REVIEW

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Assessment of Cardiovascular Risk for Noncardiac and Nonsurgical Activities

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ABSTRACT

Cardiovascular risk stratification is a frequent evaluation performed by health professionals. Not uncommonly, requests for risk stratification involve activities or procedures that fall outside of the scope of current evidence-based guidelines. Estimating risk and providing guidance for these requests can be challenging due to limited available evidence. This review focuses on some of these unique requests, each of which are real examples encountered in our practice. We offer guidance by synthesizing the available medical literature and formulating recommendations on topics such as the initiation of testosterone and erectile dysfunction therapy, SCUBA and skydiving, polygraphy, and electroconvulsive therapy.
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INTRODUCTION

Risk stratification is a broad topic for which cardiology evaluation is frequently sought. The often-requested "cardiac clearance" generally refers to estimating a patient's risk of a cardiovascular event during noncardiac procedures or activities and offering recommendations about how to potentially reduce that risk. Evidence-based guidelines from the American College of Cardiology and the American Heart Association about perioperative cardiovascular evaluation and management prior to noncardiac surgery are well established, outlining recommendations about risk quantification, further diagnostic testing, and medical optimization.[1] Less defined is the role of assessing cardiovascular risk prior to a variety of other activities or nonsurgical procedures, including the initiation of erectile dysfunction medications, polygraphy, electroconvulsive therapy, and more. All of the examples below are requests that have been sent to our clinic for assessment and management of cardiovascular risk. This review focuses on some of these uncommon risk stratification requests, synthesizing the available literature to inform responses to similar inquiries in the future.

ELECTROCONVULSIVE THERAPY

Background

Electroconvulsive therapy (ECT) is a longstanding, once maligned, but effective treatment for refractory psychiatric illness.[2] Developed in the 1930s, it is used to treat an array of psychiatric illnesses, and was originally influenced by studies demonstrating a potential association between schizophrenia and epilepsy. Despite early evidence demonstrating a low risk profile and benefit in schizophrenia, refractory depression and suicide, ECT became an increasingly maligned procedure due to the negative public perception and stigmatization that developed during the middle twentieth century. In recent decades, ECT has experienced a resurgence due to data repeatedly substantiating its

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efficacy, as well as review articles highlighting its underutilization as a result of its negative public perception.[3-5]

Physiology

ECT involves the delivery of direct current electrical stimulus via electrodes placed on the patient's head. The aim is to exceed the seizure threshold and induce a controlled seizure. Most ECT sessions require 50-100 joules, roughly half of the typical 120-200 transthoracic joules utilized in biphasic defibrillation. As this mechanism may suggest, the predominant cardiac event associated with ECT is arrhythmia, although this is relatively uncommon at 5 events per 1000 sessions, according to a large systematic review.[6] Another analysis based on pre/post Holter monitoring found an increased likelihood of supraventricular tachycardia and bigeminy; however, ventricular tachycardia following the procedure was rare.[6]

CLINICAL SIGNIFICANCE

- Clinicians are sometimes asked to assess cardiovascular risk for nonoperative procedures or activities that fall outside of the scope of current evidence-based guidelines.
- Cardiovascular testing is rarely beneficial for many of these situations.
- Informed, patient-centered conversations about cardiovascular risk are preferred and should be based on the best available medical literature.

Recommendations

Despite its mechanism and associated risks, ECT is generally a well-tolerated procedure. Major cardiac events seem to occur in roughly 1 in 50 patients, and death in 1 in 200-500 patients. A recent meta-analysis on over 100,000 ECT patients found an overall modest risk association with decompensated heart failure, life-threatening arrhythmia, and myocardial infarction.[7] Due to ECT's arrhythmogenic potential, it is reasonable for a cardiologist to assess a patient's antiarrhythmic medications and anticoagulation prior to the procedure. Routine performance of stress testing is neither recommended nor sufficient as a screening process. It is reasonable to avoid ECT in those with recent unstable arrhythmias; however, it should not be avoided in patients with a history of stable cardiovascular disease.[8] Implantable cardioverter defibrillators should be managed in a similar fashion to noncardiac surgery by suspending therapies either using the manufacturer's programmer or by placing a magnet over the device. Telemetry should be utilized during the procedure with an external defibrillator available at bedside, and proper device function should be confirmed following the procedure via device interrogation. Delay of ECT may also be reasonable following a recent myocardial infarction (MI) or heart failure exacerbation, however, the risk–benefit profile must be examined carefully, as post-MI depression has been independently associated with both death and poor clinical outcomes following MI.[9]

