Literature Review

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Various Therapies for Lymphedema and Chronic Venous Insufficiency, Including a Multimodal At-Home Nonpneumatic Compression Treatment

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ABSTRACT

Lymphedema and chronic venous insufficiency (CVI) affect millions of people and require lifelong management. Many compression options exist for the long-term management of these conditions; however, limitations in patient mobility and adherence are common. Current options for care often present challenges with adherence because they are time-intensive and cumbersome. Innovation is needed to improve compression options for patients with chronic edematous conditions, particularly because lymphedema and CVI benefit from combination interventions. In this narrative review, the authors focus on long-term management strategies for lymphedema and CVI and highlight a nonpneumatic compression device designed for ease of use in the management of lymphedema and CVI. Using a nonpneumatic compression device that combines multiple treatment modalities demonstrates improved efficacy, quality of life, and patient adherence.

KEYWORDS: adherence, advanced pneumatic compression device, chronic edema, chronic venous insufficiency, compression, lymphedema, nonpneumatic compression device, quality of life

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INTRODUCTION

Edema can represent an accumulation of fluid in the interstitial or extracellular compartment of the body that occurs when preload volume of fluid exceeds transport capacity.[1] Because the circulatory system, including the lymphatic system, can be affected by a multitude of factors, extracellular fluid homeostasis is a very complex process.[2] The lymphatic system consists of tissues (nodes and organs) and vessels (including capillaries and collectors).[3] The lymphatic capillaries form a network within the dermal tissues and perform the key function of collecting and admitting lymph fluid. The collectors and collecting ducts, through their auto-contractile properties, enable the pumping of lymph into the nodes for drainage and filtration.[3] Lymphangions, the basic functional units within the collector vessels,[4] contract approximately 6 to 10 times per minute at rest, but contractions may increase 10-fold during exercise due to extrinsic skeletomuscular contractions (muscle and joint movement).[3–5]

Edema can occur at a systemic level (anasarca) or in a regionalized pattern. At the systemic level, allergic reactions, angioedema, cardiac/renal/hepatic diseases, pregnancy, and malabsorption/protein malnutrition can lead to changes that might include increased capillary hydrostatic pressure, increased capillary permeability, decreased plasma oncotic pressure, and increased plasma volume, all of which are potential causes of edema. At a more localized level, chronic venous insufficiency (CVI) and associated venous hypertension can result in edema because of increased hydrostatic capillary filtration in the affected extremity. Deep vein thrombosis resulting from trauma, stasis, or thrombophilia is an important contributor to venous hypertension. Postthrombotic syndrome, a frequent and sometimes disabling sequela of chronic deep vein thrombosis, can develop in up to 20% to 50% of these patients[6] and can present with a spectrum of symptoms ranging from pain and edema to fibrosis and recurrent

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leg ulcerations. Edema of the adipose tissue is the substrate of lipedema and characterized by the accumulation of fluid in adipose tissue. In addition, edema can occur from lymphatic obstruction, malfunction, or excessive lymphatic preload.[2] Edema related to lymphatic impairment can be primary or secondary in origin. Primary forms of lymphedema are congenital and often associated with dysplasias of the vessel system. Secondary forms of lymphedema are acquired as a result of surgery, trauma, infections, or other insults to the lymphatic system leading to obstructions of the vessels or nodes.

Recently, Lurie et al[7] reported that a consensus panel of clinician experts identified cancer, infection, chronic venous disease, and surgery as risk factors for secondary lymphedema. The consensus also defined that clinical examination alone is adequate for diagnosing lymphedema. Moreover, all patients with venous insufficiency (CEAP [clinical, etiological, anatomical, pathophysiological] score C3-C6) are considered to have a component of lymphedema (phlebolymphedema) and should be treated as such. The various forms of chronic edema, for which there is no cure, share the common characteristic of impairment to the lymphatic system. These chronic conditions are often overlooked by healthcare providers because they fail to recognize the magnitude and impact of these conditions and their manifestations.

Literature Search

PubMed and Research Gate were the primary indexes used for the literature search for this narrative review. The authors conducted the literature search in early 2023 using key words such as lymphedema, chronic edema, CVI, compression devices, and lymphedema management.

HEALTH AND FINANCIAL BURDEN

The financial and personal burdens of chronic edema have been linked to increased depression, anxiety, and pain, and low health-related quality of life.[8] Lymphedema remains an incurable, lifelong chronic disease, and patients face increasing out-of-pocket costs. Proper management of lymphedema has lasting impacts on lowering an individual's healthcare expenditures, increasing productivity, and reducing episodic clinical deterioration from cellulitis and resultant hospitalization.[8,9] From 2012 through 2017, lymphedema-related hospitalizations resulted in more than $1 billion of reimbursed costs in the US healthcare system.[8]

A consensus from The American Venous Forum, the American Vein and Lymphatic Society, and the Society for Vascular Medicine published in 2022 by Lurie et al[7] and a systematic review by Torgbenu et al[10] both recommend early intervention for the management of lymphedema. Current clinical practice often begins with a multimodal treatment strategy, which typically consists of self-management, elevation of the affected limb, exercise, compression, skin care, and manual lymphatic drainage (MLD). Among the various modalities, elevation, exercise, and compression are the foundational mainstays for adjunctive treatments.

