of pre-eclampsia
Obesity	History of gestational diabetes
Metabolic syndrome	Spontaneous pregnancy loss
Diet	Pre-term birth (spontaneous delivery <37 weeks estimated gestational age)
Sedentary lifestyle	
Excess alcohol intake	
Inflammatory/rheumatic diseases	

As people age, cardiovascular disease becomes more prominent. In men, there is a linear correlation with aging, but with women, due to estrogen having a beneficial effect on the cardiovascular system and being protective against atherosclerosis, it is not as common until menopause [11]. Once women reach menopause the incidence of stroke, for example, and the prevalence of hypertension increases significantly [11].

Coronary Heart Disease

After menopause and after the age of 65, when estrogen levels decrease, the incidence of myocardial infarction (MI) increases and 1 in 3 of these women will have cardiovascular symptoms [10]. As previously briefly mentioned, chest pain is the most common presenting factor for an MI, but women are likelier to present with other symptoms at higher rates than men – 19% *vs* 13.7% [10]. Moreover, a study showed that 42% of women *vs* 30.7% of men who present with an MI do not have chest pain symptoms [12]. In particular, the incidence of fatal coronary

CHAPTER 19

The Geriatric COVID Patient

Osama M. Sayed[1] and **Michael R. Schwartz**[1,*]

[1] *Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

Abstract: The COVID-19 pandemic resulted in a significant impact on healthcare across the world. The pandemic is caused by the coronavirus SARS-CoV-2 and is transmitted through respiratory secretions. The geriatric population comprised most morbidities and mortalities related to COVID-19. Common symptoms include fever, cough, dyspnea, myalgia, and culminating in acute hypoxic respiratory failure and acute myocardial injury. Geriatric patients with COVID-19 who require surgery are at a greater risk of postoperative complications. An assessment of the risks and benefits of surgical intervention relies on the degree of COVID-19 pathology and the type of surgery whether emergent or elective. The presence of COVID-19 does not warrant a change in the modality of anesthesia that would be performed for any given surgery in the absence of COVID-19.

Keywords: Acute hypoxic respiratory failure, Acute respiratory distress syndrome, COVID-19, Coronavirus, Pandemic, Personal protective equipment, Preoperative testing, SARS-CoV-2, Vaccination.

INTRODUCTION

The COVID-19 pandemic has had a profound effect on global healthcare, with geriatric populations experiencing the most significant risks. This chapter explores the challenges of providing surgical care to elderly patients affected by COVID-19 and the pivotal role of anesthesiologists in ensuring safe and effective care. The diversity of underlying comorbidities, degree of symptoms, and the need for elective or emergent surgical intervention are factors that must be considered in the perioperative planning of geriatric patients with COVID-19 undergoing surgery. This chapter will address the importance of ongoing adaptability during a pandemic in caring for the elderly as a vulnerable population.

[*] **Corresponding author Michael R. Schwartz:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA; E-mail: schwartz-michael@cooperhealth.edu

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COVID BACKGROUND HISTORY AND EPIDEMIOLOGY

The COVID-19 pandemic presented a global threat to modern healthcare. The Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV-2) is one of many viruses classified in the family of Coronaviridae. Coronaviruses are single-stranded encapsulated and enveloped RNA viruses [1]. Coronaviruses are rapidly evolving viruses and have been responsible for many diseases that range from variants of the common cold to outbreaks such as SARS (severe acute respiratory syndrome) and MERS (Middle East Respiratory Syndrome).

The COVID-19 Pandemic is the first pandemic in human history to be the result of a coronavirus [2]. Coronaviruses are a rapidly evolving family of viruses that contributed to the evolution of multiple strains of SARS-CoV-2 during the pandemic. The viral strains varied in terms of the rate of transmission and the type and severity of symptoms produced. What makes the SARS-CoV-2 virus unique among coronaviruses is the combination of high morbidity and the high rate of transmission common amongst coronaviruses. The high rate of viral shedding during the pre-symptomatic phase of infection allowed a greater rate of transmission compared to past coronavirus outbreaks such as SARS and MERS [3].

Infection occurs through the contact of respiratory secretions and droplets from infected individuals and transmission through mucosal membranes. The virus enters the host cells through the Angiotensin-Converting Enzyme Receptor-2 (ACE-2). The incubation period of the virus and its ability to transmit between hosts during the pre-symptomatic phase was a major contributing factor for its rapid rate of spread. A diagram of the coronavirus structure can be seen in Fig. (**1**).

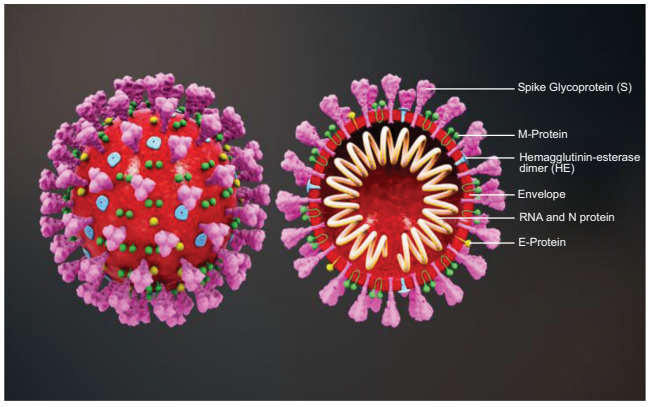

Fig. (1). Coronavirus structure, replicated from Scientific Animations under Creative Commons License.

