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Cardiac surgery as a stressor and the response of the vulnerable older adult

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ABSTRACT

In an aging population, recovery and restoration of function are critical to maintaining independence. Over the past 50 years, there have been dramatic improvements made in cardiac surgery processes and outcomes that allow for procedures to be performed on an increasingly older population with the goal of improving function. Although improved function is possible, major surgical procedures are associated with substantial stress, which can severely impact outcomes. Past literature has identified that frail patients, who are vulnerable to the stress of surgery, are more likely to have postoperative major adverse cardiac and cerebrovascular events (OR 4.9, 95% confidence interval 1.6, 14.6). The objective of this manuscript is to examine preoperative frailty in biological, psychological, and social domains using cardiac surgery to induce stress. We systematically searched PubMed for keywords including "cardiac surgery, frailty, and aged" in addition to the biological, psychological, and social keywords. In the biological domain, we examine the association of physiological and physical vulnerabilities, as well as, the impact of comorbidities and inflammation on negative surgical outcomes. In the psychological domain, the impact of cognitive impairment, depression, and anxiety as vulnerabilities were examined. In the social domain, social structure, coping, disparities, and addiction as vulnerabilities are described. Importantly, there is substantial overlap in the domains of vulnerability. While frailty research has largely focused on discrete physical vulnerability criteria, a broader definition of frailty demonstrates that vulnerabilities in biological, psychological, and social domains can limit recovery after the stress of cardiac surgery. Identification of vulnerability in these domains can allow better understanding of the risks of cardiac surgery and tailoring of interventions to improve outcomes.

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Clinical Vignette:

Mr. P is 86 year old man develops typical crushing chest pain with exertion that does not respond to medical therapy. On non-invasive testing he is found to have ischemia with mild activity and a large reversible defect. Catheterization demonstrates three-vessel coronary disease and he is scheduled for cardiac surgery.

1. Introduction

Frailty has been defined as a vulnerability to stressors (Fried et al., 2005; Quinlan et al., 2011). Preoperative frailty predisposes a patient to negative consequences after the stress of surgery. Recent work has identified that frailty is a major risk factor for negative outcomes after cardiac surgery (Afilalo et al., 2012; Beggs et al., 2015; Green et al., 2012; Sepehri et al., 2014; Sundermann et al., 2011), with a systematic review demonstrating a five-fold increase in postoperative major adverse cardiac and cerebrovascular events (OR 4.9, 95% confidence interval 1.6, 14.6) (Sepehri et al., 2014). While the literature has largely focused on the biological aspects of frailty as a risk factor (Walston et al., 2006; Fedarko, 2011), psychological and social frailty can also result in negative postoperative outcomes. This is particularly important in the context of cardiac surgery being offered in an increasingly older and frailer population (Mozaffarian et al., 2015; Seco et al., 2014; Altarabsheh et al., 2015; Singh et al., 2015).

Frailty has also been defined as a geriatric syndrome (Inouye et al., 2007), a broader concept where accumulated deficits (Rockwood and Mitnitski, 2011) on many pathophysiologic pathways can lead to a similar constellation of symptoms (or phenotype). For example, when an older adult suffers femoral fracture following a fall, the phenotype and risk of negative outcomes are clear. However, the cause of the phenotype is multifactorial with the physical environment, sensation, cognition, the emotional state, and social factors all contributing to the fall and fracture. Importantly, focusing on a pre-emptive treatment of a single cause is unlikely to modify the risk (e.g. removing throw rugs

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does not compensate for reduced muscle strength, poor eyesight, or post-prandial hypotension) (Moore et al., 2010). Additionally, the literature supporting biological underpinnings is limited with respect to the phenotypic expression of frailty.

Successful surgical correction of cardiac disease has the potential to restore biologic function and provide substantial benefit for older, symptomatic patients (Mariotto et al., 1999; Bouma et al., 2004). However, while many older adult patients survive surgery and return to preoperative functional levels, the perioperative risk of mortality and morbidity from cardiac surgery is higher than in younger patients undergoing similar procedures (Afilalo et al., 2012; Beggs et al., 2015; Green et al., 2012; Sepehri et al., 2014; Sundermann et al., 2011). While the techniques and processes of cardiac surgery have progressed to allow older adult patients to be considered as surgical candidates, the surgery remains a physiological, psychological, and social stressor (Miller et al., 2012; Schoenenberger et al., 2013; Webb et al., 2010).

