CARDIOVASCULAR REHABILITATION THROUGH AQUATIC EXERCISES IN CORONARY ARTERY DISEASE

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I. INTRODUCTION

Coronary artery disease (CAD) is the main cause of death in both industrialised and underdeveloped countries.[1] The four main symptoms of CAD, an inflammatory atherosclerotic disease, are stable angina, unstable angina, myocardial infarction (MI), and sudden cardiac death.[2] Cardiovascular disease development is threatened by factors such as lifestyle, environment, and hereditary. Diabetes mellitus, high blood pressure, smoking, hyperlipidemia, obesity, homocystinuria, and psychological stress are all risk factors for coronary artery disease.[2] Treatment and preventative strategies have considerably improved the prognosis of those suffering from CAD or other cardiovascular diseases during the last several decades.[3]

II. ETIOLOGY

Atherosclerotic occlusions of the coronary arteries or atherosclerotic occlusions themselves are the cause of the cardiovascular condition known as CAD. [4] The development of atherosclerosis begins when lipoprotein droplets gather in the intima of coronary capillaries, compromising the endothelial function of the arterial wall. [3-4] Water-insoluble lipids are transported through the circulatory system by apolipoproteins, which are water-soluble lipoproteins. High concentrations of low-density lipoproteins (LDL) have the potential to penetrate the damaged endothelium and continue the oxidation process [5] Leukocytes are drawn to the oxidised or changed LDL, which allows macrophages to scavenge them and create foamy cells. [5] These foamy-structured cells reproduce and develop "fatty streaks," which are lesions. This atherosclerotic lesion type is the first one that is recognised. [6]. An imbalance between the supply and demand of oxygen in the myocardium is brought on by the development of atherosclerotic plaque in the coronary artery. [4-6] The soreness, heaviness, and pressure-like substernal symptoms of CAD are brought on by this blockage and may also affect the jaw, shoulder, back, or arm. A big meal, mental stress, physical activity, or a cold are frequently responsible for these sensations,

which can occasionally last for several minutes With rest or Nitroglycerin, these symptoms may disappear in a matter of minutes.[7]

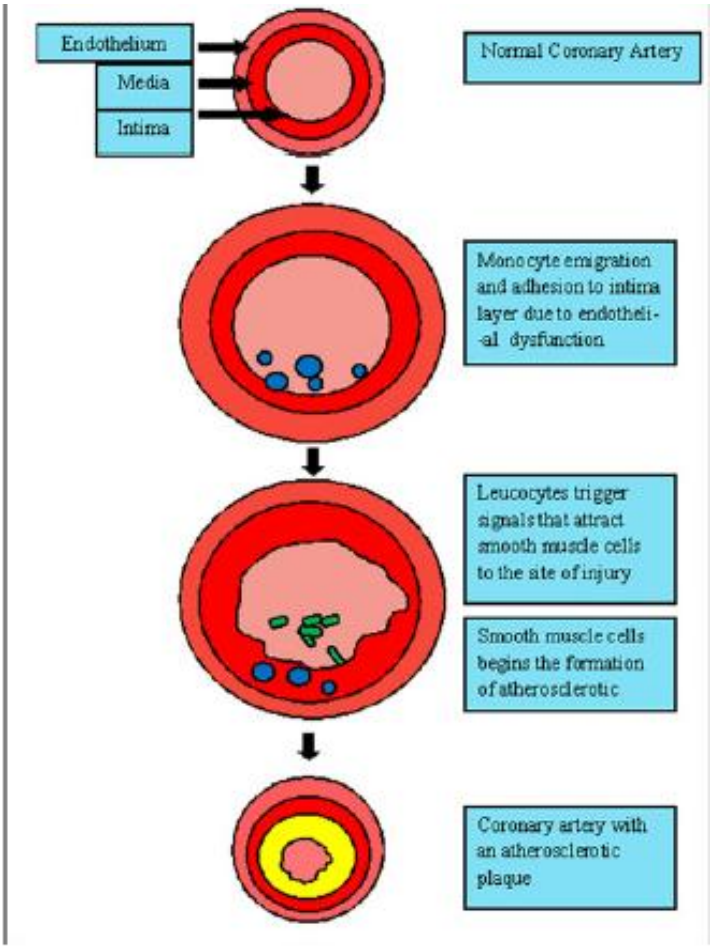

FIGURE 1 Pathophysiology of coronary artery disease depicting the formation of atherosclerotic plaque in the arteries that leads to obstructed blood flow through the arteries [Color figure can be viewed at wileyonlinelibrary.com]