POLYGRAPHY

Background

A polygraph test, commonly referred to as a "lie detector test," has been utilized for the detection of deception since the early 1900s, despite historical evidence containing poor results regarding accuracy.[10] Polygraphs are most frequently used by law enforcement, and sometimes in the pre-employment screening process for high-security occupations.

Physiology

Polygraph testing consists of noninvasive physiological measurements of cardiovascular, respiratory, and electrodermal activity in response to interrogation.[11] Cardiovascular activity, consisting of heart rate and blood pressure, is measured via sphygmomanometer cuff, while respiratory activity is assessed via pneumography and electrodermal activity via galvanometry. Collectively, these measurements are analyzed to detect changes in autonomic arousal, which has been theorized to be associated with dishonesty. Despite being susceptible to significant confounding from other psychological and physiological variables that may further affect the body's autonomic response, polygraph has been utilized for decades.[12]

Recommendations

Because the test seeks to measure autonomic arousal from the stress of being dishonest, a subject could theoretically experience a cardiovascular (CV) event during a polygraph; however, there is no CV risk associated with the measurement of bodily functions. Given the negligible risk and noninvasive methods of measurement with polygraph testing, it would be inappropriate to perform cardiac testing prior to polygraphy.

ERECTILE DYSFUNCTION PHARMACOTHERAPY

Background

Erectile dysfunction (ED) has several potential pathophysiologic mechanisms including endocrine and nonendocrine. Increasingly prevalent in men as they age, 52%-65% experience ED by their seventh decade of life.[13] During intercourse, myocardial oxygen demand increases as heart rate and blood pressure increase. Young, healthy individuals may reach energy expenditures of 6 metabolic equivalents (METs), which lessens with age to roughly 4 METs.[14,15] As ED is commonly associated with metabolic syndromes and cardiovascular disease, questions often emerge regarding cardiac risk assessment in men with ED.[13] We specifically

focus on the utility of cardiac risk stratification prior to the initiation of phosphodiesterase-5 (PDE-5) inhibitors, the most common pharmacologic therapy for ED.

Physiology

PDE-5 inhibitors act by enhancing nitric oxide-mediated smooth muscle relaxation both in the corpus cavernosum and systemic vasculature.[15] With PDE-5 inhibition, there is an increase in intracellular concentrations of cyclic guanosine 3′, 5′ monophosphate causing amplification of the endogenous nitric oxide−cyclic guanosine 3′, 5′ monophosphate pathway,[13] leading to an increase in blood flow and engorgement of the corpus cavernosum. There is often an associated decrease in systemic arterial pressure, typically mild, but can be accentuated by the concomitant use of organic nitrates through their synergistic effects.[16]

Recommendations

Literature has shown that in clinical trials of men with chronic ischemic heart disease, coronary artery disease, and hypertension in men with ED, there was no increase in serious CV events with prescription of PDE-5 inhibitors, including myocardial infarction or death, as compared with placebo.[17,18] Any risk appears to be related to the sexual activity rather than the medication itself. Any testing performed for cardiac risk assessment should therefore be based on the patient's choice to engage in sexual activity, not the prescription of a PDE-5 inhibitor. Routine performance of stress testing is neither recommended nor sufficient as a screening process. PDE-5 inhibitors, specifically sildenafil, have been well studied as chronic therapy in patients with heart failure and pulmonary hypertension. The safety of PDE-5 inhibitors has not been well studied in patients with recent MI, stroke, or life-threatening arrhythmia, although sexual activity is reasonable ≥1 week after uncomplicated MI if the patient has no cardiac symptoms during mild/moderate physical activity.[19] Shared decision-making should primarily focus on risks associated with sexual activity and review of their pre-existing medications; ED medications should not be withheld unless the physician was already counseling the patient against performing activity involving 4-6 METs.