Any surgery, including cardiac surgery, is a stressor to the patient. This manuscript examines frailty by using cardiac surgery as a "stressor" event in the older adult population. A vulnerable patient, who is more susceptible to the complexity of surgical process, will be at-risk for complications of the surgery and will be less likely to return to function postoperatively (Fig. 1). The process of cardiac surgery is typically very structured: a) there is a baseline assessment; b) the surgical procedure (i.e. stressor) most commonly occurs a predetermined time and place; c) there is measurable systemic response; and d) there is anticipated survival and recovery course. (Box 1 describes stressors associated with cardiac surgery). By expanding the scope of vulnerability within the construct of the biopsychosocial model after cardiac surgery, we acknowledge that the surgical process includes factors that are outside of the control of the peri-operative team and may influence outcomes.

1.1. The biopsychosocial model and frailty

This biopsychosocial model has been applied in multiple conditions to understand the impact of illness (Engel, 1977), particularly complex diseases. The syndrome of frailty has been applied to the Biopsychosocial Model using the stressor of cardiac surgery in this review. In the biological, psychological, and social domains, the literature supports frailty as a vulnerability to the stress of cardiac surgery. In the following sections, the association of frailty in each of the biopsychosocial domains with negative health outcomes after cardiac surgery will be reviewed. Importantly, there is a substantial overlap among the domains. (See Fig. 2.) For example, cognitive frailty has biological, psychological, and social underpinnings that contribute to negative outcomes after surgery. Describing the overlap of domains is not possible within the scope of this manuscript.

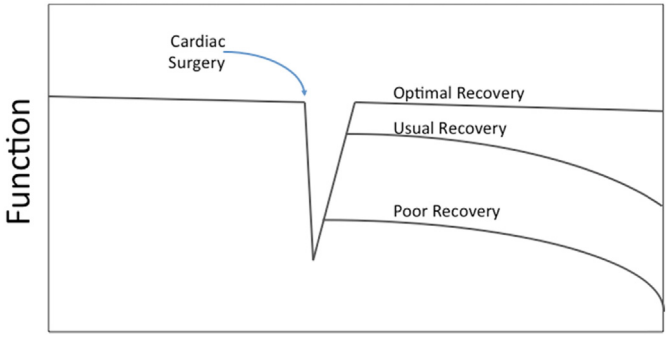

Fig. 1. Response to stressors. When a frail patient is subjected to a stressor, such as cardiac surgery, there is a reduced ability to return to the prior level of functioning and frequently negative outcomes. They tend to attend a new "baseline". As these stressors become more severe or more often, the baseline status continues to trend down. Patients with pre-existing vulnerabilities may undergo cardiac surgery at lower functional levels (i.e. cardiac surgery stress is shifted right).

Box 1
Stressors of Cardiac Surgery

Biological	Psychological	Social
Inflammation	Cognition	Physical limitations
Anesthesia	Depression	Care demands on family
Fluid Shifts	Anxiety	Financial resources
Cardiopulmonary Bypass	Delirium	Access to necessities
Pain	Self-perception	Community isolation
Immobilization		Threats to independence
Sleep Deprivation		

1.2. Age, vulnerability, and frailty

One of the critical areas of overlap — age deserves mention. Age is inextricably linked to frailty, but not causally related (Inouye et al., 2007; Rockwood, 2005). In the case presented, the patient's age is a risk factor for perioperative morbidity and mortality. However, the acuity of the patient's cardiac illness (Alexander et al., 2000), physiology as well as the underlying comorbid disease (Srinivasan et al., 2004) and functional (Alexander et al., 2000) status, should be considered in the decision for cardiac surgery. Chronological age alone cannot be the sole factor in determining operative vulnerability.

2. Biological frailty

2.1. Case continued

Mr P. has many chronic medical conditions including hypertension, hyperlipidemia, benign prostatic hypertrophy, osteoarthritis of the knees and hands, gastroesophageal reflux, and constipation. He takes 8 different medications and a multivitamin every day. He is able to walk about 100 m before the chest pain causes him to stop. Mr P. develops chest pain during the climbing of one flight of stairs to his bedroom. He frequently complains of fatigue and takes an afternoon nap daily. He has had an unintentional 4-kilogram weight loss in the 12 months.

When considering the biological domain, there is a significant body of evidence that the contribution of physiological function (Nashef et al., 2012; Anderson, 1994), comorbidity (Anderson, 1994; Head

Fig. 2. Biopsychosocial model for frailty. As a vulnerability to stress, frailty can occur in the biological, psychological, or social domains. Importantly, there is overlap among the domains, resulting in vulnerability outside of the narrowly defined physical frailty criteria.

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