1. **Prevalence of CAD:** Depending on location, race, and gender, CAD, also known as coronary heart disease (CHD), is far more common in some areas than others. [8] Seven different countries looked at the connections between nutrition, lifestyle, CAD, and stroke. Additionally, this study discovered that, regardless of the nation or culture, there was a clear correlation between total cholesterol levels and the risks of heart attack and stroke. [9]These cardiovascular illnesses have been the subject of epidemiological research, which has produced information that may be utilized to inform preventive and eradication efforts at the individual and population levels. The Monitoring Trends and Determinants in Cardiovascular Illnesses (MONICA) project, which lasted for ten years, was one of the largest and most significant studies to determine the global prevalence of CHD and cardiovascular disorders in various populations. Another significant development in the field of CAD epidemiology was the INTERHEART research, which contributed to our understanding of the prevalence of CAD in various populations and encompassed 52 countries from 52 different continents, including Africa, Asia, Australia, Europe, the Middle East, North and South America. [9] The highest prevalence of CAD was found in those over 65 (19.8%) in the United States in 2010, followed by those between the ages of 45 and 64 (7.1%), and then those between the ages of 18 and 44 (1.2%)[10]. 46% of all cardiovascular-related deaths in the UK in 2012 were attributed to

CAD. According to the American Heart Association's 2016 Heart Disease and Stroke Statistics, 15.5 million Americans over the age of 20 have CHD. It has been demonstrated that both in men and women, this incidence increases with age. [9-10]

2. **Risk Factors Associated with CAD:** Smoking, diabetes, hyperlipidemia, and hypertension have all been linked to CAD risk factors by extensive epidemiological studies. [8]

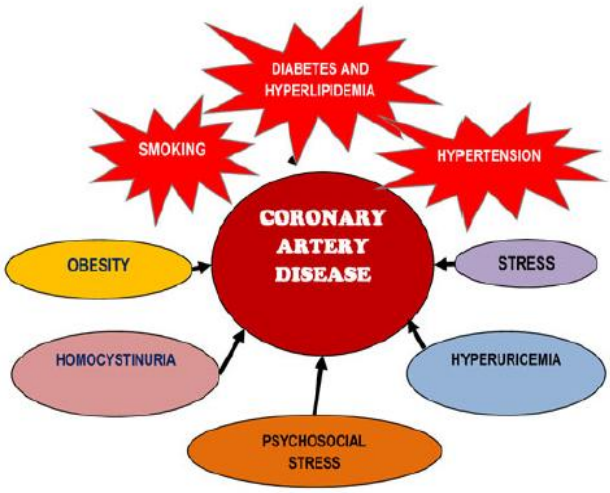

FIGURE 2 Various risk factors associated with coronary artery disease [Color figure can be viewed at wileyonlinelibrary.com]

[7]

Smoking-related CAD is thought to be the cause of 30–40% of yearly fatalities. Smokers died from CAD at a rate that was 70% greater than non-smokers. Coronary artery disease is a risk factor for diabetes, especially diabetes mellitus or type 2 diabetes.[11]Patients with diabetes have a greater chance of getting CAD than people without diabetes. After a four-year follow-up, the PROCAM research demonstrated a strong correlation between CAD and hypertension, indicating the prevalence of hypertension in MI patients. [11]. Hypertension has also been linked to metabolic disorders such dyslipidemia, insulin resistance, and hyperinsulinemia, which are known risk factors for coronary artery disease (CAD). One of the biggest risk factors for cardiovascular disease in industrialised countries is obesity, also referred to as an excess of fat in the adipose tissues. Stress is a significant, controllable risk factor for cardiovascular disease. Examples of such reactions include enhanced hemostasis, endothelial dysfunction, reduced insulin sensitivity, and raised blood pressure. Psychosocial stress associated with job stress has been recognised as a CAD risk factor. In an INTERHEART case-control study, work stress was linked to a higher risk of MI in males than in women. Additionally, several studies have shown that younger employees were more affected by workplace stress than older employees were. [12]

III. AQUATIC THERAPY

1. **Introduction:** Since the beginning of recorded history, water has been used regularly in the treatment of medical issues because it is supposed to promote healing. Immersion in water has significant physiological repercussions that touch almost all homeostatic systems. [13]Due to the rapid and delayed nature of these effects, water can be utilised

therapeutically to address a variety of rehabilitation-related problems. Aquatic therapy can help people with heart illness, neurological issues, musculoskeletal issues, and other diseases. [13]. With understanding of these biological impacts, a qualified rehabilitation specialist may design an effective rehabilitation plan by modifying aquatic activities, immersion temperatures, and therapy duration as required.[12-14].