The disease was first noted in December 2019 when 27 patients in Wuhan China were hospitalized with similar symptoms suggestive of viral pneumonia. Early reports suggested a zoonotic source of infection originating from close human contact to animals present in wet markets in Wuhan, however, various other theories have arisen without a clear consensus over its origins.

Due to the high infectivity rate of SARS-CoV-2, the virus was able to cause infection during pre-symptomatic and early symptomatic stages and its spread was facilitated by mass transit. COVID-19 quickly spread across borders and by February 2020, The World Health Organization had determined an estimated one hundred million cases worldwide [4].

COVID STATISTICS IN THE GERIATRIC POPULATION

According to public data published by the Center for Disease Control (CDC), there is a direct correlation between advanced age and COVID-19 mortality. Patients over the age of 65 comprised approximately two-thirds of COVID-1--related deaths between March 2020-November 2022 as reported by the CDC (Fig. **2**). The mortality rate consistently increased with increasing age, putting elderly people at the greatest risk of COVID-19 related mortality. Initial data out of China showed that the population under 50 years old had death rates under 0.4%, however the death rate increased up to almost 15% in those greater than 80 years old (Fig. **3**).

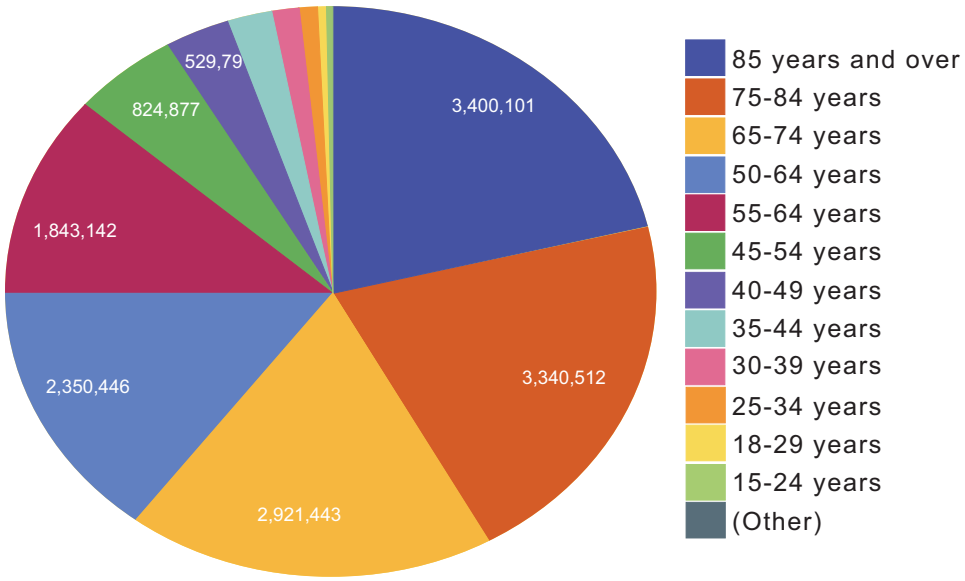

Fig. (2). COVID infections by age groups, created using public data published by CDC for the period of March 2020 – November 2022.

CHAPTER 20

Common Surgical Procedures in Geriatric Patients

Christopher Potestio[1,*] and **Mary Katherine Carney**[1]

[1] *Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA*

Abstract: Demographic studies show that life expectancy for people in the USA has been trending upwards for the past several decades. As the population ages, the number of geriatric patients who will require surgery has also increased. Information from the National Hospital Discharge Survey reported that in 2006, 35.3% of all inpatient procedures and 32.2% of all outpatient procedures were in patients aged 65 and older. Common elective surgeries in elderly patients include cataract and lens procedures, spinal fusions and laminectomies, and total or partial hip and knee replacements. Common urgent surgeries in this population include thoracic and abdominal cancer resections, breast and prostate cancer resections, and cholecystectomies. Finally, common emergency surgeries in the elderly population include hip fracture repairs and other geriatric traumas.

Keywords: Abdominal surgery, Breast cancer, Cancer surgery, Cataract, Cholecystectomy, Colorectal cancer, Elective surgery, Emergency surgery, Geriatric surgery epidemiology, Geriatric trauma.