TESTOSTERONE REPLACEMENT THERAPY

Background

The use of testosterone replacement therapy (TRT) for hypogonadism in young male patients is well established and has not been associated with an increase of adverse cardiovascular events.[20] In the last decade, a growing percentage of the population receiving TRT has shifted to middle-aged and older men targeting low libido and lack of stamina related to aging and chronic medical comorbidities. Some studies of this population have shown an associated increase in CV risk with TRT, which resulted in the US Food and Drug Administration adding a boxed warning. Currently ongoing is the TRAVERSE trial, a randomized controlled trial with 5246 hypogonadal men between the ages of 45 and 80 years, evaluating the effect of TRT on the incidence of major adverse CV events.

Physiology

It is well established that testosterone has direct cardiovascular effects, and studies have shown a relationship between low endogenous testosterone levels and premature cardiovascular disease in men.[21] Low testosterone levels also have been associated with metabolic syndromes, including type 2 diabetes mellitus, dyslipidemia, and non-alcoholic fatty liver disease (known cardiovascular risk factors). Interestingly, in hypogonadal men with type 2 diabetes, testosterone replacement correlated with reduction in low-density lipoprotein and total cholesterol;[22] however, there have also been prior trials in men receiving TRT that show a significant increase in coronary plaque burden.[22] It is unclear if this directly correlated to an increased risk for adverse CV events.

Recommendations

TRT use has increased over the past decade across a broad range of patient ages. It is challenging to provide a focused recommendation for assessing CV risk in this population due to the range of individual characteristics that should be considered. Routine performance of stress testing is neither recommended nor sufficient as a screening process. Recent guideline updates from the society of clinical endocrinology and metabolism in 2018 also recommend against starting testosterone therapy in hypogonadal men with uncontrolled heart failure or a recent myocardial infarction or stroke in the last 6 months.[23] The patient should undergo thorough examination with review of their comorbidities and history, then risk assessment should be performed based on the current available literature.

SCUBA DIVING

Background

Self-contained underwater breathing apparatus (SCUBA) diving and free diving are increasingly popular activities that may seem safe and effortless, but for certain patient populations can pose considerable danger requiring thorough risk assessment. Approximately one-third of all diving fatalities (roughly 16 of 100,000 divers/year) are associated with an acute cardiac event, and the mortality risk increases with age.[24] One study found that 26% of disabling injuries were associated with cardiac events, the majority occurring in those with history of cardiovascular disease and age >40 years.[25] Multiple societies exist with varying recommendations about which divers should undergo cardiovascular screening and the methods in which it should be performed. Many of these societies utilize the Recreational Scuba Training Council Medical Statement, which is a questionnaire screening the patient's past medical history,

as well as for signs and symptoms of disease. Positive screenings prompt patients to seek medical evaluation by a cardiologist prior to diving.[26]

Physiology

Diving exposes the body to multiple distinct stressors, including immersion, cold temperatures, hyperbaric gases, elevated breathing pressures, physical exertion, and emotional changes, with limited ability to withdraw from the activity. Physiologic changes occur, including increased preload and cardiac output due to immersion-induced increased central venous return, increased afterload due to peripheral vasoconstriction secondary to cold temperatures and increased partial pressure of oxygen, and bradyarrhythmias due to cold temperatures and breath holding. Diving-related complications extend well beyond the cardiovascular system, further including pulmonary, hematologic, musculoskeletal, and neurologic, among others. For instance, patients with asthma are at an increased risk during the ascent, as ambient pressures decrease and the volume of air in the lung increases due to Boyle's Law. If this expanding volume is not exhaled, it can cause air trapping, pulmonary barotrauma, and possible alveolar rupture, placing divers at risk of all, which can lead to pneumothorax, pneumomediastinum, arterial gas embolism, and death.