2. **Application in Cardiovascular and Cardiopulmonary Rehabilitation:** Because a person submerged in water experiences external water pressure in a gradient that exceeds venous pressure within a relatively small depth, blood is displaced upward through the venous and lymphatic systems, first into the thighs, then into the abdominal cavity vessels, and finally into the great vessels of the chest cavity and the heart[15]. When submerged up to the xiphoid, the central venous pressure rises and continues to rise until the body is entirely submerged. In thermoneutral or cooler immersion, pulse pressure rises due to increased cardiac filling and a reduced heart rate. [16] After being immersed into the neck, the heart uses up one-third of the extra volume of central blood, and the neck's major arteries use up the remaining 60%.[17] With neck immersion, the heart's volume increases by 27%–30%. The greater stretch causes the stroke volume to increase. Even while at rest, the average stroke volume increases by 35% following a neck-deep immersion. Symphysis to xiphoid immersion depths lead to a rise in cardiac filling and stroke volume as well as a typical 12%–15% fall in heart rate. [16-18]

   The magnitude of the drop changes according on the water's temperature. Warm water often causes a significant rise in heart rate, which helps to boost cardiac output when the temperature is high. [7]

   After a collarbone-deep plunge, the cardiac output improves by about 1,500 mL/min, with 50% of that increase going towards improving muscle blood supply. Because immersion to this depth results in a cardiac stroke volume of around 100 mL/beat, a resting pulse of 86 beats per minute yields a cardiac output of 8.6 L/min, which already results in a substantial cardiac workload. The increase in cardiac output was higher in younger patients (up 59%) than in older participants (up just 22%), indicating that the increase in cardiac output is age-dependent. Furthermore, it appears to be closely correlated with temperature, rising from 30% at 33°C to 121% at 39°C. [8]

   Recent studies have generally supported the use of aquatic environments in cardiovascular rehabilitation following myocardial infarction or ischemic cardiomyopathy. They discovered that a single 10-minute soak in a 41°C hot water bath reduced right atrial and pulmonary wedge pressure by 25% and increased cardiac output. [19]. The aquatic environment offers a wide range of rehabilitation alternatives, from the treatment of acute injuries to health maintenance in the face of chronic illnesses, despite the fact that it is an underutilised modality. There is a substantial body of research supporting water treatment in both basic scientific and clinical literature [20]. More details on some of the research that supports cardiac rehabilitation are provided below:

   - The aquatic treadmill has a similar effect on CAD patients as the land treadmill and can be used in cardiac rehabilitation, according to Choi et al.'s randomised controlled trial (RCT) of 21 stable patients with coronary artery disease (CAD) to compare

cardiorespiratory responses during exercise stress tests using an aquatic treadmill and a land-based treadmill. [21]

- Fiogbé et al. (2018) conducted an RCT in which 26 male CAD patients were randomly divided into a training group (n = 14) and a control group (n = 12) to examine the effects of water aerobic exercise training (WAET) on the autonomic modulation of heart rate (HR) and body composition in the rehabilitation of CAD patients. The WAET protocol can be used as an exercise training method in cardiac rehabilitation programmes to enhance patients' cardiac autonomic control.[22]

- A randomized controlled study (RCT) was undertaken by Jug et al. in 2022 to investigate the effects of 14 days of short-term, land- and water-based exercise training on heart rate variability (HRV). 90 patients were assigned into three groups following a recent CAD event: controls, water-based or land-based exercise training (14 days, two 30-minute sessions per day), or both. It was shown that training in aquatic exercise was linked to a considerable rise in the linear LF/HF metric. As a result, a training programme for aquatic exercise raises certain HRV metrics, suggesting that this kind of exercise is secure and could be advantageous for CAD patients. [23]

- In a comprehensive investigation, Guimares et al. 2023 investigated the effects of water-based exercise on peak oxygen consumption, activity duration, and muscular strength in CAD patients. Researchers found that as compared to control groups who did not exercise, water-based exercise increased peak VO2, exercise duration, and whole-body strength. As a consequence, he claimed that water-based training might improve exercise capacity and be used as a different approach to CAD patients' rehabilitation.[24]

- Korzeniowska-Kubacka et al. (2015) want to conduct an RCT to examine the effects of exercise training in relatively cool water (28–30°C) on arrhythmia and physical competence in stable CAD patients with intact left ventricular (LV) function. Sixteen 55-minute water-based training sessions (WBT) in water that was 28 to 30 degrees Celsius were performed twice a week on sixty-two male patients who had recently suffered a myocardial infarction. WBT considerably improved patients' physical endurance over the course of a year while more frequently causing arrhythmia, particularly supraventricular ectopic beats (SVEBs). Additionally, water-based training in relatively cold water is an effective and secure form of physical exercise for males with stable CAD and intact LV function.[25]

IV. CONTRAINDICATIONS

Care must be taken while working with those who have significant valvular insufficiency since the expansion of the heart during complete immersion could potentially make the problem worse. [26].According to Swiss researchers who investigated individuals with progressively severe heart failure, water therapy is probably not safe for those with extremely severe or uncontrolled heart failure or people who have just had a myocardial infarction. A recent review of the published research in this area suggests that aquatic and

thermal therapy may be very beneficial rehabilitation techniques for people with mild to severe heart failure. [25-26]. However, it is entirely logical to assume that in situations of uncompensated congestive failure or a recent myocardial infarction, aquatic treatment, hot tub exposure, and possibly even deep bathing should be avoided. Programmes usually involve brief to moderate bouts of temperature-neutral aerobic activity. [27]

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