JOURNAL OF GERIATRIC ONCOLOGY 6 (2015) 178–184

Available online at www.sciencedirect.com

ScienceDirect

Physiology of Aging

The changes in cardiac physiology with aging and the implications for the treating oncologist

Dipti Gupta[a,b,*], *Shivani Verma*[a], *Shawn C. Pun*[a], *Richard M. Steingart*[a,b]

[a]*Memorial Sloan Kettering Cancer Center, New York, NY, USA*
[b]*Weill Cornell Medical College, New York, NY, USA*

ARTICLE INFO

Article history:
Received 20 November 2014
Received in revised form 16 January 2015
Accepted 19 February 2015
Available online 7 March 2015

Keywords:
Aging
Cardiovascular aging
Geriatrics
Elderly
Oncology
Cancer

ABSTRACT

The link between cancer, cardiovascular disease, and aging is well documented. In this review, we highlight the physiologic and pathologic changes associated with the cardiovascular aging process, the role they play when interfaced with various cancer therapies and the implications for the treating oncologist.

Contents

* *Corresponding author at:* Memorial Sloan Kettering Cancer Center, 1275 York Ave, New York, NY 10065, USA. Tel.: +1 212 639 5037; fax: +1 646 422 2332.
E-mail address: guptad@mskcc.org (D. Gupta).

http://dx.doi.org/10.1016/j.jgo.2015.02.004
1879-4068/

1. Introduction

The elderly have an 11-fold higher incidence of cancer and around 70% of cancer-related deaths occur in this vulnerable cohort [1,2]. A leading cause of death in the elderly is cardiovascular disease [3]. The proportion of elderly in the United States is rapidly increasing and is expected to exceed 20% by 2030, highlighting the growing burden of disease [1,2]. The management of cardiac-oncologic complications poses a clinical challenge due to the lack of clinical trial data and hence evidence-based guidelines.

1.1. *The Concept of Aging*

Aging is a physiologically complex and continuous process, which is largely irreversible. Age-related physiologic changes, the superimposed lifelong injury and reparative processes and the increased prevalence of cardiovascular and noncardiovascular comorbidities should be all viewed as a continuum in the aging process. Age-related changes in the cardiovascular system include decreased cardiac reserve, increased vascular stiffness and abnormal left ventricular diastolic function [4–6]. Age-associated changes in the cardiovascular system result in reduced aerobic exercise capacity and diminished ability to tolerate the physiological stressors associated with surgical intervention or critical illness. There is also a gradual decline in the function of other organ systems, resulting in changes in the metabolism of medications, reduced muscle mass and increased susceptibility to infections. Additionally, there is age-related increase in prevalence of cardiovascular conditions including hypertension, left ventricular hypertrophy, left atrial enlargement, abnormal left ventricular ejection fraction (LVEF), atrial fibrillation (AF), heart failure with preserved ejection fraction, coronary artery disease, ischemic and thromboembolic stroke, peripheral and carotid arterial disease, aortic stenosis and regurgitation, mitral regurgitation, mitral annular calcification, hypertrophic cardiomyopathy, and pacemaker rhythm [7–9] (Table 1).

2. Structural Changes and Functional Mechanisms Associated with Cardiovascular Aging

2.1. *Ventricular Structural and Functional Changes*

Anatomical changes to the heart begin at a cellular level. With aging, there is a reduction in cardiac myocytes caused by increased myocyte apoptosis and necrosis. To compensate, the remaining myocytes increase in size [10–13]. Increased collagen, cross-linking of collagen and decreased elastin also contribute to the increase in myocardial thickness.

Left ventricular (LV) wall thickness increases despite the reduced myocyte concentration because of increased collagen matrix deposition and cross-linking as well as secondary interstitial fibrosis. In normal aging, there is no change in overall cardiac mass, LV cavity size nor LVEF. However, decreased LV compliance leads to significant changes in diastolic function with a 50% reduction in the early diastolic

Table 1 – Age-associated changes mechanisms and clinical consequences associated with normal aging.

Age-associated changes	Possible mechanisms	Clinical consequences
LV remodeling and increased LV thickness	Increased myocyte size	Impaired diastolic filling
	Reduced myocyte number	Diastolic dysfunction
	Increased collagen	Increased LV filling pressures
	Increased fibrosis	
Changes in conduction	Reduced number pacemaker cells	Increased AV block
	Increased SA node fat and collagen	Increased atrial arrhythmias
	Increased calcification of AVN, LBB, RBB	
Increased arterial stiffness and wall thickness	Increased collagen	Accelerated atherosclerosis
	Reduced elastin	Hypertension
	Endothelial dysfunction	LV hypertrophy
Reduced CV reserve, oxygen consumption and max heart rate	Decreased β-adrenergic response	Decreased exercise capacity
	Decreased myocardial contractility	Decreased threshold for heart failure

Abbreviations: AV, atrioventricular; AVN, atrioventricular node; CV, cardiovascular SA, sinoatrial; LBB, left bundle branch; RBB, right bundle branch.