Recommendations

As with any other physical activity, shared decision-making with a patient-centered approach should be utilized between divers and experienced providers. A practical reminder for patients is that if diving is done in a remote area far from land, response time for emergency services will be prolonged and may turn a survivable event into a fatal one. Some societies recommend stress testing for divers older than age 45 years or with cardiac symptoms, and asymptomatic patients with significant cardiovascular risk factors.[26] Most societies agree that sustaining 6 METs for 20-30 minutes or a peak exercise capacity of more than 12 METs constitutes an adequate exertional tolerance to proceed with diving. Routine performance of stress testing is neither recommended nor sufficient as a screening process. Overall, there are few studies to provide firm evidence on how screening and fitness to dive should be determined. Medical problems that are strong contraindications include unstable coronary artery disease or arrhythmias, moderate to severe valvular disease, complex congenital cardiac disease, dilated or obstructive cardiomyopathy, pulmonary hypertension, acute deep vein thrombosis or pulmonary embolus on anticoagulation, and recurrent syncope. Patients with a patent foramen ovale are disqualified from commercial diving due to a fourfold increase in risk of decompression sickness; however, routine screening for patent foramen ovale is not currently recommended by professional societies. Heart failure patients should be monitored closely as diving can cause increased central vasculature blood flow and lead to decompensation, and exercise tolerance may not be adequate to meet the needs of diving. Patients with defibrillators should be evaluated as to why the device was placed and be sure that it can perform at a depth of at least 40 meters and during rapid pressure changes.

SKYDIVING

Background

Skydiving comes with substantial risks that extend well beyond the cardiovascular system. With evolving skydiving techniques, fatality rates have been reduced to 0.28 deaths per 100,000 jumps in 2021, compared with 1.19 deaths per 100,000 jumps in 2000. Not insignificant is the risk of cardiovascular events associated with this activity.[27] Notably, there were 3 reported mid-skydive cardiac arrests occurring in 2018, with 36 other cardiac-related fatalities among skydivers in the last 20 years.[27,28]

Physiology

Typical recreational skydivers jump from approximately 10,000-14,000 feet, where partial pressure of oxygen is around 12.3%.[29,30] This can result in momentary hypobaric hypoxia with reflexive tachycardia, increased cardiac output, and hypertension. Freefall time generally lasts 45-60 seconds, obtaining terminal velocity at about 200 feet per second, or 120 miles per hour.[31] This provokes a catecholaminergic surge with subsequent increase in heart rate, cardiac output, respiratory rate, and blood pressure. Upon parachute deployment, thoracic organs experience a deacceleration force approximately 4 times the force of gravity, further amplified the closer the parachute opens to the ground. For those with underlying cardiac disease or the unconditioned heart, these physiologic stressors during skydiving may increase oxygen supply−demand mismatch, inducing myocardial ischemia. The deceleration force may also provoke aortic dissection or dislodgement of implantable cardiac device leads from the myocardium.[31]

Recommendations

Medical screening is reasonable prior to stepping off a plane into an atmospheric free fall. Assessment of cardiac risk prior to skydiving is, at best, an extrapolation from more traditional cardiac risk stratification, given the scarcity of available literature. Routine performance of stress testing is neither recommended nor sufficient as a screening process. Shared decision-making is essential in patients with preexisting cardiovascular disease such as arrhythmias, cardiomyopathies, aortic root disease, cardiac surgery, implantable cardiac devices, or other cardiac risk factors.

CONCLUSIONS

Clinicians and patients are justifiably concerned about cardiovascular risk, and may seek expert consultation for estimating risk prior to a wide range of activities. In many instances, evidence-based guidance beyond the established

guidelines of traditional preoperative risk stratification is limited or nonexistent. Although noninvasive cardiac testing is widely available, it does not necessarily mitigate risk or even provide adequately informative risk estimation. This is especially true for the multitude of activities in which noninvasive testing has not been adequately studied. When evaluating a patient planning to participate in activities outside of noncardiac surgery, a more helpful, patient-centered approach is to assess their cardiovascular risk after consulting the current medical literature on the topic rather than reflexively ordering tests. Remaining informed on the risks of a given activity and how they may impact a patient with particular comorbidities or cardiovascular risk factors is crucial in providing an informative risk estimation to the patient or referring clinician.

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