INTRODUCTION

As the population ages and the proportion of elderly patients increases, the number of geriatric patients who require surgery has also increased. In this chapter, we will discuss the common procedures in geriatric anesthesia patients, the epidemiology of those procedures, important preoperative considerations, and important aspects of the management of these cases. This chapter will split common geriatric anesthesia procedures into three categories, elective, urgent, and emergency surgery cases. Elective surgeries include cataract surgery, spinal surgeries, such as fusions and laminectomies, and hip and knee arthroplasty. Urgent procedures will be split into high-risk cancer resections, low-risk cancer resections, and others. High risk, urgent surgeries include thoracic and abdominal cancer removal procedures. Low-risk, urgent surgery includes breast and prostate

* **Corresponding author Christopher Potestio:** Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Health Care, Camden, NJ, USA; E-mail: potestio-christopher@cooperhealth.edu

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cancer removal procedures and cholecystectomy. Finally, the section on emergency geriatric procedures section will include information on hip fracture repair procedures and other geriatric traumas.

EPIDEMIOLOGY

Demographic studies show that life expectancy for people in the USA has been trending upward for the past several decades [1]. This has resulted in a significant increase in the elderly population, with projections that the number of people in the USA aged 65 years and older will reach 98 million by the year 2060 [2]. As the population ages, the number of geriatric patients who will require surgery has also increased [3]. A recent study shows that one out of seven Medicare patients underwent at least one major surgery over a five-year period [3]. Two out of five of those major surgeries were unplanned procedures.

Information from the National Hospital Discharge Survey reported that in 2006, 35.3% of all inpatient procedures and 32.2% of all outpatient procedures were in patients over the age of 65 [4]. A study of the National Anesthesia Clinical Outcomes Registry revealed statistics for types of procedures performed for different age groups, with geriatric group split into 65-69, 70-79, 80-89, and 90+ years old groups. In age groups 65-89 years old, more than 95% of cases were elective, but in the 90+ age group, 7.3% of cases were classified as emergency surgery [4]. For those aged 65-69, 70-79, and 80-89, the most common surgeries were lens and cataract procedures [4]. For those aged 90 and above, the most common procedure was the treatment of fracture or dislocation of the hip and femur [4]. Other common surgeries for all age groups were hip and knee arthroplasties, cholecystectomies, and spinal fusions.

COMMON ELECTIVE SURGERIES

Cataract and Lens Procedures

Epidemiology

Cataract surgery is the most common procedure in patients aged 65-89 years old and the second most common procedure in the 90+ age group [4]. The majority of blind adults are geriatric, with cataracts among the most common causes of blindness [5]. Up to 63% of patients undergoing cataract surgery have significant underlying disease, most commonly hypertension, gastro-esophageal reflux disease, prior myocardial infarction or angina, diabetes, and asthma [6]. Even with many patients having significant comorbidities, cataract surgery is still very safe, with a mortality rate of just 0.014% [7].

Preoperative Considerations

Preoperative history and physical exam are essential to assuring the safety of patients undergoing cataract surgery, but preoperative testing does not affect outcomes and does not increase safety [7]. Geriatric patients are frequently on anticoagulants or antiplatelet therapy, with many being at high risk for thrombotic events, such as those with atrial fibrillation, prosthetic heart valves, carotid stenosis, or drug-eluting stents. Generally, cataract procedures have minimal bleeding, so it is acceptable for patients to remain on anticoagulants. If anticoagulants are continued, there is a potential risk of surgical bleeding, hematoma formation, or retrobulbar hemorrhage, but continuation of these drugs has not been shown to significantly increase the risk [6]. There is insufficient data on the safety of continuation of newer anticoagulant drugs, such as dabigatran, rivaroxaban, and apixaban [7].

The most common method for cataract removal surgery is phacoemulsification (PKE), a technique in which the lens is fragmented using an ultrasound probe and pieces are removed using an aspiration-irrigation system. An artificial lens is then inserted, after which sutures are not generally required as the incision is small enough to heal on its own [6]. The ultrasound probe immobilizes the eye, so akinesia is rarely required with this method, and some patients require no anesthesia at all [6]. Alternatively, extracapsular cataract extraction (ECE) can be performed when patients are not candidates for PKE. In this procedure, the cataract is removed but the posterior capsule remains intact [7]. This method requires a larger surgical incision, hypotonia of the eye, as well as akinesia [6].

Anesthesia for Cataract Surgery

Topical Anesthesia: Topical anesthesia (TA) is the most common anesthetic method used in cataract surgeries [7]. The PKE method of cataract removal does not require akinesia, so the procedure can be performed under TA. Anesthesia providers generally use lidocaine or tetracaine eye drops, though the use of levobupivacaine or ropivacaine for longer acting TA is being studied [6]. TA is also frequently combined with intracameral anesthesia, an injection of local anesthetic into the anterior chamber, to reduce patient discomfort. Topical anesthesia avoids the risk of retrobulbar hemorrhage and is the anesthetic of choice for patients on anticoagulation [6]. TA has been shown to have fewer associated adverse events than needle blocks [7]. There are many reasons why TA is a popular choice for cataract surgery, but it is not without its drawbacks. Studies have shown that topical anesthesia may not provide complete analgesia, with one study showing patients preferred retrobulbar anesthesia to TA [6].

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