TREATMENT MODALITIES

Elevation and Exercise

Early intervention in the form of limb elevation, compression, and exercise can ameliorate and stabilize lymphedema in its early phase. Meta-analyses from two separate reviews (total of 80 studies) published in 2020 by Hasenoehrl et al[11] and in 2022 by Hayes et al[12] reported that early intervention and exercise remain foundational tools to manage lymphedema and improve range of motion.[10–13] Exercise reduced pain and improved strength, function, and quality of life. Separately, Chen et al[14] demonstrated that even with brief (15 minutes) exercise, indocyanine green patterns of dermal backflow improved in the lymphedematous limb in comparison with the limb without exercise.

Static Compression

Textile compression garments are routinely used for managing lymphedema and CVI by providing static compression to enable containment of intracellular and/or extracellular fluid. These compression garments are worn daily throughout waking hours, and special garments for night use can also be worn. Appropriate preemptive use of a compression garment during the first few months after axillary node dissection could reduce the likelihood of lymphedema in high-risk patients.[15] In addition, current lymphatic and CVI guidelines and expert consensus favor routine use of compression garments to reduce lymphedema progression.[7,10] However, the donning and doffing of these garments remain a challenge, which can lead to poor adherence.[16] Ostby and Armer[17] and Bar et al[18] demonstrated poor adherence over a 20-year investigative period in relation to lower extremity lymphedema/venous disorders.[17,18] Adherence issues arise when patients need to wear a snug or tight garment to help contain edema for lifelong management. A person's dexterity and mobility can further contribute to poor adherence. Compression pumps (ie, advanced pneumatic compression devices [APCD] and nonpneumatic compression devices [NPCDs]) are easier to don and doff because the application involves Velcro or simple proprietary closure mechanisms that are designed for ease of use.

Gradient Sequential Compression

Adjunctive treatment such as pneumatic compression devices provides gradient sequential compression to

mimic the effects of MLD, which may be provided either by a licensed trained therapist or by oneself in the home setting. Blumberg et al[19] and Muluk et al[20] have shown that APCDs manage lymphedema by reducing limb volume and that they decrease potential episodic complications of cellulitis and skin breakdown.[19,20] Further, APCD treatment of lower extremity lymphedema elicits reduced limb volume and improved patient-reported outcomes.[20] Additional studies have shown favorable health economic impacts from the use of APCDs for patients with lymphedema, including reductions in hospitalization from complications and reductions in outpatient care (up to 37% reduction in total costs related to the disease).[21,22] However, APCDs are bulky, nonportable medical equipment that are cumbersome to use, with reported poor adherence.[23]

More recently, clinical studies[25–27] involving an NPCD have reported an approach that encompasses multiple established treatment modalities and shows early promise of improved clinical efficacy, quality of life, and patient adherence.

Active Compression beyond a Single Treatment Modality

Recent innovations in medical science and biomaterial technology have enabled the development of an NPCD (Dayspring; Koya Medical) that delivers additional adjunctive treatments rather than exclusively gradient sequential compression. Active compression offers practitioners the opportunity to provide static and gradient sequential compression and enable therapeutic exercise with the use of a single device. The Koya Dayspring for upper and lower extremity chronic edema/lymphedema management is currently the only NPCD on the market.

Pamplin et al[24] described the NPCD as providing both static compression through the garment using inelastic material and gradient sequential compression via electroactive shape-memory material within the garment that contracts and relaxes to deliver pressure ranges comparable to those provided by APCDs when specified by the mobile NPCD controller. The combination of these compression types mimics the action and effect of MLD, stretching the anchoring filaments that attach the dermal lymphatic capillaries to the surrounding connective tissue. This type of action opens the lymphatic capillary, allowing fluid to enter the lumen, and drives the fluid to the precollectors and down to the deep, valved collectors where the lymph fluid is transported to regional lymph nodes. The NPCD technology also incorporates compression and exercise into a single treatment. For the underlying lymphatic physiology to function optimally, both the capillaries and the deeper lymphatics must work in tandem. This can be more readily achieved using NPCD because it is portable and can be worn during activities of daily living and walking, allowing the muscle pump to support venous and lymphatic flow.

In contrast, APCDs are nonmobile, pneumatic, air-based devices that inflate and deflate air chambers to provide sequential gradient compression. With traditional APCDs, treatment requires patient immobilization in supine positions, which prevent optimal lymphatic and venous functioning. In contrast, intervention with NPCD enables the necessary muscle and joint contractions that are essential to increasing lymphangion action. The ability of patients using NPCD not only to perform the treatment easily but also to remain mobile and active results in potential added quality-of-life benefits. The design and usability of the NPCD device enable easy donning and doffing. Further, its portability allows for minimal disruption in a person's daily routine, improving adherence as well as quality of life.

Three clinical studies[25–27] have demonstrated the clinical benefits of NPCD, noting that its light form factor encourages patient use and improved adherence. Results from these studies, including a multicentered randomized crossover trial, indicate that the NPCD provided better edema reduction per patient self-reporting, greater edema volume reduction, and increased quality of life and patient satisfaction compared with APCD.[25–27]

CONCLUSIONS

Treating and managing chronic edema require a deep understanding and appreciation of the lymphatic system, an often-overlooked part of the circulatory system. To date, it is evident that no single treatment modality on its own will likely be successful in managing this complex, chronic, lifelong condition. With a treatment approach that combines multiple well-established treatment modalities vetted by multiple clinical studies, NPCD offers an at-home lymphedema and CVI treatment that improves both clinical outcomes and the quality of patients' lives. ●

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